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HIGH-SPEED RAIL OPPORTUNITIES AROUND METROPOLITAN REGIONS: THE CASES OF MADRID AND LONDON

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ABSTRACT

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The original main aim of High-Speed Rail (HSR) was to link big metropolitan areas 400-600 km apart. Recently, intermediate HSR stations have also been created in suburban areas or small cities within the limits of metropolitan areas (up to 100 km), opening up new metropolitan transportation opportunities, notably the strengthening of inwards and outwards commuting and through traffic across the metropolis. The argument advanced in this paper is under which conditions HSR could facilitate the development of small HSR suburban cities as special subcenters of the metropolitan area, with particularly good connections to the metropolitan center and to other distant metropolises. The paper focuses on a comparative study of this new type of metropolitan HSR by analyzing the Madrid (Toledo, Segovia and Guadalajara stations) and the London (Ashford, Ebbsfleet and Stratford stations) cases. Infrastructure lay-out, station typologies and rail services are compared, together with each city's territorial contexts, activities and connections to other transport modes. This case-study approach, taking account of specific circumstances and contexts, facilitates the understanding of the HSR impact on metropolitan development, offering new transport alternatives.

Keywords: *High-Speed Rail, metropolitan regions, peripheries, subcenters, commuting.*

INTRODUCTION

High-Speed Rail (HSR) lines were originally conceived as an alternative to air travel between metropolitan areas at distances of from 400 to 600 km. Intermediate stations have progressively appeared on these lines, some for purely technical safety-stop considerations, some for socio-economic and political reasons so as to avoid leaving particular cities or regions without a HSR station, and some because of the convenience

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of siting a station in cities through which a HSR line was already planned to pass in the hope that these could act as a stimulus to local economies.

Whilst early examples in France and Germany have not shown any such outcomes, in Spain, long distance commuting and discontinuous metropolitan processes have increased considerably in these intermediate cities. It is difficult though to distinguish accurately the specific effects of HSR connectivity on major cities, like Madrid, Paris or London, from those of other transport improvements, or of changes in economic and town-planning strategies (Bonnafous 1987). Moreover, big cities already had excellent high-speed air transport links before the arrival of HSR, and HSR meant for them only a marginal improvement of their connectivity (Plassard 1991; Vickerman et al. 1999).

However, understanding HSR strategies and their impact on small cities distant from major metropolitan areas has been relatively straightforward given these cities' previously low levels of dynamism (Banister and Berechman 2000; Ureña et al. 2005). HSR studies on small cities recommend considering two factors when investigating the territorial qualities which are favored by the introduction of a HSR infrastructure. Firstly, the *distance* between the cities in question and the major cities or metropolises (Klein 2004; Fröidh 2005), where the appearance of a new type of traveler has been identified, the long distance commuter, when HSR travel time is around one hour or 200 km (Ureña et al. 2005). Secondly, their particular *location* advantages before the arrival of HSR (Menerault 1998; Auphan 2002), where the HSR has been shown to have quite different effects if these cities were or were not already within significant transport corridors before its introduction (Torchin et al. 2009).

Ureña et al. (2009) was a detailed analysis of ten European small cities at less than 100 km away from a metropolitan area, classifying them in accordance with their

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connectivity into the HSR network. They demonstrated that a third identifiable type of HSR connectivity has been established – the first being that of big cities 400-600 km apart and the second that of small cities some 200 km away from metropolitan areas.

In these territorial conditions (within 100 km of the center of a metropolis), it is almost impossible to isolate the purely HSR-related consequences from others derived from integration into metropolitan processes –indeed they should be considered integral parts of the same. However, the fact that this new type of HSR connection facilitates or reinforces the integration of these small cities or suburban areas at the metropolitan corridor is foreseeable. Besides, the way they are incorporated into metropolitan and national corridors and the characteristics of the aforementioned corridors will have a considerable effect on the opportunities generated by HSR.

The debate that this paper addresses is what function these HSR stations not far away from a metropolis do actually fulfill and what opportunities may open at their urban areas, especially the likely formation of a metropolitan subcenter. The study is divided into three main sections. In the first one the paper points out some of the recent changes suffered by metropolitan areas, as their functional reorganization, the greater importance of peripheries and the role of transport infrastructures as a driving force of metropolitan expansion. In the second section the paper states the hypothesis and the case studies. Finally, in the third section the paper presents the main opportunities opened up by HSR in the Madrid and London metropolitan regions.

RECENT URBAN PROCESSES IN METROPOLITAN REGIONS

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METROPOLITAN FUNCTIONAL REORGANIZATION

Economical, technical, social, political and territorial changes, especially from the second half of the 20th century, have caused a spatial reorganization in big metropolitan areas. The recent division of labor reinforces the metropolitan functional specialization on the most competitive sectors, while other activities remain in decline and move outwards to other territories. In addition, such displacements do not happen randomly in the territory but usually take into account factors like the spatial distribution of population and firms.

Location and relocation of economic activities and housing towards the metropolitan peripheries has taken place for a long time. In the first instance it happened with low class and high class housing and with industry, meanwhile offices and commerce remained polarized in the metropolitan center. More recently offices and shopping malls have started to appear and relocate to more peripheral places.

The greater importance reached by metropolitan peripheries as "areas of opportunity" and potentially receivers of different metropolitan population and activities from the center (García-Palomares 2010; Gallo et al. 2010) opens new challenges for renovation and/or reorganization in certain peripheral spaces (edge cities, subcenters, medium-sized cities, activity poles, infrastructure cross-points…). The processes shaping new centrality nodes/spaces in metropolitan peripheries lead to decentralization processes in some cases (Clark 2000; Coffey and Shearmur 2002), while to *spatial reassignments of functions and activities* in other cases (Gallo et al. 2010; Romero et al. 2010). In this way, it is not that the metropolitan center is losing importance, but rather a new system of interconnections in both directions has been put in place (Cervero 1995; Solís 2008), in between central and peripheral spaces and peripheral-peripheral ones.

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The most recent relocation towards metropolitan peripheries is that of the service sector, which can be subdivided into the trivial one, which is more or less proportional to the number of residents and/or workers following the sprawled metropolitan urban pattern; and the more specialized one, the so-called "high-order service/office subsector", whose spatial rationale tends to be more concentrated, in many cases to facilitate face-to-face contacts.

The metropolitan locations of this "high-order service/office subsector" are threefold. First, they intensify their location in the traditional metropolitan center, because the central city as a tertiary and commercial centrality is still paramount for some companies (Mignot 1999; Coffey and Shearmur 2002), in some cases by using rehabilitated historic buildings and in others by increasing the office building surface.

Second, the expansion of the traditional center to new areas beside it, in a concentrated manner, in some cases by large scale renovation processes (Canary Wharf in London), in others by using land that was preserved for this objective in special quarters (AZCA in Madrid or La Défense in Paris), benefiting thus from the proximity to other similar companies or specialized labor force and creating a first-order CBD centrality.

Third, new concentrated big surface activity areas created in specific peripheral areas not too distant from the metropolitan traditional center and with good accessibility. This process is taking place nowadays in London towards places either just inside or outside the greenbelt, in many cases along the M-25 ring road (Thames Gateway/Ebbsfleet, Watford; IAURIF 2008). In Madrid the situation is similar but closer to the center (15 km), in many cases by the M-40 ring road (Banco Santander or Telefónica HQ), and mainly to the north-west.

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In this outward process, metropolitan expansion has traditionally included small villages or towns, increasing their size, and transforming them into typical suburban areas with low level administrative and office activities. On the other hand, cities that have already played relevant regional roles (administrative capitals, university cities, with public services, railway nodes, etc.) have also been included in this process. In very big metropolises, such as London, this has happened some time ago, in other smaller or denser metropolises, such as Madrid, more recently (Bontje and Burdack 2005). These cities are now immersed in two processes, their traditional role which polarizes and serves a certain region; and their new suburban role in relation to the metropolis, which means that some metropolitan activities may localize and/or re-localize at them (Romero and Garmendia 2009).

In this sense, and depending on their own urban characteristics, the metropolitan role may facilitate the trivialization of their previous functions, being increasingly transformed into mere suburban places, it may facilitate industrial and logistic roles or it may facilitate the increase of their polarizing roles as subcenters of the whole metropolis. The latter occurs mainly regarding the activities characterizing the metropolitan centers, that is, high-order tertiary functions. Similarly, the environs of metropolitan airports have become much sought-after locations for particular economic activities.

TRANSPORT INFRASTRUCTURES AND METROPOLITAN STRUCTURE

The relationship between transport infrastructures and metropolitan structure is quite clear, as new urban developments have always entailed changes in the functioning of already existing territorial structures. Both urban and infrastructure developments have an influence on each other, either a new urban development exerts a pull on the

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necessity of an infrastructure or an infrastructure fosters the emergence of an urban development (Conrad et al. 1998; Ribalaygua 2005). Thus, as Israel and Cohen (2010) point out, changes in transport technologies and/or urban patterns lead to a reorganization of the urban or metropolitan functions: "by affecting accessibility and location decisions, the transport system affects urban form and development" (p.523).

Metropolitan regions have grown through transport infrastructures, either radials (motorways, suburban rail, regional rail…) or orbitals (motorway or rail rings). The farther they reach, the farther the population and the activities will locate or relocate from the metropolitan center; both in a sprawled or a compact pattern (Romero and Garmendia 2009). Planning a suburban radial railway system, along with dense satellite centers, lead to a polycentric city in Stockholm (Cervero 1995); while in other cases, the development of a transport network of different modes is the back up of a subsequent, but not planned, "population and activities decentralization", as in Madrid (Calvo et al. 2007).

The contribution of accessibility amelioration to regional polarization or decentralization is not clear; nevertheless, it is widely accepted that efficient transport networks are vital for economic development in the disadvantaged peripheral regions (Vickerman et al. 1999; Givoni 2006; Garmendia et al. 2008), where the most relevant changes will occur, as in the metropolitan center the transport connections, urban and economical characteristics are already good. In addition, improvements in the accessibility level of territories have been proved greater when it comes to railways than roads (Baum-Snow and Kahn 2005; Gutiérrez-Puebla et al. 2006).

HSR offers positive global effects on economic sectors in growth, that is, the tertiary sector (Bonnafous 1987; Ureña et al. 2005). Thus, HSR results in synergies with

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metropolitan "high-order services", while it has negative or no effects in primary and secondary sectors. Baum-Snow and Kahn (2005) point out that the number of commuters switching from car to rail "will depend heavily on the travel speed on the rail line", suggesting that the metropolitan HSR should attract new travelers either from other transport modes (suburban/regional rail, bus, car…) or new users that did not travelled at all.

RESEARCH HYPOTHESIS AND CASE STUDIES

Small cities or suburban areas up to 100 km of a metropolitan area are already quite integrated into them (Anas et al. 1998; Giuliano and Small 1991) and HSR can increase their level of metropolitan integration through this new communication infrastructure, due to the increase of point to point accessibility that usually will not connect them to other intermediate zones within the same metropolitan area, but will instead connect them directly with that metropolitan center.

These HSR stations can play at least two distinct roles. Firstly, they can act simply as an additional mean of metropolitan transport, of a particular kind (fewer routes, fewer stops and faster travel than other metropolitan railways). And secondly, they can also act as a secondary metropolitan HSR station, more accessible to those who live or work in the peripheries of the metropolis or other non-metropolitan places and enabling them to travel to and from faraway places (see Figure 1).

FIGURE 1

Given that many other means of communication already exist, such as motorways, suburban railways and bus services, the most significant new opportunity opened up for

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these suburban areas by HSR might not be the strengthening of their metropolitan integration. Yet, this paper suggests that the same HSR transport mean accessible from the metropolitan center may now also be available from some small cities of the metropolitan periphery, transforming themselves into special metropolitan subcenters. Both, the increase of their metropolitan integration and the increase of outwards accessibility can foster the role of these suburban areas as metropolitan subcenters.

According to Ureña et al. (2009), the specific factors which could determine the extent of such opportunities to help these small cities to convert themselves into metropolitan subcenters are:

(1) the small city's good connections with the other transport networks/services in the metropolitan area, both for long distance and intra-metropolitan travel;

(2) whether the particular metropolitan transport corridor within which the suburban areas with HSR station are located, houses significant population of highly-skilled professionals and a well-developed high level service sector;

(3) the quality and variety of the city's urban, environmental and service characteristics;

(4) the particular siting, accessibility and/or the projects which spring up around the HSR station in the small city;

(5) the specific means by which the stations are connected to the HSR network.

These factors have been proved to be the most relevant to infer HSR spatial implications, as they are relatively permanent (Menerault 1998; Burmeister and Colletis-Wahl 1996; Ureña et al. 2009). However, other general transport factors –

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frequency, schedules and destinations- must be taken also into account (Klein 2004; Rabin 2004). In this sense, the contribution of this paper to such debate focuses on the issue that, even if there is the same transport means either in both the metropolitan center and the peripheries, there won't be the same quantity and diversity of such transport services (contrary to the case of airports), and the subcentering process will be softened.

The paper examines the new metropolitan processes that HSR is starting to encourage around the metropolitan regions of Madrid and London, and debates the way the abovementioned functions of HSR (inwards/outwards relationships) are taking place in the suburban areas and small cities up to 100 km from their metropolitan center having a HSR station.

The Madrid Urban Region has traditionally been very polarized and spatially segregated: the north and north-west being the residential area of high income population and the economic area of offices, the north-east and east being the residential area of medium income population and the economic area of big technologically sound industries and logistics, and the south being the residential area of low income population and the economic area of small and low technology industries. The Madrid metropolitan area now reaches up to 80 to 100 km outwards including parts of the adjacent regions.

The London Urban Region, in contrast, has been developed in a polycentric manner with a larger commuter catchment area. The London labor market area stretches typically around 100 km radius and London's economic influence spills over into all the adjacent regions. The outer areas, particularly those to the west in easier reach of Heathrow airport have however been the main destination of newer high-technology

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employment in both the manufacturing and service sectors of the knowledge economy. It seems that the presence of the main metropolitan airport with the greater number of business flights has attracted this kind of activities.

Within a 100 km radius, Madrid has two central terminus stations, one by the south of its CBD (Atocha) and one by the north (Chamartín), and three stations rather far away from the metropolitan center, at about 60-70 km distance, at or nearby the small provincial capitals of Guadalajara, Segovia and Toledo, each one in a different HSR radial line (see Figures 2 and 3).

FIGURE 2

On the other hand, London currently has just one central terminus station for HSR services at the north of its CBD (St. Pancras) and three stations at one sole HSR line which connects London with the Kent and Medway counties and the continent, progressively distant from its center, at 9 km (Stratford), 37 km (Ebbsfleet) and 88 km (Ashford) (see Figures 2 and 3).

OPPORTUNITIES OPENED UP BY HSR IN THE MADRID AND LONDON URBAN REGIONS

Inherent qualitative characteristics to the metropolitan HSR stations and cities

The opportunities for the creation of new metropolitan subcenters in HSR cities in the area of London are greater than in Madrid, because some of the HSR stations locations are closer to the metropolitan center in comparison to its size and because the HSR

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connection types fulfill better the long distance, metropolitan and local sub-regional services (see Figure 4 and Figures 2 and 3).

HSR stations, like metropolitan airports, are becoming increasingly attractive locations for economic activities and, thereafter, potential centers of economic growth (Van den Berg et al. 1996; Burmeister and Colletis-Wahl 1996; Ribalaygua 2005; see Figure 3).

FIGURE 3

In the Madrid case, HSR stations have three different types of network connection, in three different corridors at the outermost edge of the metropolitan periphery (around 60-70 km from its center), quite far from the metropolitan center to promote office decentralization, and one central and two peripheral stations in small cities (two administrative provincial capitals and one regional capital).

Only Toledo has the local required characteristics to become a subcenter, but lacks good long distance transport connections; Guadalajara, the one that fulfils the best the long distance transport connection is the one that fulfils worse the local requirements (see Figure 4); and Segovia has the local and the corridor's required characteristics but is not located on a national corridor. Hence, there are strong contradictions between the most appropriate corridors, cities and type and location of HSR stations for office decentralization, each HSR city having a mixture of positive (white) and negative (grey) characteristics to produce synergies with HSR (see Figure 4).

FIGURE 4

In the case of London, the metropolitan area is in much greater need of office decentralization and reduction of inward commuting. The three HSR stations are in all types of metropolitan peripheries, they are through stations, two of them with transport

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services to their sub-region, which strengthens connections with the metropolitan center, with their sub-regions and with other more distant cities, in this case all of them foreign (France, Belgium…). The three stations are in one sole HSR line at different distances from the metropolitan center, which may facilitate the definition of a more robust activity decentralization strategy. Nevertheless, attracting offices towards the east and south-east of the metropolis would have to change the existing tendencies whereby the west has been the main destination of newer high-technology employment of the knowledge economy.

Stratford, just north-east of the CBD and due to the planned important redevelopment and urban transportation connections may attract some offices of the type: "extension of the existing metropolitan center". Office decentralization seems more difficult in Ebbsfleet, and if any take place they might be of the type: "new big concentrated activity in specific peripheral areas not too distant from the metropolitan center". Finally, office decentralization at Ashford may be quite unlikely, although it has been designated as a Growth Area for many years, most recently by the South East Plan (2009).

In London, Stratford and Ebbsfleet depend more on the redevelopment projects that are being undertaken, and Ashford lacks some of the local requirements (i.e. no university, no county or regional roles), fulfils others (i.e. central HSR station) and fulfils very well the existence of other means of transport (apart from HSR), both metropolitan and long distance.

Using the infrastructure: HSR transport services around metropolitan regions

Great Britain has a long tradition in high-speed (as opposed to very high speed) on traditional main lines to the north and west of London with speeds of 200km/hr in

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regular service for over 30 years, having the same rail gauge for all train services. However, Spain has two different rail gauges, traditional and high-speed, making it difficult for HSR trains to continue along traditional lines. In these metropolitan and infrastructural contexts, Spain has three types of HSR services while Great Britain only two:

- Pure long distance services (AVE in Spain and EUROSTAR in Great Britain):
  - only along HSR tracks, all national in Spain and international in Great Britain,
  - most stop only in major stations,
  - expensive fares,
  - abundant number of services between major cities (15-20 / day and direction).
- Metropolitan services (AVANT and AVE Lanzadera in Spain and DOMESTIC HIGH SPEED in Great Britain):
  - connect metropolises to cities at 30-200 km distance,
  - along HSR tracks in Spain, in Great Britain along HSR and traditional ones,
  - stop in most stations,
  - fare is cheaper than long distance and has reductions for frequent travelers,
  - few services (6-12 / day and direction) in Spain and many more (30-80 / day and direction) in Great Britain,
  - useful for commuting on long distances or with congestion near metropolises
- Long distance mixed services (ALVIA and ALTARIA in Spain):
  - partially along HSR and partially along traditional tracks,
  - most stop in all stations and are less punctual,
  - fare is slightly cheaper than pure long distance services,

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- small number of services to each final destination (2-3 / day and direction)

Keeping the comparison between HSR stations and airports, it is important to remark that the metropolitan airports generally gather almost the totality of the flights available from/to them –though sometimes, several airports on a sole metropolitan region share out flights and destinations (high/low cost, national/international…), while HSR stations at the metropolitan periphery have fewer train services than central metropolitan HSR stations (usually termini stations of all the HSR services), modifying the subcentering process in the metropolitan peripheral areas.

In this way, even if there is the same transport mean in the metropolitan center and in the periphery, none of the secondary metropolitan HSR stations have similar number and diversity of **long-distance HSR services** as available from the central metropolitan HSR stations (see Figure 5):

- In Madrid, they are about 4 times less numerous at Guadalajara and about half at Segovia, while at Toledo there are none.

- In London, the international services are about 3 times less at Ebbsfleet and 6 times less at Ashford, while there are no international services at Stratford.

FIGURE 5

Meanwhile, the six stations are much more linked with **HSR services towards the metropolitan center** than to distant cities (see Figure 5). This is so at Madrid, with 20% more metropolitan than long distance HSR services at Segovia, none at Guadalajara, while Toledo has only (metropolitan) HSR services with Madrid. On the other hand, they are significantly more numerous at London, 6 to 7 times more at Ebbsfleet and Ashford, while Stratford has no long distance ones but about 80 metropolitan ones.

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Regarding the **metropolitan HSR** frequencies, they are significantly small in the case of Madrid (6 and 8 per direction), while in London they are much more numerous (between 38 and 78 per direction), similar to normal frequencies of traditional suburban trains (around 100 in the London-Ashford one and 60 in the Madrid-Guadalajara one).

In relation with the **operation of a high-speed line** that is intensive used two aspects are crucial. First, intermediate stations (and services that stop at them), unless provided with bypasses, may cause time decrements in long distance services, diminish the capacity and change the economic appraisal of the line. Second, commercial speeds of HSR trains should be similar, otherwise similar problems may happen. In Madrid, the main problem is HSR commercial speeds, because metropolitan HSR services use rolling material with 260 km/h maximum commercial speed and long distance HSR services have 300 to 350 km/h maximum commercial speed; while there are no intermediate stations in any of the three HSR lines between their HSR metropolitan periphery station and Madrid. Nevertheless, the Madrid problem is also limited for two reasons; first, because the coinciding part of the lines with long distance and metropolitan HSR services are about 60 km long, and second, because there are a small number of metropolitan services (see Figure 5). In London, the main problem is caused by intermediate stations together with a greater number of long distance HSR services and a very numerous number of metropolitan HSR services, since most metropolitan HSR services stop at several stations (Ashford, Ebbsfleet and Stratford), but each of these does provide a through rout enabling non-stopping services to pass through at speed.

Therefore, according to the quantity and quality of HSR services and the rest of factors, it is more likely to Toledo to become a subcenter of Madrid than it happens with

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Guadalajara, since the former is (advantageously) only connected to Madrid and the latter fulfils better the long-distance destinations. On the other hand, Segovia could be a mix of both processes as it is now connected to a very important HSR future national corridor towards the north and northwest of the country and it is also linked by metropolitan HSR services to Madrid. In London, though the number of metropolitan HSR services is very high, there is adequate capacity for all foreseeable services.

Using the HSR metropolitan services, first realities, first opportunities

The use of the HSR has already been measured in the three Madrid stations by means of several on-board survey campaigns (more than 10.000 valid questionnaires) carried out by the authors in 2008 and 2009 (Menéndez, J.M., unpublished internal report, November 2009). However, it has not been measured in London because the metropolitan services only started in December 2009 (although a preview service began on 29th June 2009), so reliable data is not still available, and there are only opinions derived from a few qualitative interviews.

In general, most metropolitan commuting now made in HSR services most probably is derived from modal transfers of people that already commuted by conventional rail, bus or private car, decreasing the use of some transport infrastructures and increasing the use of others. Nevertheless, there is no precise data on this, but only side data. The increase of speed in the metropolitan line between Stockholm and Eskilstuna to an almost HSR one (115 kilometers in 1 hour and four intermediate stations) has meant that the number of travelers has been multiplied for seven (Fröidh 2005). Or that 82 and 80% of the HSR passengers between Madrid-Toledo and Madrid-Segovia, respectively, would have accomplished the journey although the HSR had not existed (Garmendia et al. 2009). In the case of Madrid-Segovia, 49% of HSR users are commuters and 71% of

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them were already commuters before the arrival of HSR (69% used private car, 29% used bus and just 2% used conventional rail to commute).

The use of HSR at these peripheral stations of Madrid has to consider that commuting HSR passengers are of higher socio-economic strata that the Spanish average, 41% having university degrees and 13% being entrepreneurs (Menéndez et al. 2002), that there are not very high numbers (in 2009 Madrid-Segovia were 600,000 both ways and Madrid-Toledo 1,5 million also both ways including 30% of them tourists) and that housing prices per square meter in the three cities with HSR stations are about 30% smaller than the municipalities adjacent to Madrid in their corresponding metropolitan radial corridor, except in the case of Toledo which are similar (Ureña et al. 2012).

So far, the first opportunity is that the metropolises have *additional stations to be used as alternatives to central stations for long distance travel*. This happens in Guadalajara, Ebbsfleet and Ashford.

> The north-east Madrid-Guadalajara corridor offers multiple means of communication. A radial suburban rail with a much more central station, several intermediate stops in places with important job opportunities, four stops at the Madrid center (Atocha, Recoletos, Nuevos-Ministerios and Chamartín), a great frequency (60 per day in each direction compared to only 3 HSR services) and low fares (0,06 €/km). There are also suburban buses, with similar characteristics to the suburban rail and two motorways. Suburban rail to Madrid takes only one hours' travelling time, while HSR takes 25 minutes. In these circumstances, aside from the HSR station location at 8 km from Guadalajara, passengers use the limited HSR services available as an alternative station for long distance travel rather than for

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commuting to/from Madrid (82% of users). Besides, 18% of users come from the north-east Madrid metropolitan transport corridor.

Currently, in Ebbsfleet and Ashford HSR stations, the inhabitants of Great Britain board and disembark on their journeys to and from the continent, mainly for leisure/holiday purposes (74% of travelers; Arkenford Ltd. 2006). This is so especially for those for whom these stations are more convenient than the central London one, given its good conventional rail connections with the rest of the south-east (Ashford), its easy accessibility by private car (both stations) and the fact that it enables passengers to avoid London's traffic congestion and lack of parking space.

The second opportunity is *to increase their metropolitan integration* by inwards commuting. This happens especially in Segovia and also in Ashford, Ebbsfleet and their sub-regions.

In Segovia, HSR is mostly used for commuting (49% of users), almost only inwards (95% of commuters), and many of them previously used other means of transport (66% of users). This inwards commuting by HSR is due to that suburban traditional rail services (7 per day and direction) take 2 hours while HSR takes 25 minutes, because road distance is 90 km while HSR distance is 60 km and because inwards traffic congestion is very high. Reversely, HSR commuting outwards from Madrid to Segovia is very small (5% of commuters) for four reasons: because there is little traffic congestion in that direction, because the station is 4 km away from the center of Segovia, because possible commuters (fairly high socio-professional level) live in the same north-west corridor and find it much easier to commute by car, and because of the limited high-level jobs offered in this small provincial capital –in 2007, 11,3% of the total employment in Segovia was of the type "knowledge-

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intensive business services" or KIBS, while 14,5% in Toledo and 16,7% in Guadalajara.

The traditional rail network allows good services for Kent to reach several stations in the southern part of central London: Victoria, Waterloo, Charing Cross, Cannon Street and London Bridge; while the metropolitan HSR services allow good opportunities for a lesser number of places in Kent to reach one sole place in the northern part of central London: St Pancras. From all these stations there are good underground connections to all places in central London, but underground comfort and speed are low, thus most people might prefer to arrive as close to their work as possible either by suburban traditional rail (southern part of central London) or HSR trains (northern part).

Absolute time reduction using HSR metropolitan services is not that relevant (47' for Dover or Ashford to London, although relative time reduction is very large – 50% in the case of Ashford and the time saving for cross-London journey is even greater), while frequencies (75 HSR and 313 traditional rail services in Ashford, both directions) and stations served (22 stations out of 109 in Kent) are less than traditional rail, and price is higher (>£6). Time reductions are more relevant for those using HSR services entering the HSR infrastructure in Ashford than for those entering in Ebbsfleet because the distance travelled on HSR infrastructure is longer (Abbott 2011; see Figure 2). In this sense, a greater level of commuting would be expected from Ashford than from Ebbsfleet.

The third opportunity is not only *to reinforce* the inwards metropolitan commuting relations but also *the outwards metropolitan ones* that may be helping to decentralize

some activities to the metropolitan periphery. This happens in Toledo, but has not yet happened towards Ashford or Ebbsfleet.

In Toledo, where HSR only allows travelling to/from Madrid, a significant proportion of its passengers commute outwards from Madrid to Toledo (24% of commuters). This is important due to four reasons: (1) because Toledo has become the regional capital of the third (in surface area) and the ninth (in population) largest Spanish region and the number of jobs of high socio-professional level has increased importantly (from 2000 to 2007, total and tertiary employments have grown 152% and 153% respectively, while "knowledge-business intensive services", or KIBS, have grown 231%), (2) because the station is within walking distance from the urban center (1,8 km by foot), (3) because the traditional suburban rail has been suppressed to build the HSR (although traditional suburban rail services took 90 minutes while HSR ones take 25 minutes), and (4) because possible commuters (fairly high socio-professional level) do not live in the same south corridor (they live either at the Toledo or Madrid cities). Additionally, quite a number of tourists based in Madrid use morning HSR trains to access Toledo and return in afternoon ones (36% of users, in both directions).

Ebbsfleet is the 'international gateway' key point in the *London Thames Gateway* renewal strategy, while Ashford is a 'growth area' for regional development, investment, economic growth and housing. Both might fulfill the outwards metropolitan commuting from London in the long term.

The fourth, and long-term, HSR opportunity is *to cross the metropolis*, that is, to be able to avoid the congestion traversing the metropolitan area, in order to travel from a periphery of the metropolis to a distant place to the other side of the metropolis.

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In Madrid, HSR metropolitan services offer a good connection either to the north (from Chamartín station) or the south/east (from Atocha station) parts of the country. On the other hand, the future HSR tunnel linking both stations may facilitate access to more metropolitan central places.

In London, HSR metropolitan services allow a good connection of the south-eastern metropolitan London to the north of the country, since they reach St Pancras station which is adjacent to Kings Cross station and close to Euston station, the two termini stations of most northern trains. The limited places HSR services access central London and the greater variety of central metropolitan places accessed by traditional suburban rail may not compensate the small time savings of using HSR.

SUMMARY AND CONCLUSIONS

At the beginning of the HSR in Europe, already 30 years ago, it was thought of as an alternative to air transport connecting large cities between 400 and 600 km apart. Yet, the implementation of different HSR networks is showing other uses and concepts of HSR, particularly more intermediate stations and mixed services using both HSR and traditional infrastructures to irrigate the benefits of HSR to more places.

This paper makes clear that another new concept of intra-metropolitan HSR is getting established, that of HSR stations at/by small cities or suburban areas already integrated in metropolitan processes. Moreover, the cases of Madrid and London are compared, highlighting the key territorial, infrastructural and service factors to understand the opportunities opened up by HSR in such situation.

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The analysis of the abovementioned factors shows that HSR stations around metropolitan regions represent a limited role of this infrastructure to connect them towards the exterior, in the long distance relationships. Yet, much more numerous metropolitan HSR services mean a fostering of their metropolitan integration.

HSR stations in metropolitan peripheries are facilitating the following opportunities:

- Alternative stations to central ones for long distance travel, in order to avoid metropolitan center congestion and to benefit from easier access and parking.
- Inwards commuting to a limited number of places in the metropolitan center.
- Outwards commuting only towards those places that offer high level professional jobs.
- The new HSR investments in metropolitan regions will facilitate through traffic across the metropolis in order to access a few other metropolitan peripheries or distant places.

The paper shows that the two eastern London HSR stations closer to the center (9 km and 33 km) are at distances where office decentralization is already taking place, although preferentially towards the western peripheries more than the eastern ones, so the redevelopment projects of their surroundings combined with HSR and the government planning decisions may result in the attraction of offices and the change of existing tendencies.

Meanwhile, the three Madrid HSR stations are quite far from the metropolitan center to attract offices, and more so because the corridor that attracts more office decentralization (the north-west corridor) has a HSR station 4 km from the center of a

small city (Segovia) with a small office attraction potential, and the city with more office attraction potential (Toledo) is located in a metropolitan corridor that does not attract offices and its HSR infrastructure and station does not allow for long distance HSR services. It looks as if the existing HSR network in London (one line with three stations) has been thought of more in relation to metropolitan planning, while the Madrid one has only been thought of as an additional transportation tool.

Indeed, it does not seem to be any coordination strategy taking into account the city or suburban area and the most suitable HSR service. The factors analyzed here –territory, infrastructure and services- should be taken into account in the future HSR infrastructure (lines and stations) and service planning. Besides, the complexity of HSR services and their territorial implications urge to consider HSR in territorial planning, and should not be left exclusively to transport planners.

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LIST OF FIGURE CAPTIONS

Figure 1. Cities half an hour away by HSR (100 km) from the center of a metropolitan area.

Source: adapted from Ureña et al. 2009

Figure 2. HSR lines and stations within 100 km of Madrid and London in 2011.

Figure 3. Metropolitan size in relation to HSR stations and airports location distances to metropolitan centers in London, Paris, Madrid, Barcelona, Lyon and Lille.

-**HSR stations**: *London*: Stratford, Ebbsfleet, Ashford; *Paris*: Massi, CDG, Marne-la-Vallée; *Madrid*: Guadalajara, Segovia, Toledo; *Barcelona*: Prat, Gerona, Tarragona; *Lyon*: Satolas, Macôn; *Lille*: Arras, Dunkerke, Calais.

-**Airports**: *London*: City, Heathrow, Gatwick, Luton, Stansted; *Paris*: Orly, CDG, Beauvais; *Madrid*: Barajas; *Barcelona*: Prat, Gerona, Reus; *Lyon*: Satolas, St.Etienne; *Lille*: Lesquin.

-Areas of office relocation have been induced from cases in London, Madrid and Paris.

Figure 4. Characteristics of Madrid and London metropolitan HSR cities, HSR stations and transportation corridors (White: positive; Grey: negative).

*London Borough of Newham (36 km^2)

**Dartford and Gravesham urban area's districts (8 km radius from the station)

Figure 5. Number of HSR outward services departing from central Madrid/London HSR stations and from the three small cities stations in their outer metropolitan periphery.

* Metropolitan services serving cities further away than Guadalajara, Segovia or Toledo

** The HSR infrastructure is established only till Valladolid, so there are few HSR services

*** There are trains that stop in this station but tickets are not available for this relation

Source: Renfe Website (www.renfe.es) and Southeastern Website (www.southeasternrailway.co.uk)

Figure1

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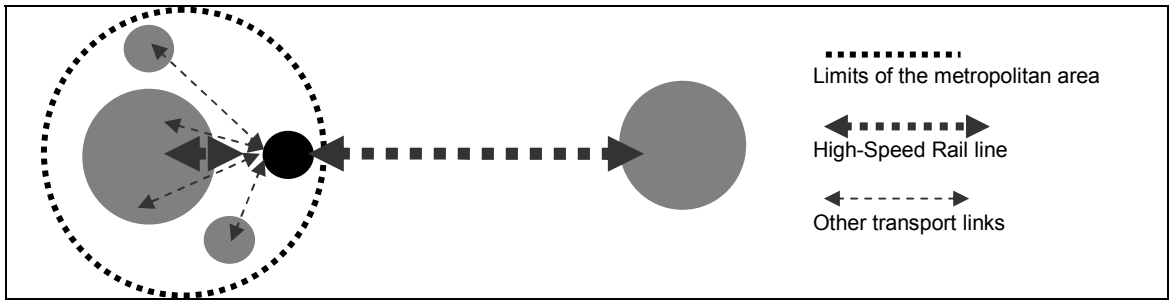

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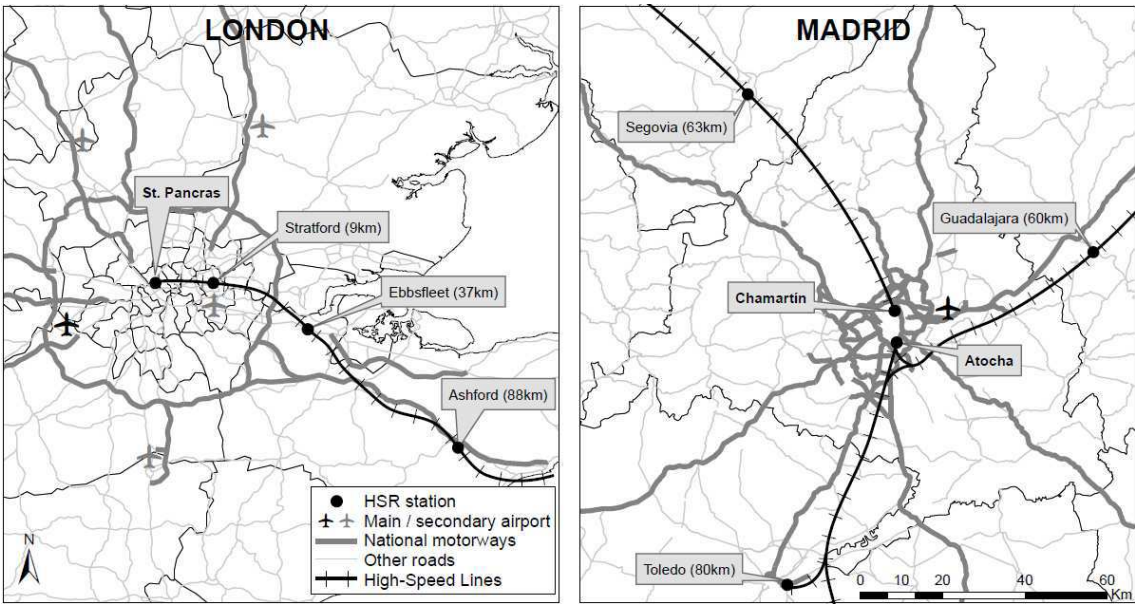

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Figure3

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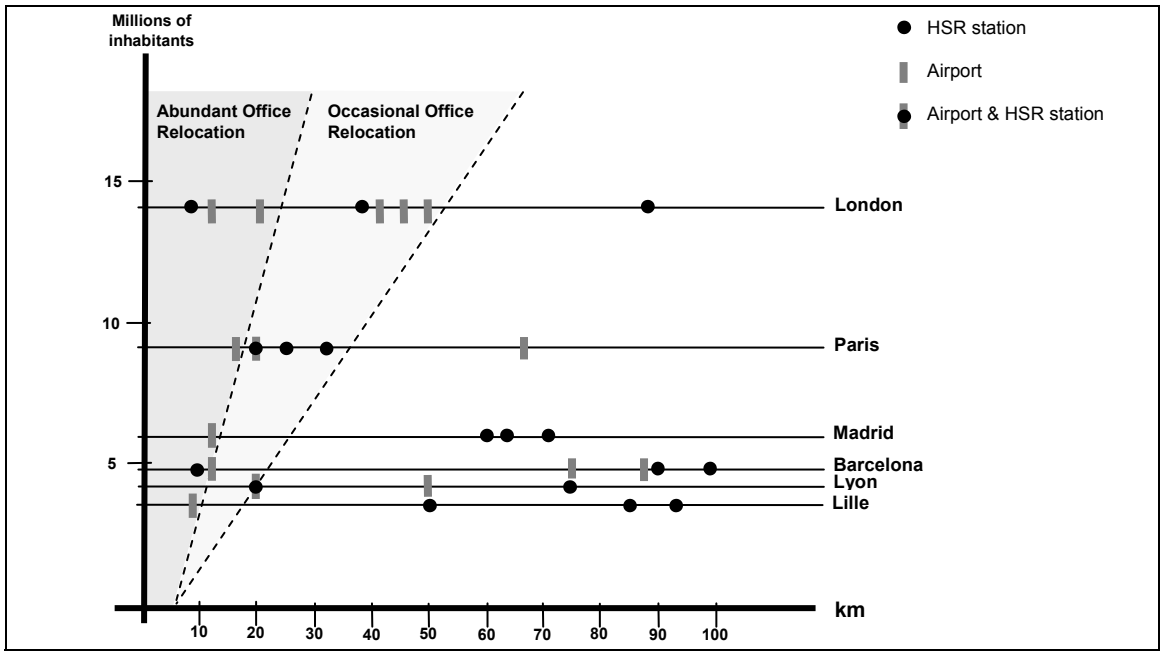

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-**HSR stations**: *London*: Stratford, Ebbsfleet, Ashford; *Paris*: Massi, CDG, Marne-la-Vallée; *Madrid*: Guadalajara, Segovia, Toledo; *Barcelona*: Prat, Gerona, Tarragona; *Lyon*: Satolas, Macôn; *Lille*: Arras, Dunkerke, Calais.

-**Airports**: *London*: City, Heathrow, Gatwick, Luton, Stansted; *Paris*: Orly, CDG, Beauvais; *Madrid*: Barajas; *Barcelona*: Prat, Gerona, Reus; *Lyon*: Satolas, St.Etienne; *Lille*: Lesquin.

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Figure4

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	Guadalajara	Segovia	Toledo	Stratford	Ebbsfleet	Ashford
Population	-83.000	-56.000	-82.000	-250.000*	-155.000**	-70.000
City's transportation location and **distance** to metropolitan centre	-On North-East strong national & metropolitan corridor -Very good suburban rail and buses -60 km from Madrid	-30 km of North-West national & metropolitan corridor -Bad suburban rail and good buses -90 km by motorway and 63 km by HSR	-50 km west of South strong national corridor and on South-west metropolitan corridor -Suburban rail cancelled since HSR, good buses -80 km from Madrid	-Just north-east of the CBD -Near regional trains, underground and buses -9 km from London	-To the east, just outside the Green belt -No suburban rail/bus -37 km, future likely abundant office decentralization	-Important metropolitan and international corridor -Traditional Railway junction for the South-east -88 km
Corridor **lodged activities and population**	-Industry, storage and distribution firms, of big size and good technology -Intermediate socio-professional groups	-Tertiary, university and office activities -Qualified socio-professional groups	-Industry of small and low technology firms -Low socio-professional groups	-No office activities -Intermediate socio-professional groups	-High technology activities to the west, not to the east -Intermediate socio-professional groups	-Low density housing and rural areas and other more relevant cities nearby -Intermediate socio-professional groups
Characteristics and services of the city	-No research university -No quality image -Provincial capital	-Private small university -World Heritage -Provincial capital	-Public University and high quality services -World Heritage -Regional capital	-Suburban area -Redevelopment for the 2012 Olympics and regeneration area -No administration role	-No quality services -Mixed suburban area of industry, quarries and housing -No administration role	-No University or quality services -Growth Area in South East Plan -No administration role
Station's characteristics and **location**	-Through station, type 1 -8 km from city centre -Not connected to suburban/regional rail/bus	-Through station, type 4 -6 km from the city centre -Not connected to suburban/regional rail/bus	-Terminus station, type 2 -By the edge of the city centre but distant from offices -Near bus station	-Through station, type 1 -By the edge of the borough, on the 2012 Olympic site -Good urban transport connections planned	-Through station, type 5, serving the sub-region -On a brownfield site -Good transport connections and very big car park	-Through station, type 5, serving the sub-region -By the edge of the city centre -Connected to regional rail/near bus station
TOTAL / 11	**+ 5 / - 6**	**+ 6 / - 5**	**+ 5 / - 6**	**+ 8 / - 3**	**+ 4 / - 7**	**+ 7 / - 4**

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*London Borough of Newham (36 km^2)

**Dartford and Gravesham urban area's districts (8 km radius from the station)

Figure5

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	Pure long distance	Mixed long distance	Metropolitan
MADRID			
Northeast Corridor			
Central-Northeast	**21**	**5**	**0***
Central-Guadalajara	**3**	**3**	**0**
Guadalajara-Northeast	**3**	**3**	**0**
Northern Corridor**			
Central-North	**2**	**10**	**5***
Central -Segovia	**0**	**5**	**7**
Segovia-North	**0**	**5**	**5**
Southern Corridor			
Central -South	**22**	**4**	**12***
Central -Toledo	**0**	**0**	**8**
Toledo-South	**0**	**0**	**0**
LONDON			
Southeast Corridor			
Central-Continent	**30**	**0**	**0**
Central-Stratford	**0**	**0**	**78**
Stratford-Continent	**0**	**0**	**0**
Stratford-Ebbsfleet	**0**	**0**	**67**
Central-Ebbsfleet	**0*****	**0**	**67**
Ebbsfleet-Continent	**10**	**0**	**0**
Ebbsfleet-Ashford	**0**	**0**	**31**
Central-Ashford	**0*****	**0**	**38**
Ashford-Continent	**5**	**0**	**0**

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