3 CATALAN AIRPORT SYSTEM INTERCONNECTIONS: BARCELONA, GIRONA, REUS AND LLEIDA

3.1 THE KEY ISSUES ADDRESSED BY THIS CASE STUDY

This case study addresses the following key topics:

- **Improved Links, Interchanges and services**. This case study will examine the performance of the following connections:
  - *Connections between airports and high speed rail (HSR) stations*. All Catalan airports are located within a short distance of major rail corridors with regional and long-distance rail services, and high-speed services from 2012 on. The connection of airports to the HSR network will improve access to regional airports from the Barcelona metropolitan area, and access to Barcelona airport from the rest of the Catalan region. These connections are planned (different horizons) but not yet in service. This case study examines the performance of the interconnections between the rail network and airport terminals with different kinds of solutions.
  - *Connection between airports and city centres with public transport.* In most regional airports, connections to local city centres with public transport are difficult due to low demand levels. Still, it is a priority of public administrations to provide such services. On the other hand, in Barcelona the airport will be connected in the mid-term with metro and suburban train connections. This case study analyses the connection of Barcelona's airport to the city and its surrounding municipalities with different kinds of solutions.
  - *interconnection between all airports with public transport*. The global interconnection of airports could lead to integrated management of all facilities, and co-ordinated specialisation in terms of flight types (intercontinental, continental, regional…). Small airports could provide in the long term the capacity that Barcelona will lack sooner or later. This case study draws general conclusions about the potential and feasibility of Catalan airports network interconnection.
- **Legal and Organisational Arrangements**. The multiplication of stakeholders responsible of different infrastructures is an element of rigidity in the process of planning and executing integrated co-modal networks. The debate on competence distribution over infrastructures in Catalonia and Spain is currently very active and changes in involved stakeholders are likely in the mid-term.
  - Air infrastructure management is split onto different public stakeholders. Barcelona, Reus and Girona airports are managed by Aena, a public company of the Spanish Ministry of Public Works; the recent new airport in Lleida is managed by the regional government.
  - Rail services starting and ending within the region are managed by the regional government (since 2010); all other services are managed by the national administration.
  - The network of highways is managed by different public and private stakeholders depending on the different links.
- **Effective competition**. The current debate about which model should be implemented to manage airports in Spain both involves the determination of competent administrations for each infrastructure (as well as the amount of private participation), and the amount of autonomy for each facility. An increased autonomy for the airports is claimed to promote fair competition among facilities in Spain. The system for ports management in Spain is usually referred to as a good practice example to be applied to airports, where each port authority is a public entity with autonomy enough to mark its own development strategy.
- **Information and marketing**.

  Through an integrated mobility internet site (http://www20.gencat.cat/portal/site/mobilitat), the Catalan administration is launching a programme to improve information to users on how to plan journeys taking place within Catalonia using public transport, even when involving multi-modal transport chains.

This initiative is being developed as public transport ticketing is being integrated all over the regional territory through a system of concentric rings with confluences in Barcelona, Tarragona, Girona and Lleida (four provincial capitals).

- **Consistent travel information across modes**.

  Flights using regional airports, mostly Ryanair in Girona and Reus, serve onboard information about land connections to bus services, and offer the possibility to purchase tickets as well, already during the flight or even at origin airport prior to flying.

3.2 General Description of the Case Study

3.2.1 The Current Situation

There are currently four commercial airports in the Catalan region: Barcelona, Girona, Reus and Lleida.

- Barcelona is an international airport with continental flights to Europe and the Mediterranean basin, and a few intercontinental flights.
- Girona and Reus are specialised on low-cost companies (they are both permanent bases for Ryanair), and have an important number of seasonal charter flights related to summer seaside tourism.
- Lleida airport is only operative since 2010, and is intended to be a winter tourist low-cost facility with regular flights within Europe.

The Airport Master Plan of the regional administration was approved in 2009 in the frame of the General Infrastructures Plan approved later in 2010.

The airports considered of general interest (Barcelona, Reus and Girona in this case study), have specific development plans under the Spanish air administration.

Figure 3-1 Location of airports in study over the rail TEN-T

Reus, Barcelona, Girona and Lleida are located less than 200 km from each other. From Barcelona to Reus, Girona and Lleida there will be HSR services (with travel times from Barcelona of around 30 minutes to Girona and Reus, and 60min to Lleida). The airport of Barcelona will be also connected to a HSR, to the metro network, to suburban rail and to conventional regional rail.

Traffic has grown substantially in all Spanish airports since the mid 1990s, mainly due to the explosion of low cost carriers and the emergence of urban tourism in Barcelona, and infrastructures have been enlarged accordingly, to accommodate growing traffic. Global airport capacity in the region is now twice as much as existing air traffic.

Girona has grown rapidly since the arrival of Ryanair, and is now starting to become competitive not just for tourists, but also for business travellers coming to Barcelona; Reus may show similar growth over the coming years. Traffic in these airports, however, is still dominated by tourists, representing 74% and 82% of global traffic respectively in Girona and Reus airports.

Due to changes over the last few years on Iberia's commercial strategy, centralising its international flights in Madrid Barajas, international connections between Barcelona and Europe have worsened since Iberia's new subsidiary low cost company flying from Barcelona does not offer the possibility to transfer onto other flights.

Spanish airport management remains centralised in one single public company, Aena, acting with a national logic of profit and deficit compensation among national airports. This strategy has been successful both in making Madrid a major hub and in improving the smallest and medium size airports in Spain, but at the same time has worsened the capability of airports such as Barcelona or Palma to compete for the attraction of intercontinental services.

3.2.2 Airport Traffic: Recent Evolution and Forecast

Barcelona airport is the second largest in Spain after Madrid-Barajas. Air traffic has grown in Barcelona at a rate of 7.5% between 2000 and 2007, when it registered 32.9 million passengers. After the beginning of HSR services between Barcelona and Madrid in 2008[3], and with a context of crisis, the airport has lost 5.5 million passengers in two years and registered 27.3 million passengers in 2009. Forecasts are to have between 35m pax. and 52m pax. in 2020 (AENA, 2001).

Girona, managed 5.2 million passengers in 2009. In 2000, the facility was specialised on charter flights for seasonal tourism, especially in the summertime, with a volume of 0. 6 million passengers per year. Since Ryanair arrival, the airport traffic has multiplied by 7, with a far more homogeneous demand throughout the year. Forecasts pointed in 2006 towards having between 8m pax. and 10m pax. in 2020 (AENA, 2006).

Reus traffic grew up to 1.7 million passengers in 2009, from the previous 1.2 million passengers in 2008, mainly due to intensification of Ryanair flights since autumn 2008. Forecasts pointed in 2006 to have between 4m pax. and 5m pax. in 2020 (AENA, 2006).

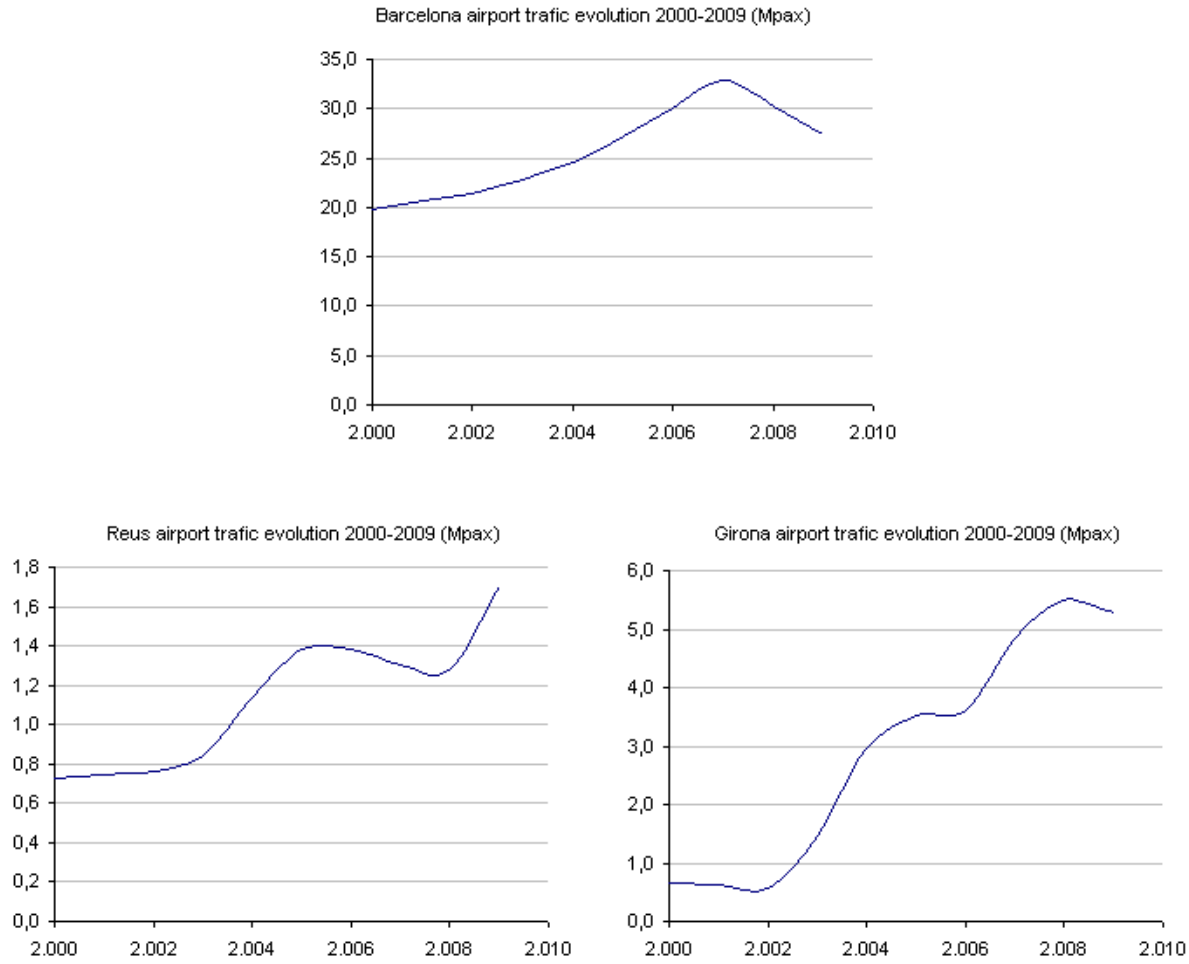
Lleida airport was inaugurated in 2010. Its Master Plan estimates passenger traffic by 2020 by 400.000 passengers per year.

Table 3-1 Passenger numbers at Barcelona, Girona, Reus and Lleida airports 2000-2009 and forecast to 2020 in Mpax

	2000	2009	2020
Barcelona	19.8	27.3	43.5
Girona	0.6	5.2	9.0
Reus	0.7	1.7	4.5
Lleida	-	-	0.4

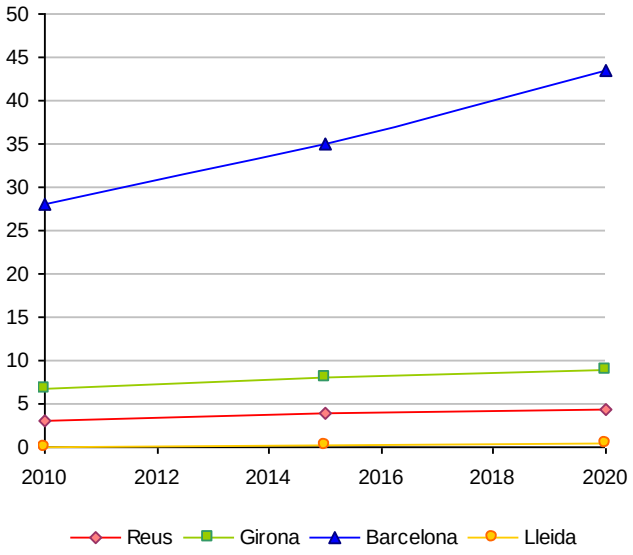
(source; AENA / Airports of Catalonia projections according to medium variant in airports' masterplans)

[3] Barcelona-Madrid air shuttle service was the world's busiest route until 2008, with the highest number of flight operations (971 per week) in 2007. The schedule has been reduced since February 2008, when a Madrid – Barcelona high-speed rail was opened, covering the distance in 2 hours 40 minutes, and quickly gaining more than 50% of quota.



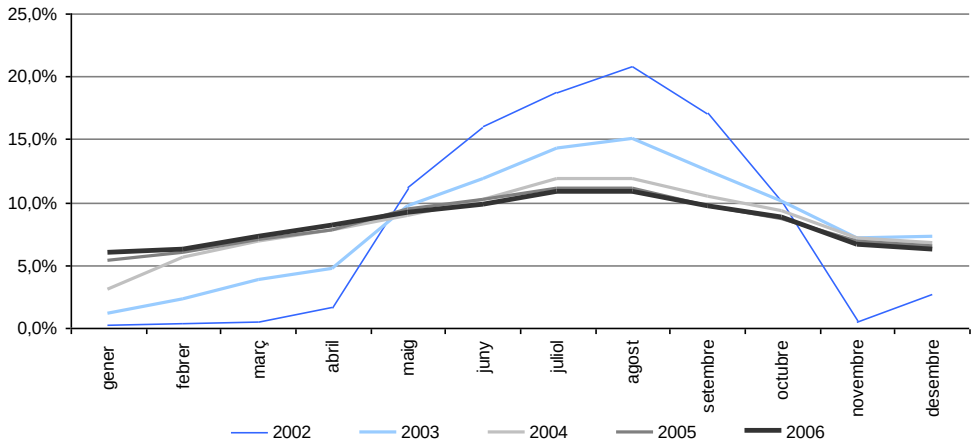
(source: AENA, 2010)

Figure 3-2 Traffic evolution 2000-2009 at Catalan airports



(source: AENA / Airports of Catalonia)

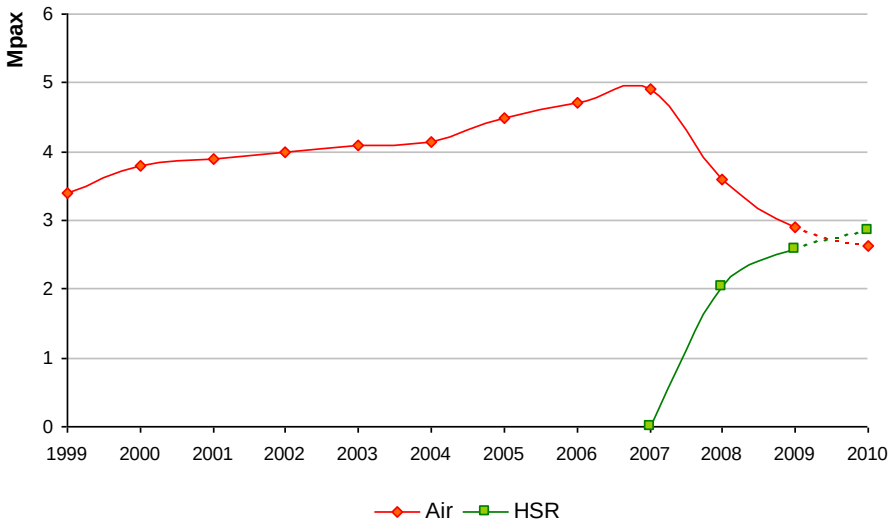
Figure 3-3 Traffic forecasts for Catalan airports for 2020 in Mpax



(source: AENA, 2007)

Figure 3-4 Monthly % of passengers related to global year traffic

Note that Girona has progressively achieved a smoother monthly distribution of passenger numbers throughout the decade.



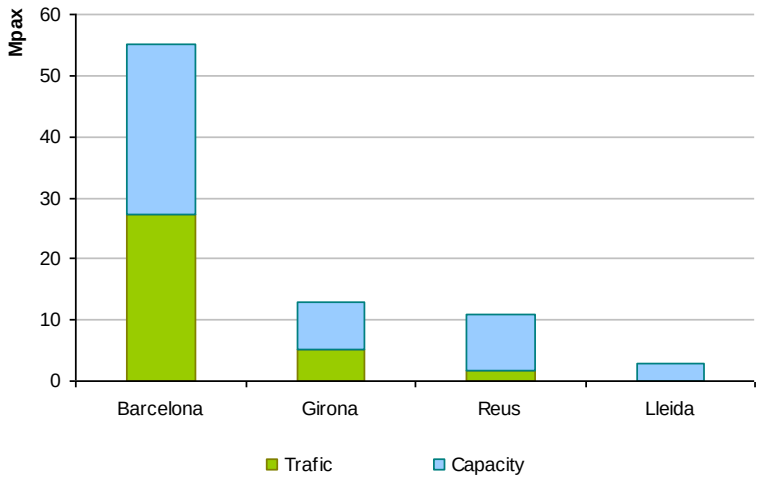
(source: AENA / Renfe, 2010)

Figure 3-5 Traffic evolution in the Madrid-Barcelona route 1999-2010

Note that high-speed rail has gained a 50% traffic share since its implementation in 2008.

3.2.3 Airport Capacity

- In Barcelona, major upgrading works were undertaken to prepare for the 1992 Olympic Games and the facilities have been upgraded and enlarged constantly since then. In 2009, a second terminal was inaugurated. Current capacity of the airport is evaluated at 55 million passengers..
- In Girona, airport capacity will be set after extension by 2020 at 13 million passengers.
- In Reus, the Master Plan will enable capacity of 11 million passengers per year after ongoing works of extension.
- Catalan airports currently have almost twice as much capacity as their current traffic volume.



(source: AENA, 2010)

Figure 3-6 Infrastructure capacity and 2009 traffic in Catalan airports

3.2.4 Geographic Coverage

The geographic coverage of this case study is the region of Catalonia. In Catalonia, 60% of the regional population live within a 30 minute car drive of an airport (4.4 million people); 97% of the regional population live within a 1 hour drive of an airport (7.2 million people). All the population lives within a 2 hour 30 minute drive from Barcelona airport.

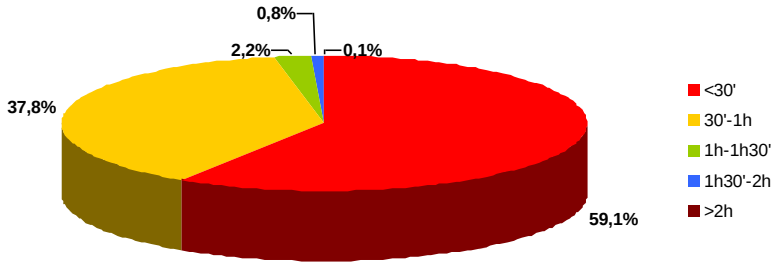


Figure 3-7 Distance from Catalan population to airport facilities within the region

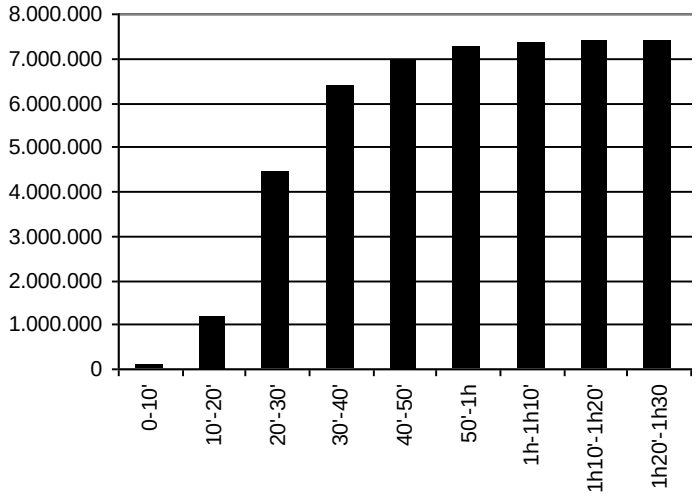


Figure 3-8 Accessibility of population to a Catalan airports, in time units vs millions of people

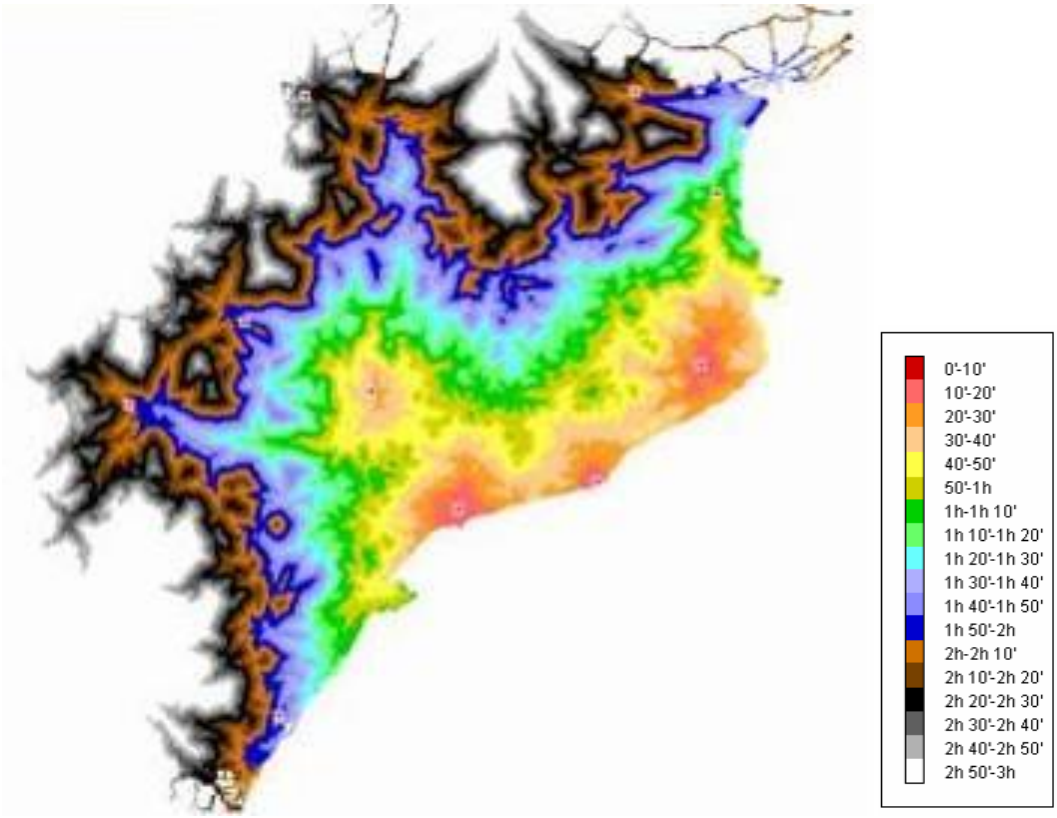
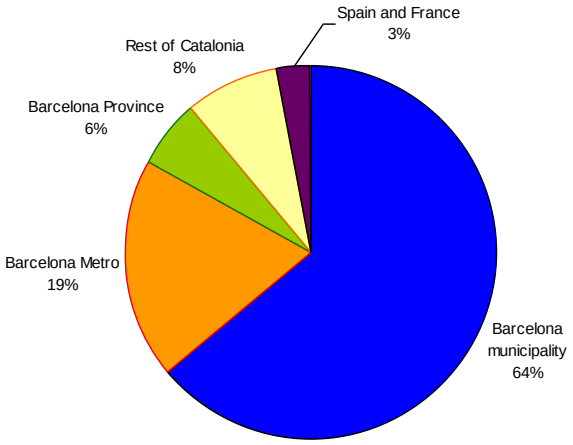


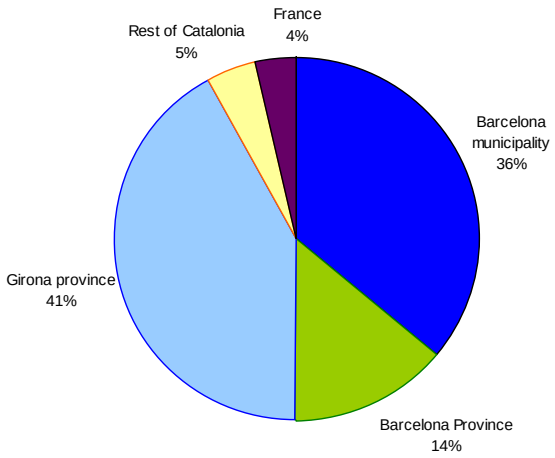
Figure 3-9 Accessibility to Catalan airports from the territory through road networks, in hours

- At Barcelona airport, 64% of travellers have their origin or destination in the Barcelona municipality, 19% in the metropolitan region, 6% in the rest of the province, 8% in the rest of Catalonia, and only 3% in the rest of Spain or Europe.
- At Girona airport, 36% of travellers have their origin or destination in the Barcelona municipality, 42% in the Girona province, 14% in the Barcelona province (excluding the BCN municipality), 3.5% in France, 1.7% in Tarragona, 0.8% in Lleida and 0.4% in Andorra.
- At Reus airport, 84% of travellers have origin or destination in the Tarragona province.

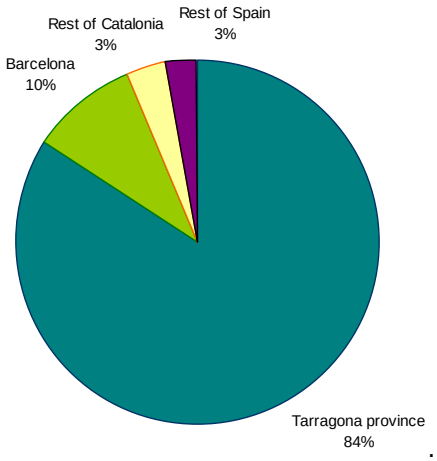
Origin / destination of trips in Barcelona airport



Origin / destination of trips in Girona airport



Origin / destination of trips in Reus airport



(source: Aena, 2003, 2006, 2006)

Figure 3-10 Origin / destination of trips in Catalan airports

3.3 SPECIFIC CHARACTERISTICS OF THE CASE STUDY

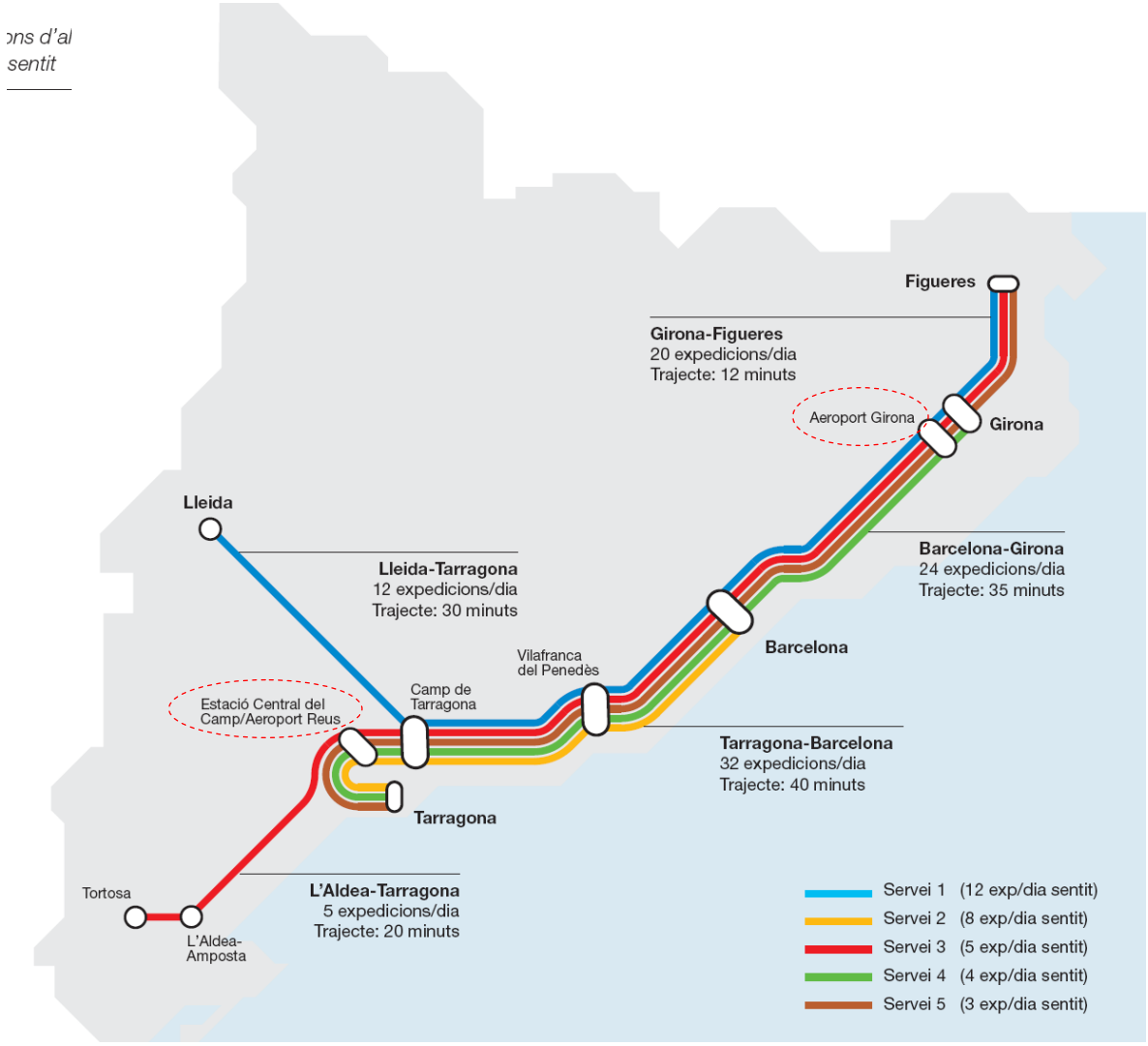
3.3.1 Modes and Infrastructure Involved

This case study involves the interconnection of land modes with air modes through the study of connections from airports to high speed rail lines and to city centres by means of different modes of transport (buses / tramways / people-mover).

The following airport interconnections are currently planned:

- Barcelona airport will be connected to Barcelona's city centre and the rest of the metropolitan area through suburban rail and subway network. HSR link to the airport will be implemented either through the construction of a new loop segment departing from the trunk line, or with a people mover between both terminals and the nearby el Prat de Llobregat rail station (no decision taken yet).
- Girona. The territorial master plan foresees a rail station for regional HSR close to the airport, though not inside the terminal. A tramway link is proposed between the terminal and the station.

- Reus. The airport will not have a rail station within its terminal, but the future regional and HSR station will be located some 4km away, over a new rail segment already under construction. The airport and this new station will be connected by the new tram network of Tarragona, still to be implemented.
- Lleida. A new rail segment of around 10km is planned to provide HSR services to the airport, but is not foreseen before 2026.



(source: PTVC 2009)

Figure 3-11 Public Transport Service Plan 2008-2012

The plan foresees regional HSR stops in Reus and Girona airports by 2012. Connection of Lleida airport is left to the long-term, not before 2026

3.3.2 Intermodal and Interconnection Opportunities

In the long term, before 2026, all airports in Catalonia should be connected to each other by HSR. At present, while all facilities are located close to rail lines, only Barcelona's airport currently has a train station, and this station only serves local suburban services to downtown Barcelona. Connections from Barcelona airport to regional and long-distance rail lines are now taking place in Barcelona's central rail station (Sants station, an 18 minute ride from the airport).

(source: General Transport Master Plan, 2006-2026)

Figure 3-12 Airports in Catalonia with planned HSR network (grey) and conventional rail (dark green)

All airports are directly connected to highways, or will be very soon (Lleida's airport is still some 12km away from the highway network, but will be connected in the short term after upgrading of N-230 and N-240). All airports will be connected to each other by highway before 2012.

(source: General Transport Master Plan, 2006-2026)

Figure 3-13 Airports in Catalonia with planned highway and road networks

The table below shows the distances between the four airports in Catalonia through the shortest possible path road itineraries.

Table 3-2 Road distance between Catalan airports in km

DISTANCE (km)	Barcelona	Girona	Reus	Lleida
Barcelona	0	110	95	170
Girona	110	0	185	240
Reus	95	185	0	125
Lleida	170	240	125	0

The next table summarises the current state of interconnections of the four airports with respect to motorways, rail networks and bus networks, and characterises the current modal shares of passenger access to airports.

Table 3-3 Connections of Catalan airports to transport networks in July 2010.

	Passenger activity in 2009 (in Mpax)	Num. of terminals	Connection to highway network	Connection to rail network	Bus connections	Preferred transport mode for access
Barcelona	27.311.765	2	Direct	Access to suburban trains in one of the terminals; only trains bound to Barcelona and its Metropolitan Area.	Express lines to downtown, urban and metropolitan lines, and some regional lines	Taxi (39%) Car (36%) Bus (18%) Rail (7%)
Girona	5.286.975	1	Direct	none	Mostly co-ordinated bus lines with flights (some regional and local lines)	Car (44%) Bus (36%) Others (20%)
Reus	1.706.609	1	Direct	none	Mostly co-ordinated bus lines with flights (some regional and local lines)	Mostly Car
Lleida	0	1	Through 12 km access road	none	One line to Lleida downtown and one line to Barcelona	Mostly car

3.3.3 Stakeholders Involved

The diversity of stakeholders involved in the management and operation of transport infrastructures in Spain and Catalonia is an element of rigidity in the process of infrastructure planning and service disposal, especially of co-ordinated and integrated services.

Barcelona airport, Girona airport and Reus airport are managed by AENA (public enterprise dependant on the national government), while Lleida airport is managed by Airports of Catalonia (public enterprise dependant on the regional government). AENA manages almost all airports in Spain in a centralised system. Since the late 1990s, strong debate has taken place to change the managing system, to allow participation of local and regional private and public stakeholders independently for each airport.

Rail infrastructure is managed by ADIF, a public enterprise depending on the national government. Rail services are managed by Renfe, a public enterprise dependent on national government, whenever services take place along more than one autonomous community. Since 2010, rail services inside Catalonia are the responsibility of the autonomous government.

Motorways (non-tolled) are managed either by the regional administration or by the national Spanish administration. Toll motorways are managed either by the private sector (Abertis) or by public companies dependant on the regional administration (Tabasa, Autema)

Table 3-4 Responsible administrations in infrastructure transport management, and manager companies in 2010

	Public National level	Public Autonomous Community level	Public Local level	Private level
Barcelona airport	AENA			
Girona airport	AENA			
Reus airport	AENA			
Lleida airport		Airports of Catalonia		
Rail infrastructure	ADIF			
Long distance rail services	RENFE Long-Distance			
Regional rail services (within Catalonia)		RENFE Mid-Distance		
Local urban and suburban services		Rodalies de Catalunya	TMB	
Road network	Spanish Ministry of Fomento	Regional Department of Public Works		ABERTIS

Abertis manages airports outside Spain (i.e. London Luton, Cardiff, Belfast, Stockholm Skavsta, and many others in the US and South America), but cannot manage airports in Spain due to current regulation.

3.3.4 Current Cohesiveness of Multi-modal Networks

Interconnections between HSR network and airports

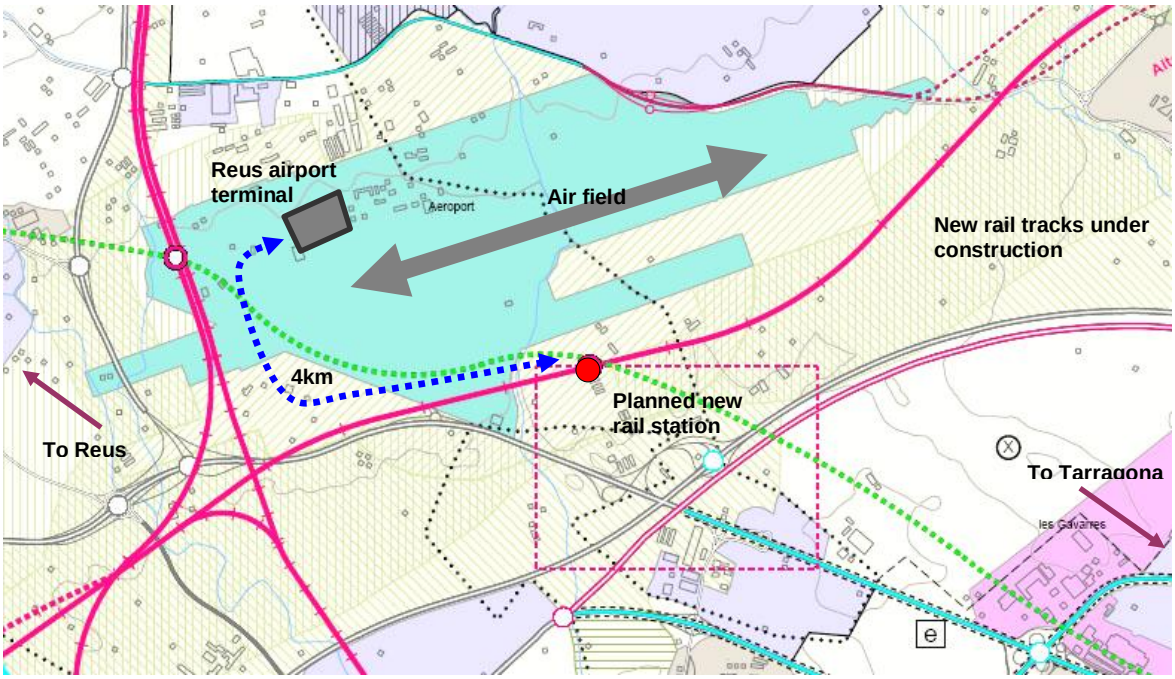
Although all airports are located near to core rail networks (0.5km in Girona, 1km in Reus, 2km in Barcelona and 6km in Lleida), none of the airports has direct access to regional rail or HSR services within the terminal.

In fact, the systematic interconnection of airports and the rail network has not been specifically planned in Spain. Master plans by the Spanish Ministry of Public Works have not specified such interconnections. In Catalonia, this interconnection is an existing concept since 20 years ago, but the implementation of rail connections in the Catalan airports has not been made explicit by any of the different Sectoral Master Plans of the autonomous administration such as the Road and Rail Master Plan in 2006, or the Airport Master Plan in 2009.

The design of interconnections has been studied, however, by Territorial Plans (at a scale of 1:50.000 / 1:30.000). Territorial Plans have been elaborated during the second half of the 2000 decade. The construction of the new HSR network was planned and executed prior to approval of Territorial Plans, with only vague considerations on airport interconnections, which has led to increased difficulties in fitting interconnections optimally a posteriori.

Specific remarks to each interconnection

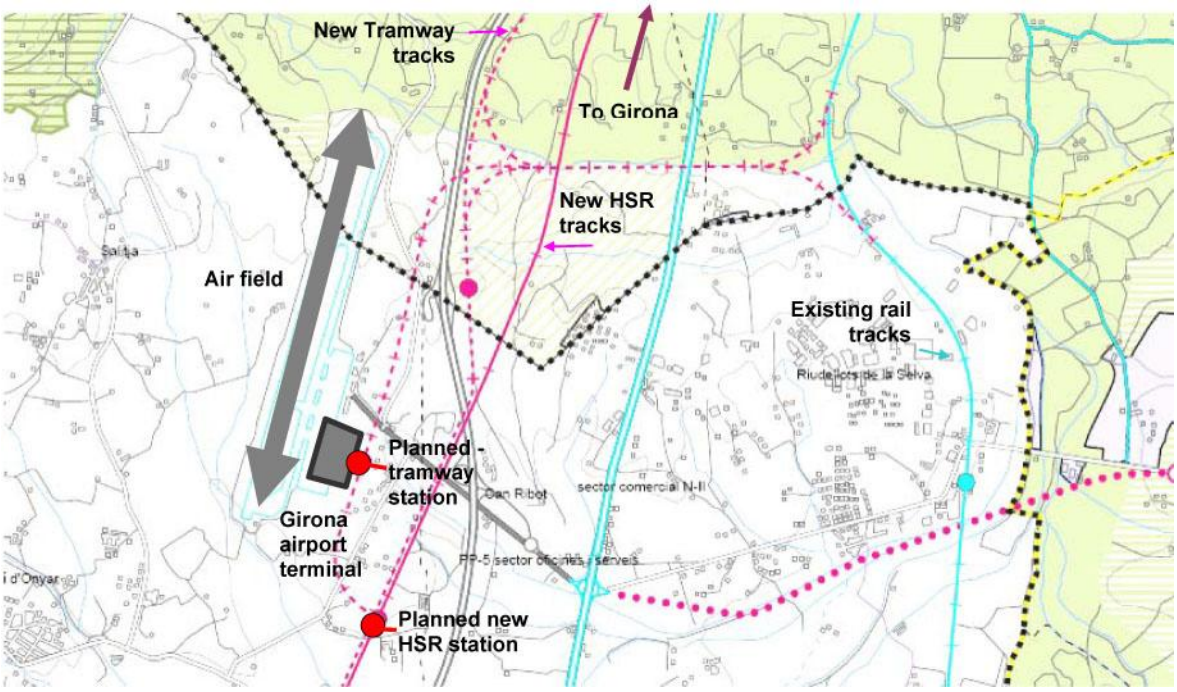
In Reus, new tracks are being built for the new HSR lines and regional train lines from Valencia to Barcelona, with a new train station on the new line. The new tracks run alongside the airport, and the station will be located right by it, but as the rail corridor will run on the other side of the airfield, the station won't be located within the terminal. A tramway connection is foreseen in the mid term.



(source: Tarragona Territorial Master Plan, 2010)

Figure 3-14 Reus airport and new rail lines and station

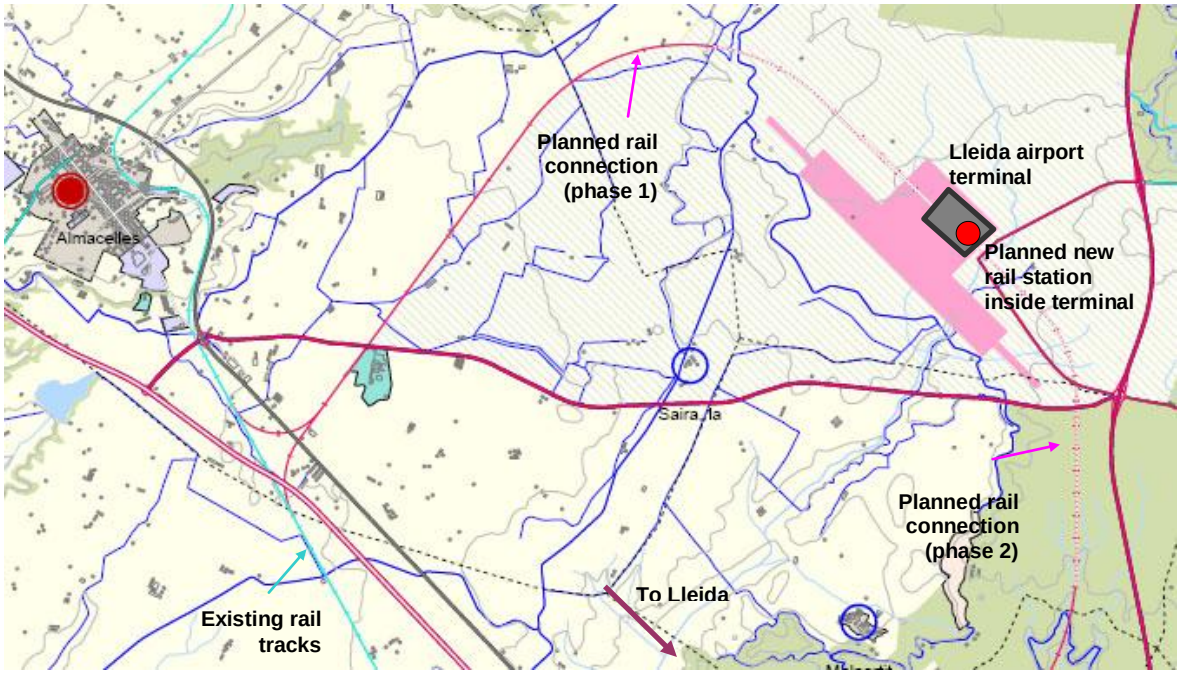
In Girona, a HSR stop is foreseen close to the airport where regional high speed services will stop, and a new tramway line will link this station to the airport and then to downtown Girona.



(source: Girona Territorial Master Plan, 2010)

Figure 3-15 Girona airport and rail connections

In Lleida, a rail connection to the airport is planned in order to implement rail services into the airport terminal, though this is not foreseen before 2026. The access is a 10km new rail segment diverting from the main rail line, which in the long term could be extended in a 10km second segment to actually form a ring bypass avoiding the station to become a terminus.



(source: Lleida Territorial Master Plan, 2007)

Figure 3-16 Lleida airport and rail connections

In Barcelona, the connection of the airport to the rail network has been discussed for long time. While the Territorial Plan by the Catalan administration foresees a rail loop coming out from the trunk line to have HSR stations in the airport terminals, the Spanish administration proposed in 2003 to build a shuttle-train / people-mover to connect the airport to the already existing train station in el Prat de Llobregat (where there would be HSR services, long-distance and regional rail services, suburban rail lines, and metro services).

Figure 3-17 Barcelona airport connection to rail line

Links from airports to city centres

In Reus, the connection of the airport to Reus and Tarragona city centres is foreseen to be served with a new tramway network, currently under study (approximately to cost of € 200M according to the *Road and Rail Master Plan, 2006*). This is the same network that is to connect the HSR station and the airport.

In Girona, the connection of the airport to the city centre is foreseen to be served with a new tramway line, currently under study (approximately to cost of € 160M according to *Road and Rail Master Plan, 2006*). This is the same line that is to connect the HSR station and the airport.

In Lleida, the connection of the airport to the city centre is foreseen to be served by rail once the connection of the airport to the rail trunk rail line is implemented. The cost of this connection could be estimated around 65M€ (at a considered standard cost for conventional rail of € 6.5M/km). This is the same line that is to connect the HSR station and the airport.

In Barcelona, connections to the city centre are currently served by suburban trains only from one terminal (T2). It is planned that suburban rail will reach both terminals by 2015 (budgeted € 220M according to *Barcelona Infrastructure Director Plan* (*PDI*), *2010*), while a new metro tunnel is going to allow metro access to the airport (budgeted € 870M for the segment linking the airport to el Prat de Llobregat, according to *PDI*, *2010*). The currently under construction L9 metro line is to reach the airport by 2012, and L2 metro line by 2015 if extended from downtown Barcelona as planned.

Bus services from airports

Services connecting regional airports to Barcelona by bus offer co-ordinated services with arriving and departing flights (in Girona, Reus and Lleida).

In the regional airports of Lleida, Reus and Girona, low volumes of passengers with trips originating locally makes it difficult to provide local connecting services to airport facilities, even by bus. More innovative transport systems, adapted to demand, are being studied.

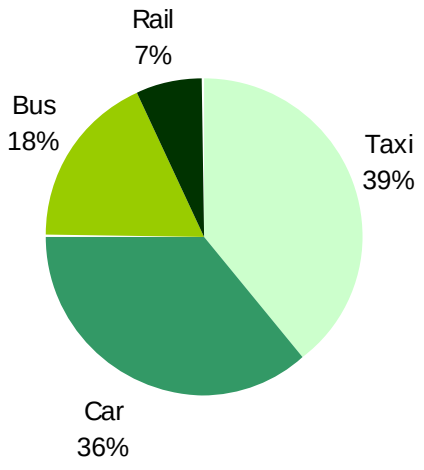
Services linking Barcelona airport and downtown are numerous. There are local and metropolitan regular lines, and express bus services to downtown Barcelona. Bus services have an 18% share of access to the airport, more than twice as rail share (7%).

There are currently no public transport services linking the Catalan airports to each other.

Detailed current state of interconnections: Barcelona airport

In Barcelona, the share of access modes to the airport leans towards high use of individual transportation modes (75%) against collective transport modes (25%). On the other side, around 60% of travellers use public transportation to access the airport (taxi, bus and suburban train).

Within the individual modes, taxis and private vehicles show high proportions (39% and 36% respectively), whereas in collective transport, buses have shares around 18% and rail only 7%. The bus shuttle to downtown Barcelona is a strong competitor to rail due to a good service (high frequencies, low travel times, € 5 cost).



(source: AENA, 2006)

Figure 3-18 Modal split for departing/arriving passengers at Barcelona airport

Barcelona airport : Road connections

Barcelona airport is directly connected to the basic network of highways through C-31. This highway connects to C-32 highway heading south of Catalonia, and to A-2 and Ap-7 heading to north, south and west Catalonia. It also connects to downtown Barcelona and Barcelona's ring road.

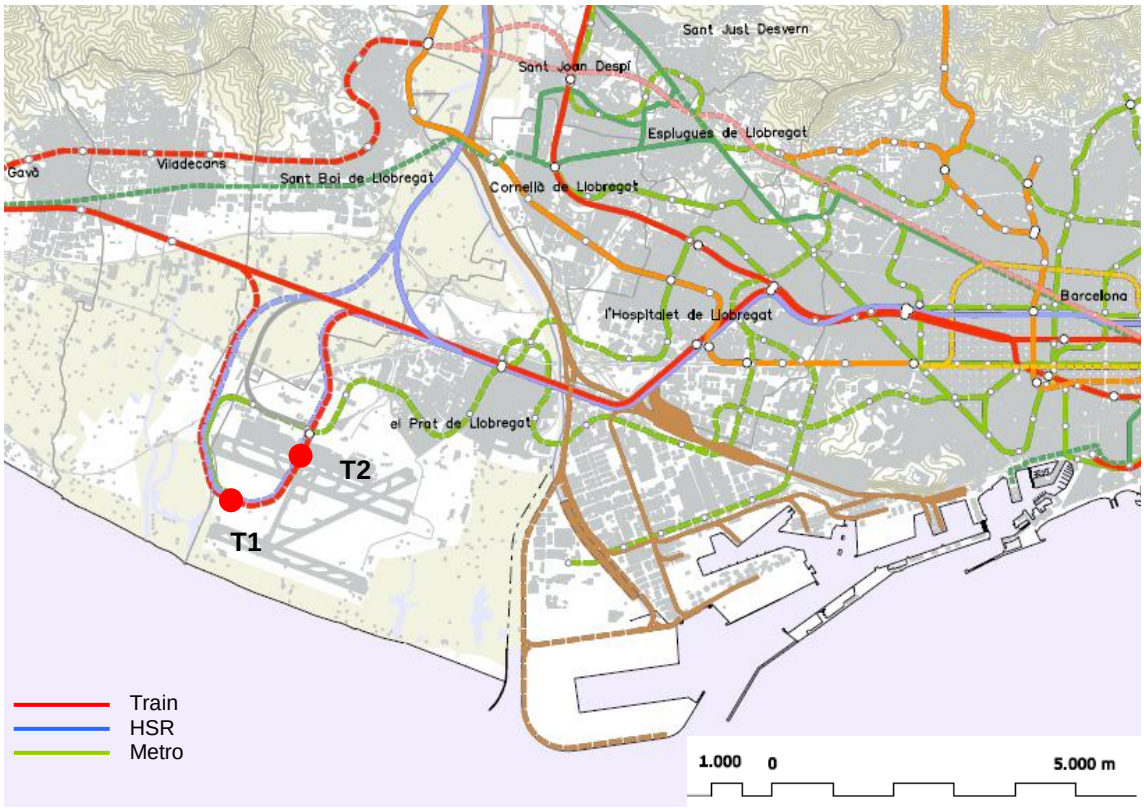
Barcelona airport : Rail connections

The suburban train station in the airport is in front of Terminal 2. Trains link the airport with Barcelona Sants train station every 30 minutes. To access the station from Terminal 1, there is a bus shuttle co-ordinated to the train. Suburban rail is to be extended up to T1 in the short-term.

By 2012 the metro line (L9) will connect airport to Barcelona. The new L9 line has a total of 47.8 km and will be the longest underground metro line in Europe. It will link Barcelona airport with the westernmost and northernmost Barcelona neighbourhoods forming a ring structure that will connect with most of the other metro lines in the network. The new HSR station in la Sagrera will be also accessible with line L9, but trips are likely to take longer than with direct suburban trains.

There are two options for the HSR connection at Barcelona airport:

- Through a shuttle service between Barcelona airport (both terminals) and el Prat de Llobregat Intermodal station. This station is currently a suburban rail station located 5 km from the airport. High speed trains run through this station but do not stop yet. It is expected, though, that HSR and long distance conventional trains will stop here when the connection to the airport is resolved.
- Through a loop of the current HSR line that would allow the arrival of trains to the two terminals.



(source: Metropolitan Barcelona Master Plan, 2009)

Figure 3-19 Rail and underground networks planned

Connections with the rail network: Barcelona Sants train station

This is the main train station in Barcelona. Currently, it is served by the HSR Barcelona – Madrid line (it is expected that HSR will reach France by 2012), long distance fast trains Barcelona – Valencia – Alicante (EUROMED), Talgo to Paris, Milan, Zurich and other services including all major destinations in Spain, regional trains to Catalan towns, suburban trains in Barcelona and the metro. The station is also the location of the bus station. By 2012, the new Sagrera train station will provide similar services in the north of the city.

Table 3-5 Number of daily services, current average travel time, fares from Barcelona Sants to main destinations in HSR or long distance trains, except Girona

	Number of daily services	Current average travel time	Fares (€)
Madrid	27	3 hours 15 minutes	120.00
Valencia	14	3 hours	42.70
Zaragoza	27	1 hour 47 minutes	63.70
Perpignan	2	3 hours	38.00
Tarragona	20	36 minutes	13.20
Girona	21	1 hour 20 minutes	8.80
Lleida	20	1 hour 10 minutes	22.50

(source: RENFE, 2010)

Access to Sants Station from the airport takes approximately 18 minutes by car. A taxi ride costs approximately € 33.

There is a direct train service between the airport (T2) and Sants Station. Travel time is 20 minutes by train. Service train runs every 30 minutes from 5.42 to 23.38.

Table 3-6 Access to Sants train station, number of daily services, current average travel time and fares (2010)

Mode of transport	Number of daily services	Current average travel time	Fare
Car or Taxi	-	18 minutes	€ 33
Train[4]	24	20 minutes	€ 2.30

Barcelona airport : Bus connections

Bus from Barcelona Airport to Barcelona City (AEROBUS). This line covers the route between the airport and the city of Barcelona (Catalunya Square). There are two bus services, depending on terminal passengers (T1 or T2). Buses can be caught directly outside of both terminals. Bus services run every 10 minutes between 06.00 and 01.00. Travel time is 30 minutes and fares are € 5 for a single ticket.

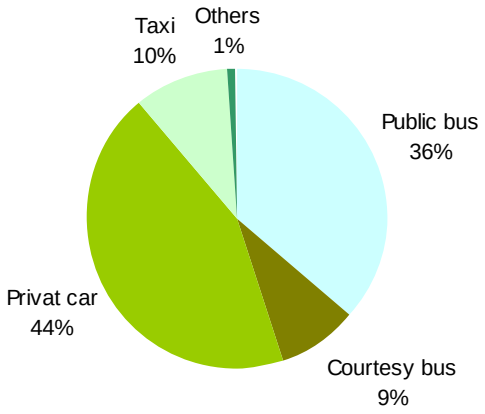
There is one Barcelona urban bus line that connects with the airport (Line 46) and other bus services linking the airport with neighbouring municipalities.

There are some regional bus destinations running through Barcelona airport (i.e. Igualada, Tarragona, Andorra), but the airport does not have a proper regional bus terminal.

[4] Train from T2. From T1, shuttle services co-ordinated by scheduled train

Detailed current state of interconnections: Girona airport

According to AENA, 36.3% of passengers access the airport by public buses (mostly linked to arriving or departing flights), while 44% arrive by private car (32% owned and 12% rented). Taxi only represents 10% of trips, while courtesy buses from hotels in tourist areas and Girona represent a 9% share.



(source: AENA, 2005)

Figure 3-20 Distribution access mode and passengers main origins: Girona

Girona airport: Road connections

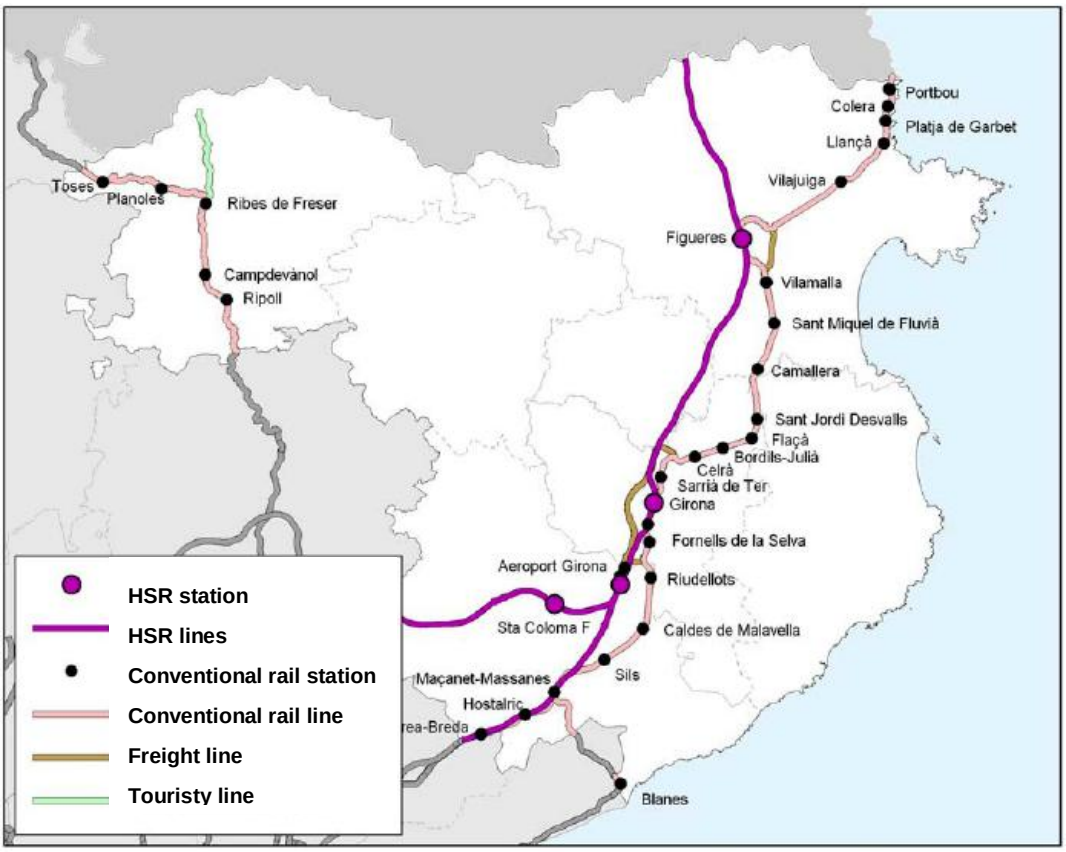
Girona airport is closely connected to the basic road network through Ap-7 Mediterranean highway (from Valencia to Barcelona and France) highway A-2 (from Barcelona to France, currently under construction) and regional road C-25 (Girona – Lleida, currently being upgraded).

Girona airport: : Rail connections

The closest train station is Girona (12 km from airport) for conventional long distance trains (Barcelona – Girona – Perpignan – Toulouse – Montpellier) and regional trains (Barcelona – Girona – Figueres – Portbou – Cervere).

There are no HSR services in Girona city yet, but these are expected by 2012. The train station is currently being upgraded, anticipating the arrival of HSR. It also hosts the central bus station.

A new HSR station is foreseen to be built by the airport. This station will be located close to the terminal but not within walking distance. The connection between the airport and the rail station must be resolved. In the long term, a tramway is expected to link the rail station with the airport terminal and downtown Girona.



(source: Girona Regional Master Plan -in process- 2009)

Figure 3-21 Rail network currently planned in Girona

Access to Girona rail station and bus terminal

Access to Girona train station. From the airport it is possible to access Girona through regular bus service, stopping at the train station and bus terminal. Services link the airport and the station every hour from 04:30 until 00:30. A taxi ride costs approximately € 15.

Table 3-7 Access to Girona train station, current average travel time and rates (2010)

connection	Number of daily services	Current average travel time	Optimised	Fare
Car/ Taxi	-	18 minutes	-	€ 15
By bus	20	60 minutes	40 minutes	€ 2.35

Connections with the rail network at Girona train station

Long-distance trains. This is the station for long-distance trains (Talgo) from Montpellier to Barcelona, Valencia and Cartagena. Main stops are Girona, Tarragona, Castelló, Valencia and Alicante. There are two trains per day in each direction.

Regional trains. There are local train services that connect Girona with Barcelona and Figueres. Some trains go as far as the French border in Cervère / Portbou. Trains depart every 30 minutes -1 hour from 06:11 until 21:19.

Table 3-8 Long-distance trains: destination, number of daily services, travel time and fares from Girona

Destinations	Number of daily services	Travel time from Camp de Tarragona	Fare (€)
Montpellier	2	3 hours 13 minutes	50.30
Barcelona	2	1 hour 8 minutes	17.40
Tarragona	1	2 hours 18 minutes	34.80
Castelló	1	3 hour 43 minutes	40.50
Valencia	1	4 hours 33 minutes	44.80
Cartagena	1	9 hours 10 minutes	60.40

(source: RENFE, 2010)

Table 3-9 Regional trains: destination, number of daily services, travel time and fares of regional from Girona

Destinations	Number of daily services	Travel time from Reus train station	Fare (€)
Barcelona	24	1 hour 20 minutes	8.80
Figueres	24	28 minutes	3.90
Portbou	12	52 minutes	5.80

(source: RENFE, 2010)

Connections with the bus network at Girona terminal

Bus from Girona Airport to Andorra. This line covers the route between the airport and Andorra Bus Station. There are two services per day in each direction. This service is operated by Novatel buses. The journey time *is* around 4 hours and fares are € 52 for a return ticket.

Bus from Girona Airport to Perpignan (France). This line covers the route between the airport and Perpignan train *station* (France). There are five services per day in each direction, from 11.15 until 22:45. This service is operated by Frogbus. The journey time is around 1 hour and 25 minutes and fares are € 25 for a return ticket.

Regional line bus connect Girona airport with Vic, Manresa and Lleida (two services per day, journey time is 3 hours and 20 minutes and fares are € 35) and the airport with Granollers and Mataró (six services per day, journey time is 1 hour and 10 minutes and fares are € 18)

Local line buses connect Girona airport with several beach destinations like Lloret de Mar, Calella, Blanes, Platja d'Aro, Palamós and Roses. This service is operated by Sarfa. The journey time and fares depend on the destination.

Girona airport: Connections to Barcelona by bus

Bus from Girona Airport to Barcelona (Ryanair Bus). This line covers the route between the airport and the city of Barcelona (North Station terminal). Journeys are planned to meet the Ryanair flights that arrive each day. The journey time is around 1 hour and 15 minutes and fares are € 12 for a single ticket, and € 21 for a return ticket.

Table 3-10 Number of daily services and current average travel time of Girona airport – Barcelona bus

Number of daily services	Current average travel time	Fare
41	100 minutes	€ 12

(source: Ryanair, 2010)

Detailed current state of interconnections: Reus airport

Access to Reus airport mostly takes place by bus, especially in summertime (courtesy or local buses to sea side resorts, Tarragona and Reus picking up tourists).

Reus airport: Road connections

Reus airport is closely connected to basic network of roads through T-11, linking to Ap-7 Mediterranean highway (from Valencia to Barcelona and France). Currently under construction is the future highway A-27 connecting the Mediterranean highway to Ap-2 Ebro highway (from Madrid and Zaragoza to Barcelona).

Reus airport: Rail connections

The closest train stations are Camp de Tarragona (22 km from airport) for high-speed trains (HSR), Tarragona (10 km from airport) for conventional long distance and regional trains and Reus (5km from airport) for regional trains.

It is expected that by 2012, Central Station will be finished. It will be an intermodal station where long distance trains Barcelona – Valencia –Alacant (Mediterranean Corridor) and regional trains Barcelona – Tarragona – Reus will stop. This station will be located close to the airport but not within the terminal. Exact plans for flows of passengers between the airport and the rail must be resolved.

(source: Tarragona Master Plan, 2010)

Figure 3-22 Rail network planned in Camp de Tarragona (HSR in blue; conventional rail in red)

Reus airport: Access to HSR station

Access to Camp de Tarragona HSR Station from the airport takes 25 minutes by car. A taxi ride costs approximately € 30. Due to low demand levels, there are no direct bus services and it is necessary to change bus in Reus or in Tarragona.

Table 3-11 Access to HSR station, current average travel time and rates from Reus (2010)

connection	Number of daily services	Current average travel time	Optimised	Rate (€)
Car/ Taxi	-	25 minutes	-	30.00
Bus through Tarragona		195 minutes	50 minutes	4.45
Airport - TGN	6	145 minutes	-	1.75
TGN - HSR	25	50 minutes	-	2.70
Bus through Reus		140 minutes	63 minutes	4.90
Airport - Reus	20	38 minutes	-	2.20
Reus -HSR	8	120 minutes	-	2.70

- Bus itinerary from airport to HSR station through Reus
  - Bus from airport to Reus (Reus Urban Line 50). This line covers the route between Reus airport and Reus bus station with stops in Reus Centre and Reus train station. The bus stop is directly outside the main arrivals terminal. This service is operated by Reus public transport. The journey time is 8 minutes to the bus station and 19 minutes to the train station, and the fare is € 2.20 for a single trip (2010). Buses depart every hour from 05:11 until 00:11.
  - Bus from Reus to HSR Station. This line covers the route between Reus (bus station) and Camp de Tarragona. The journey time is 33 minutes. Buses depart every 2 hours.
- Bus itinerary from airport to HSR station through Tarragona
  - Bus from airport to Tarragona. This line covers the route between Reus and Tarragona with a stops in Reus airport. This service is operated by Hispano Igualadina. The journey time is 15 minutes to Tarragona Bus Station. Buses depart every 2-3 hours from 10.30 until 00.15.
  - Bus from Tarragona to HSR Station. This line covers the route between Tarragona (train station) and Camp de Tarragona (High-speed train station) with stops in Tarragona bus station. The journey time is 28 minutes. Buses depart every hour approximately from 06.00 to 23.20. This service is operated by Autocars Planas.

Reus airport: Connections through HSR at Camp de Tarragona Station

Long distance HSR. This is the station for high-speed trains from Madrid to Barcelona. Trains stop in Zaragoza and Lleida as well. By 2012, the line will reach Girona, Perpignan and Montpellier (France). Trains to Madrid depart every 2 hours from 06.33 to 23.18 (nine trains per day) and trains to Barcelona depart every 2 hours from 08:25 to 23:22 (11 trains per day).

Table 3-12 Destinations, daily services, travel time and fares of the HSR from Camp de Tarragona

Destinations	Daily services	Travel time from Camp de Tarragona	Fare (€)
Barcelona	20	33 minutes	34
Lleida	20	34 minutes	21.30
Zaragoza	14	1 hour 15 minutes	42.30
Madrid	14	2hours 45 minutes	86.40
Girona	-	1 hour 20 minutes *(estimated)*	65
Perpignan	-	1 hour 50 minutes *(estimated)*	80

(source: RENFE, 2010)

Regional HSR. There are regional high-speed services between Lleida and Barcelona, with stops in Camp de Tarragona. Travel time to Barcelona is 40 minutes and the fare is € 13,20. Trains depart every 2 hours and 30 minutes from 07:38 to 21:38 (6 trains per day). The journey time to Lleida is 30 minutes and the fare is € 10,70.

Reus airport: Connections through conventional rail at Tarragona Station

This is the station for medium speed trains (200 km/h) from Barcelona to Alacant (EUROMED). Main stops are Alicante, Valencia, Castelló, Tarragona and Barcelona. There are eight trains per day from 07:00 to 20:30.

Table 3-13 Destinations, daily services, travel time and fares of conventional trains from Tarragona Station

Destinations	Number of daily services	Travel time from Camp de Tarragona	Fare (€)
Barcelona	14	1 hour	19.80
Castelló	14	1 hour 40 minutes	30
Valencia	14	2 hours	36
Alacant	5	3 hours 40 minutes	49.40

(source: RENFE, 2010)

Regional trains also connect Tarragona with Barcelona (1 hour 10 minutes), Lleida (1 hour 50 minutes) and Zaragoza (4 hours) with conventional trains.

Access to Tarragona train station from the airport by car it takes about 20 minutes by secondary road (T-11). A taxi ride costs approximately € 28. There is only one bus line between Reus airport and Tarragona and it takes around 15 minutes. Buses from the airport depart every 2-3 hours from 10.30 until 00.15.

Table 3-14 Access to Tarragona train Station, current average travel time and fares (2010)

connection	Number of daily services	Current average travel time	Optimised	Fare (€)
Car/ Taxi	-	20 minutes	-	28.00
By bus	6	145 minutes	25 minutes	1.75

Connections through conventional rail at Reus Station

At this station there are different local and regional trains that connect Reus with Barcelona. Trains stop in Lleida and Zaragoza as well. Trains depart every 1 or 2 hours from 05:37 until 21:18.

Table 3-15 Destinations, daily services, travel time and fares of regional trains from Reus Station

Destinations	Number of daily services	Travel time from Reus train station	Fare (€)
Barcelona	16	1 hour and 30 minutes	7.40
Lleida	3	1 hour and 30 minutes	4.90
Zaragoza	2	4 hours	17.50

(source: RENFE, 2010)

Access to Reus train station by car it takes about 15 minutes by national road (N-420a). A taxi ride costs approximately € 18. Reus urban line connects the airport with the train station.

Table 3-16 Access to Reus train station, current average travel time and fares (2010)

connection	Number of daily services	Current average travel time	Optimised	Fare
Car/ Taxi	-	15 minutes	-	€ 18
By bus	20	49 minutes	29 minutes	€ 2.20

Reus airport: Bus connections

Bus from Reus Airport to Barcelona (Ryanair Bus). This line covers the route between the airport and the city of Barcelona (Maria Cristina square and Sants central rail station). The timetables vary throughout the year as the journeys are planned to meet the Ryanair flights that arrive each day. Buses can be caught directly outside of the arrivals terminal. This service is operated by Hispano Igualadina. The journey time is around 1 hour 30 minutes and the fares is € 23 for a return ticket.

Table 3-17 Number of daily services and current average travel time of buses from Reus airport (Ryanair bus, 2010)

Number of daily services	Current average travel time	Fare
7	115 minutes	€ 13

Local line buses connect Reus airport with several beach resorts up to La Pineda, Salou, Vilaseca and Cambrils. The bus stop is directly outside the main arrivals terminal. This service is operated by Autocares Planas. The journey time is 45 minutes and the fares are approximately € 5.60 for a single trip.

Detailed current state of interconnections: Lleida airport

Lleida airport: Road connections

Lleida airport is closely connected to basic network of roads through national road 240, linking to highway AP-2 (from Zaragoza to Ap-7, Barcelona trough Tarragona) and highway A-2 (from Lleida to Barcelona).

National road N240 links Lleida and Vall d'Aran, the location of one of the most important ski resort in the Pyrenees (Baqueira – Beret).

The basic network of roads connects the airport with regional roads C-26 and C-14 that link to Andorra.

Lleida airport: Rail connections

The closest train stations is Lleida (12km from airport), for high-speed trains and regional trains.

HSR services. This is the station of high-speed trains from Madrid to Barcelona. Trains stops in Zaragoza and Tarragona as well. By 2012, the line will reach Girona, Perpignan and Montpellier (France). Trains to Madrid depart every 2 hours from 7.03 to 22.35 (nine trains per day) and trains to Barcelona depart every 2 hours from 7.54 to 22.55 (11 trains per day).

Table 3-18 Destination, daily services, travel time and fares of HSR from Lleida

Destinations	Number daily services	Travel time from Camp de Tarragona	Fare (€)
Barcelona	20	68 minutes	45.00
Tarragona – Camp de Tarragona	20	30 minutes	21.30
Zaragoza	14	44 minutes	28.90
Madrid	14	2hours 15 minutes	78.00
Girona *(estimated)*		1 hour 40 minutes	85.00
Perpignan *(estimated)*		2 hours 20 minutes	100.00

(source: RENFE, 2010)

Regional HSR services. Additionally, there are regional high-speed train services between Lleida and Barcelona with stop in Camp de Tarragona. Travel time to Barcelona is 1 hour and 12 minutes and fares are € 22.40. Trains depart every 2 hours and 30 minutes from 07:05 to 21.05 (6 trains per day).

Access to Lleida - Pirineus HSR Station from the airport takes 25 minutes by car. A taxi ride costs approximately € 30. There is a direct bus line between the airport and the HSR Station. There are two bus services on each direction on Fridays and two on Sundays, co-ordinated with flights schedules.

Table 3-19 Access to HSR Station, travel time and rates (2010)

Transport	Number of daily services	Current average travel time	Optimised	Fare (€)
Car/ Taxi	-	25 minutes	-	30.00
Bus	2	50 minutes	-	3.50

Reus airport: Bus connections

There is a local bus service to connect Lleida airport to downtown. There are four services on Fridays and Sundays (on each direction). Travel time from airport to Lleida downtown and HSR train station is 30 minutes, and to the regional bus terminal 35 minutes.

Bus from Lleida Airport to Barcelona. This line covers the route between the airport and the city of Barcelona (North Station). There are two bus services on each direction on Fridays and two on Sundays, co-ordinated with flights schedules. This service is operated by Alzina Graells. The journey time is around 2 hour 30 and fares are € 35 for a return ticket.

Table 3-20 Daily services and current average travel time

Destination	Number of daily services (only Fridays and Sundays)	Current average travel time	Fare (€)
Barcelona	2	165 minutes	19.00
Lleida	4 // 3	30 minutes	4.00

(source: Lleida Airport Corp, 2010)

3.4 SOLUTIONS ENVISAGED

3.4.1 Overview

The following solutions are going to be analysed in this section.

- connections of HSR network to airport terminals will be outlined in sections 3.4.2 (direct connection through HSR segment extensions to airports, both in Barcelona and Lleida) and 3.4.4 (connections with tramway or bus shuttles in Reus and Girona).
- connections of airports to city centres will be outlined in section 3.4.3, specifically for Barcelona.

- These solutions are going to be the object of further study through two test beds in INTERCONNECT's milestone M4.5 (*Interconnection of Catalan airports* test bed, and *Llobregat Delta Platform* test bed).
- The figure below provides a summary of main parameters related to criteria of success matrixes.

ID	Title	COST (€, €€, €€€)	Technical feasibility	Financial feasibility	Organisational feasibility	Acceptance by users	Political acceptability	Door to door travel time	Door to door travel cost	Comfort and convenince	Improve safety	Increase personal security	Increase regional prestige	Access for low income users	Access by disabled users	Modal shift	Congestion reduction	GHG emissions
2.04	HST in Barcelona airport terminal	€€€	X	XX	X	0	V	V	X	VV	0	0	V	X	0	V	0	V
2.04	HST in Lleida airport	€€€	0	XX	0	V	V	V	X	VV	0	0	V	X	0	V	0	V
2.06	Heavy rail link in Barcelona airport (suburban trains)	€€€	X	X	0	V	V	0	0	V	V	0	V	V	0	V	V	V
2.07	Metro to Barcelona airport	€€€	X	X	0	V	V	0	0	V	V	0	V	V	0	V	V	V
2.09	People mover in Barcelona airport	€€€	0	0	0	V	V	0	0	V	V	0	V	0	0	0	0	V
2.08	Tram link from HST to Girona airport	€€	0	0	0	V	V	V	0	V	V	0	V	0	V	V	0	0
2.08	Tram link from HST to Reus airport	€€	0	0	0	V	V	V	0	V	V	0	V	0	V	V	0	0
2.10	Shuttle services from Girona airport to rail	€	0	0	0	V	0	V	0	V	V	0	V	0	0	V	0	0
2.10	Shuttle services from Reus airport to rail	€	0	0	0	V	0	V	0	V	V	0	V	0	0	V	0	0

Figure 3-23 In-depth study of solutions and characterisation through criteria of success

3.4.2 HSR Direct Access to Barcelona and Lleida Airport Terminals

Problems addressed

Both in Barcelona and Lleida airports, HSR tracks run reasonably close to the terminals but not by the terminals. In both cases, HSR rail connections are planned through the construction of new rail segments diverting from trunk lines. In Barcelona, a 10km rail loop is envisaged as an option to connect the airport to HSR, while in Lleida 10km of new rail tracks are required.

Performance against main toolkit criteria

Cost

The cost of implementing HSR connections into the terminals of Barcelona and Lleida airports has to be considered very high.

In Barcelona, the project of the HSR loop to the airport terminals has been budgeted at € 440M for a 13km track (partly in tunnel) and two stations (Barcelona Metropolitan Territorial Master Plan, 2010).

In Lleida, the connection of the airport to the HSR requires the construction of 9km of new rail tracks. Although there is no official budget for this operation, it can be estimated to cost around € 65M considering a standard cost of construction for conventional rail of € 6.5M/km.

Technical feasibility

In Barcelona, the technical feasibility of construction is likely to become a problem at some point due to the geologic complexity of the area. The airport is built in a deltaic area, with very high groundwater level, little cohesive soils, and the existence of a confined freshwater bog which cannot be drilled. Not far from the airport, an accident in 2008 during the construction of the HSR tunnel in the entrance of Barcelona interrupted the suburban rail system for a period of 3 months due to the collapse of part of the ground. The impacts of this accident had a cost estimated at € 1M per day to pay for the compensation to users (rail services were set free of charge) and for alternative bus services to replace interrupted suburban services.

Additionally, the HSR tunnel at the airport needs to run under the airfield. Surface deformations on the runways are highly restricted, in order not to endanger the security of airplanes landing and take off.

In Lleida, on the other hand, it is not very likely that serious technical problems exist.

Financial feasibility

The financial profitability of the operation is expected to be relatively poor in the short term. However, as this project is considered of territorial strategic interest in the mid-term, implementation of interconnection could be still brought forward, even if changes might possibly be introduced to reach optimal solutions.

Organisational/legal feasibility

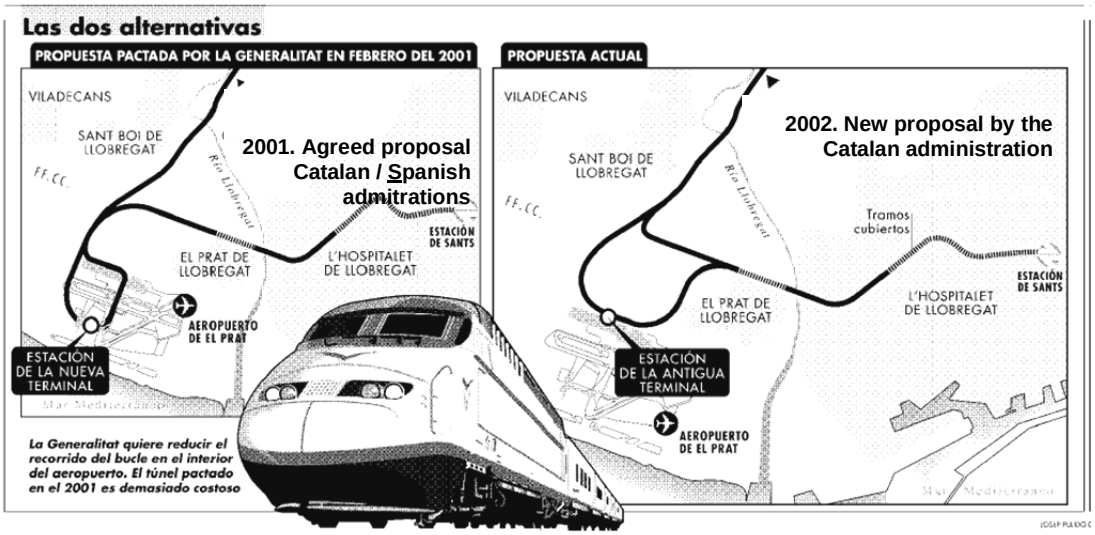
In Lleida, organisational issues will probably not be major issue. The interconnection of the airport to the HSR network in Barcelona, however, has been under discussion since the year 2000 and does not have a consensus solution yet. The difficulty to agree a unitary project with all the different administrations (Spanish administration, Regional administration, Barcelona municipality, other neighbouring municipalities, rail and airport infrastructure managers) was very important, almost insurmountable in the early 2000s. Debate is to be reopened in the short term to adopt a final solution.

The main components of the debate were the following:

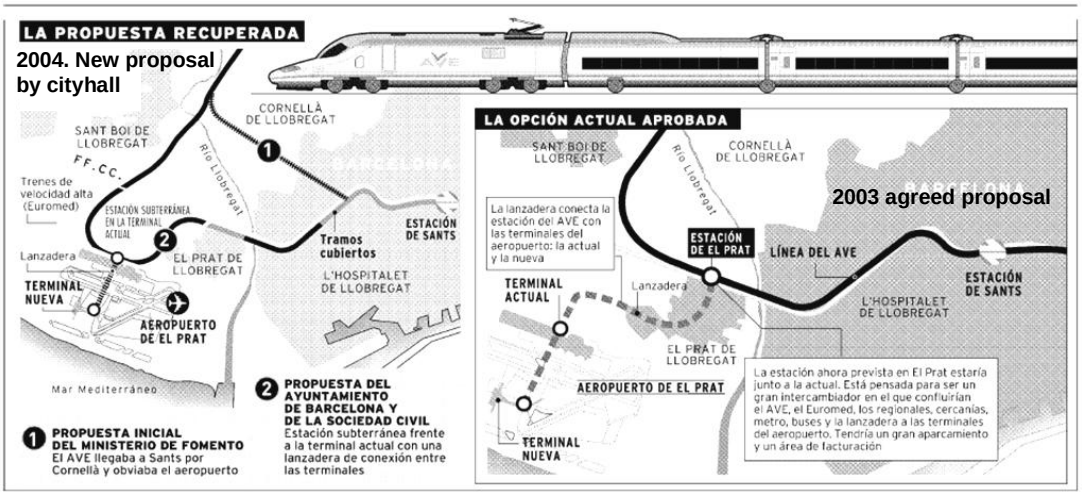
- The interconnection to the airport was not included in the first project for the HSR line Madrid-Barcelona-France by the Spanish Ministry of Civil Works in 2000.
- The Catalan administration noted the importance of the interconnection. It first proposed a secondary terminus track to reach the airport from the main HSR line in 2001, then proposed to make it a loop so that trains would reach the airport through on the trunk line. This second proposal had the support of the Barcelona municipality.
- The loop was initially accepted by the Ministry in 2002, but rejected after further feasibility analysis.
- In 2003 an agreement was reached between all administrations, , on the implementation of a people-mover / shuttle service from the HSR station of el Prat de Llobregat, located 5km from the terminals on the main rail line. Construction works of the HSR access to Barcelona were engaged according to this scheme, included the upgrading of the el Prat de Llobregat station.
- In 2004 a political change in both in the Spanish administration and the Catalan administration reopened the debate once again, with new proposals on 2004.
- The debate has been on hold since then, but still there is not any fully agreed solution to bring HSR to the airport.
- In 2010, the Territorial Master Plan for Barcelona's Metropolitan Region was passed, and its proposal runs back again to the 2001 loop proposal.

The proposed solutions are outlined below.

The initial proposals by the Ministry of Public Works (year 2000). *Out of the three alternatives, the Ministry is more favourable to the third one, with the line running straight into Barcelona and having a conventional shuttle train from Barcelona to the airport.*



The 2001-2002 negotiation. *After negotiations between all administrations in 2001, the HSR is set to run through the airport with a loop, having two stops, one in each terminal. In 2002, the Catalan administration proposed an alternative loop reducing its length within the airport enclosure, with only a stop in the old terminal.*



The new institutional framework after 2003 and 2004 elections. *In 2003, a compromise agreement was reached to bring the line close to the airport, though not through the airport. The stations would be located in el Prat de Llobregat, and a shuttle / people-mover would transport passengers from there to both terminals. In November 2003 there was a change of government in the Catalan administration. In March 2004 the Spanish government changed as well. With this new institutional situation, in 2004 the negotiation is once again opened. The city hall proposed to revive the proposal, which had a stop in the old terminal, with a shuttle service to the new one.*

The new party on the opposition (who had been in charge of the negotiation since 2000) agreed with the proposal by the cityhall, but proposed to bypass the airport provisionally in order not to further delay the arrival of the HSR to Barcelona (scheduled for 2004)

Acceptance by users

Making all HSR services access the airport is a popular element for those travellers who will actually transfer to the airport. It will increase convenience of their trips as it won't be necessary to travel into the centre of Barcelona anymore.

For those users who won't be transferring to the airport, the acceptance and popularity of this new stop (maybe two stops), will run from indifference to relatively low acceptance depending on the magnitude of resulting additional travel times. On trips like Barcelona-Madrid, where most passengers are frequent business travellers, and where there is 50% / 50% rail-air modal shares (2010) travel time is a crucial variable. It seems reasonable that only non-direct services between Barcelona and Madrid would finally stop at the airport.

In Lleida, the HSR line stop in the airport would be a terminus, thus it would only affect users to the airport for whom acceptance is likely to be very high.

Other aspects of political acceptability

The political acceptability of having airports connected to the HSR network is generally high.

Impact on users' door to door travel time

In Barcelona, for those users willing to transfer from HSR network to the airport, the reduction in travel time is to be expected to be high (approximately 50 minutes per passenger), compared to a situation where travellers are forced to travel into Barcelona. Compared to other alternatives, such as the shuttle service from the nearby el Prat del Llobregat station, the reduction of time may not be that important if services are properly co-ordinated or shuttle frequency is high (even less than 10min). For airport non-related HSR users the increase in travel time due to running on the new loop and having 2 stops in the airport terminals can be estimated at 20 minutes.

In Lleida, the implementation of the HSR station in the airport would result in important time savings for airport users. Currently, it is necessary to use bus services from Lleida rail station to the airport, a 30 minute journey.

Impact on users' door to door travel cost

High-speed rail links are not expected to lead to travel cost reductions, but instead, there could be some cost increase for travellers due to increased service comfort and convenience.

Initial impact on comfort or convenience, on safety and security

High –speed rail links are likely to increase comfort for users, but neither safety nor security.

Region's prestige

As a limited and expensive mode of transport, HSR may be perceived as an element of prestige to some.

Access for people on low incomes and people with physical disabilities

HSR is not an particularly equitable infrastructure. HSR services are more expensive than average regional or mid/long distance conventional services. High-speed rail in itself is unlikely to have any particular influence on people with disabilities.

Mode shift, congestion and GHG emission

The interconnection of airports to the HSR network can lead to some modal shift from the car to rail, especially in trips to the airport for citizens living along the rail corridors and relatively close to HSR stations.

It could be stated that as far as this modal change may take place, there will be GHG reductions associated (i.e. an average traveller accessing the airport from Tarragona -around 100km drive- can save up to 12kg of CO2 emissions). The overall impact on climate change, however, is minimal, as this kind of user is only a small portion of the totality.

As for congestion reduction, the introduction of these services is very unlikely to have any perceivable impact on motorway congestion.

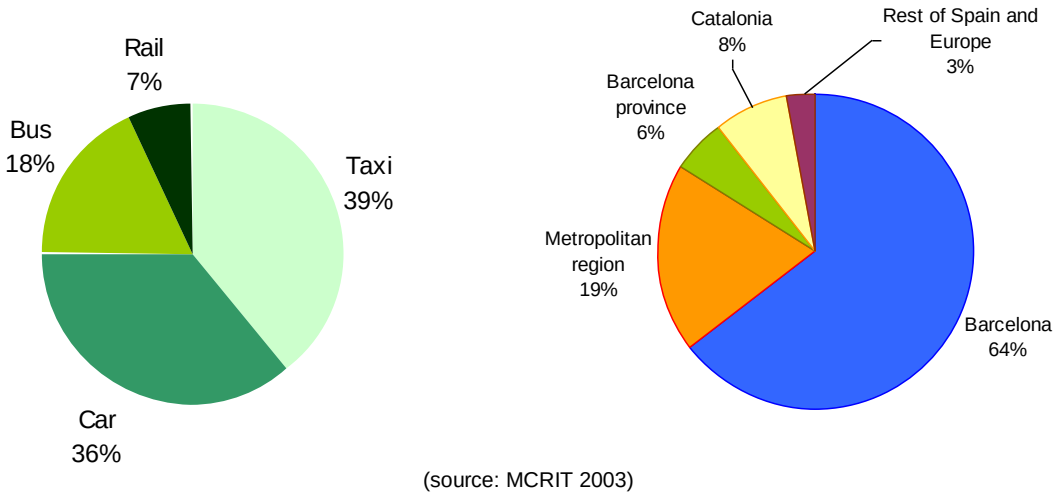
Transferability of findings

- HSR interconnections with airports require major investments. Only in a few cases where the location of airports and rail corridors is very favourable, and constraints (such as the presence of other infrastructures, urbanisation…) are few, direct connections of HSR to airports may appear relatively simple and inexpensive.
- Organisational issues, especially when negotiation involves multiple stakeholders, can be difficult. Strong political debate on this kind of project may result in cost increases for interconnection projects and substantial delays of project calendars. If interconnections take place in urban / semi-urban areas (where airports are usually located), difficulties can be even more important.
- Travel time savings can be substantial for airport users accessing by rail when stations are within terminals, especially compared to a situation where transfer from rail to airport requires travel through the city centre. However, other rail-air interconnections (i.e. frequent shuttle services from nearby rail station) may provide travel time savings within the same order of magnitude at considerable less economic costs.
- Travel time increase to non-airport HSR passengers may be significant in some airport interconnections (almost up to 20min in Barcelona). Minimising this time increase is crucial in order to grant acceptability by users and positive social cost-benefit evaluations.

3.4.3 Barcelona City - Airport Interconnection: People-Mover, Metro and Heavy Rail Link Compared

Problems addressed

Access to Barcelona's airport currently takes place mainly by car and taxi (75%). Although suburban rail services arrive at the old terminal, the service has only a 7% share, with bus services being more competitive due to higher frequencies, similar travel times and more convenient destination stops compared to the train.



(source: MCRIT 2003)

Figure 3-24 Modal split for departing/arriving passengers in Barcelona airport (AENA, 2006) and origin/destination of Barcelona airport users

Facing the need to provide public transport access to the new terminal of the airport inaugurated in 2009 (3km from the old terminal), and with the aim to increase the share of public transport access to the airport, an ambitious operation of public transport provision has been undertaken. More specifically:

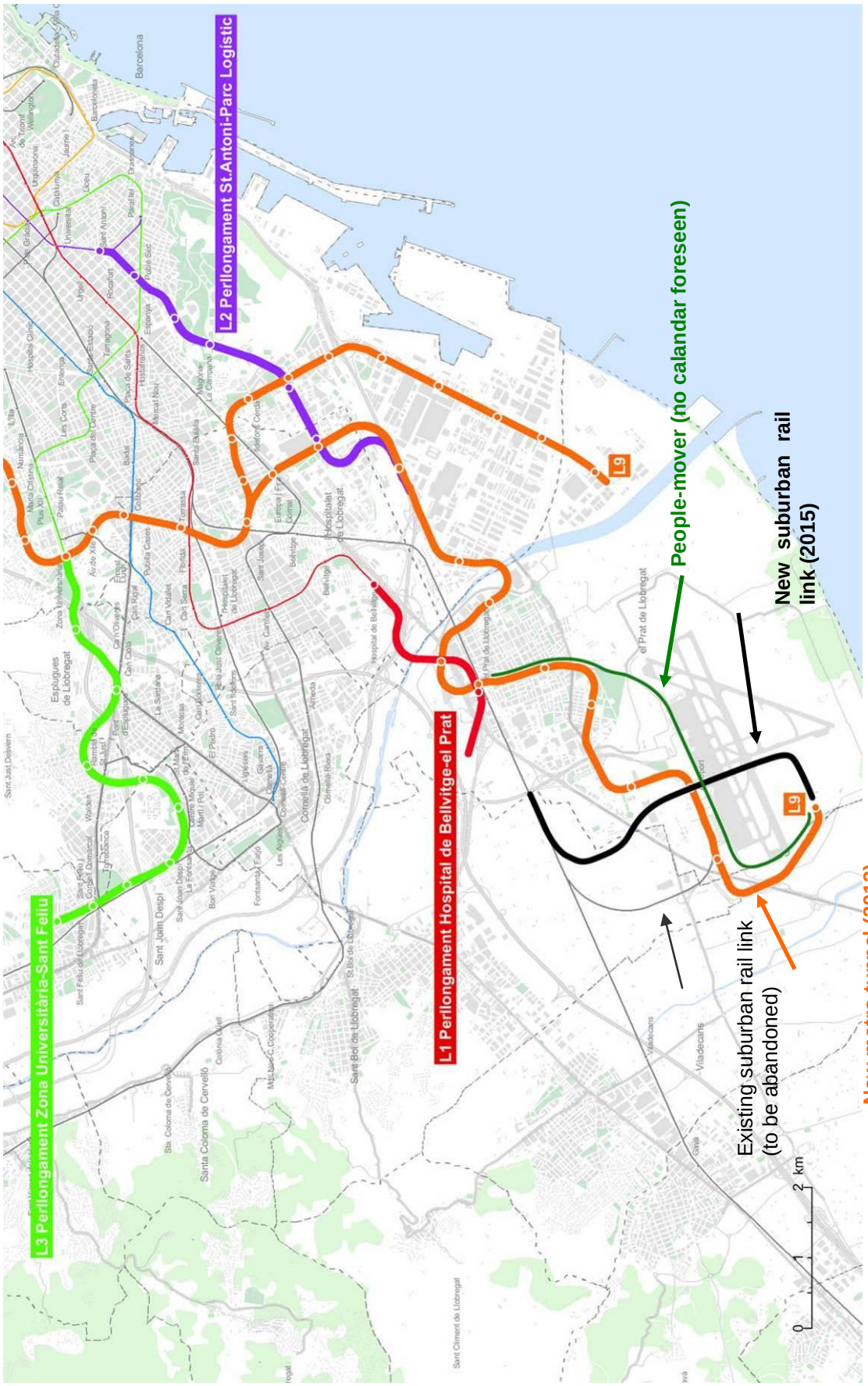
- a new metro L9 line is currently under construction and set to be inaugurated in 2012
- planned metro L2 line extension is to reach the airport in 2015, partly sharing the tunnel of L9 line
- a new suburban rail connection from el Prat de Llobregat will allow the arrival of suburban trains to both terminals in 2015 (now trains only reach the old terminal)

- a people-mover has been proposed (but not included in any planning document) to connect both terminals and the HSR station in el Prat de Llobregat (if the alternative loop project is finally abandoned). The people mover would have 2 or 3 stops in each terminal and would then use the L-9 metro tunnel to reach el Prat de Llobregat train station (where a luggage check-in area could be implemented as well)

Table 3-21 Public transport alternatives to Barcelona's airport

	Km of new tracks	Underground tracks (km)	Number of stations (including El Prat Intermodal Station)	Cost (€ M)
Metro L9 // L2	8.5 km	8.5 km	7 stations	870 M
Suburban rail	4.5 km	4.5 km	3 stations	220 M
People Mover(*)	6 km	0 km	6 stations	160 M

** The people mover would partly use the L9 metro tunnel to el Prat de Llobregat*



(source: MCRIT from ATM, 2010)

Figure 3-25 Foreseen airport rail access infrastructure scheme

Performance against main toolkit criteria

Cost

The construction of a new metro tunnel to the airport will allow from 2012 metro services of the L9 line (new 47.8km line with 52 stations currently under construction) and from 2015 metro services of the L2 line (after extension from central Barcelona to Zona Franca under the Mount Montjuïc). The arrival of the metro to the airport will be done from el Prat de Llobregat intermodal train station (HSR, conventional rail, suburban services C2 and C10 and metro L1) on an 8.5km tunnel with a cost of € 870M *(Infrastructure Director Plan, ATM 2009)*.

The renewal of the suburban rail link from el Prat del Llobregat to the airport in order to be able to serve both terminals requires the construction of a new 4.5km double-tracked rail segment from el Prat, which has been budgeted at € 220M *(Infrastructure Director Plan, ATM 2009)*.

The people-mover would connect the two airport terminals with several stops, and use the L9 metro tunnel to reach the intermodal train station in el Prat de Llobregat. The additional infrastructure required by the people-mover has been estimated at € 160M *(estimation)*.

Technical feasibility

The ongoing works of the L9 metro tunnel have faced technical problems which resulting in an increase in foreseen costs at the beginning of the works (almost €100M/km). The deltaic soil of the area has been an element of technical complexities because of a very high groundwater level (tunnel impermeability complications), the existence of a fresh water confined aquifer under the saltwater surface aquifer not allowing deep drilling, and the need to avoid other projected tunnels, mainly the suburban rail tunnel.

The suburban rail tunnel is affected by the same elements, only it does not run under inhabited areas making works slightly simpler on this side. However, the need to drill under the airport runway highly restricts the magnitude of differential seats, increasing difficulty of the works.

As the people-mover is intended to be on surface, technical problems should be much lower than in other solutions.

Financial feasibility

For the L9 metro line in Barcelona, financial problems due to increased costs from the original project (from € 3,000M to € 6,500M, from contingencies and changes in the original trace) resulted in 2008 in the need to include private operators in the financing of the line. The funding of the line was assumed in 2003 by Ifercat (Railroad Infrastructures of Catalonia), with loans in a 50-year horizon from EIB (€ 1300M originally) and a pool of banks formed by Santander, BBVA and la Caixa (originally € 1500M), and financing from the Catalan Administration (originally € 800M). With a strong need to increase resources, one of the adopted solutions consisted on the concession of the construction, maintenance and exploitation of 26 out of the 52 stations of the line for a period of 30 years, including all the stations in the airport segment. This operation injected an extra € 1700M to the works of L9 metro line from the private sector. The Administration will pay yearly cannon to the operators during the concession period.

The current period of economic crisis and the need for budget adjustment in the Spanish administration has put a delay in the beginning of construction of the suburban rail segment to the airport.

Organisational/legal feasibility

Organisational issues where not an insurmountable problem in defining the extension of the metro lines to the airport in Barcelona. The institution in charge of planning the project was the ATM (Metropolitan Transport Authority), which included this new line in the 1997 PDI (Infrastructure Director Plan). ATM is a consortium integrated by the Catalan administration's Department of Public Works and Territorial Policy (51%) and the municipalities in the Barcelona Metropolitan Area having collective public transport services and who voluntarily want to be part of it. Ifercat (Catalan Rail Infrastructures)

was the commissioner entity of the line and will be the owner of the infrastructure. Ifercat is a public entity dependant of the Catalan administration's Department of Public Works and Territorial Policy. The funding of the line was assumed by Ifercat. Being dependant on the Catalan administration, of the same political colour as the city halls of all affected municipalities, negotiations on the trace of the line and disposition of the stations was not an insurmountable source of organisational trouble.

Table 3-22 Implicated stakeholders in metro L9 line construction

Entity	Political Parties involved
Catalan administration	PSC (socialists), ICV (greens), ERC (republicans)
Public Works department	PSC
Barcelona City Hall	PSC, ICV
L'Hospitalet del Llobregat City Hall	PSC
Badalona City Hall	PSC
Santa Coloma City Hall	PSC
El Prat de Llobregat City Hall	ICV
Sant Adrià City Hall	PSC
Ifercat	Public entity dependant of the Public Works department of the Catalan Administration
ATM	Inter-administrative consortium composed by the Public Works department of the Catalan Administration (51%) and the municipalities of the Metropolitan Area of Barcelona (49%)

For the suburban rail extension to the airport, organisational issues have not been a major problem up until now. There is a compromise by the Spanish Administration to bring forward the project, and stakeholders mostly agree on this.

The people-mover has not been subject to formal debate yet. Organisational issues should not become insurmountable as it is a rather small operation compared to all others.

Acceptance by users

In all cases, acceptance by users should be very high, as public transport services both from downtown Barcelona and from its Metropolitan Area will be improved substantially.

Acceptance by other operators such as taxi operators (39% share in travels from and to the airport), parking operators and bus operators is likely to be low.

Other aspects of political acceptability

The political acceptability of having airports connected to public transport network is generally high.

Impact on users' door to door travel time

For users willing to transfer from HSR / regional rail network to the airport, the change in travel time compared to the present situation will be relatively important, between 20min and 30min depending on the implemented interconnection solution (people-mover, metro, suburban rail). The most efficient solution in terms of travel time would be the people-mover, as long as it is a high frequency service or co-ordinated with rail schedules.

The access to the airport by metro from central Barcelona is likely to be less competitive than by suburban rail if no direct services are implemented. For mid range distances (>10km), it is likely that metro services imply increases in travel time with respect to suburban services. The metro will be more useful for users travelling to other non-central neighbourhoods.

For users from the metropolitan region using suburban rail, travel times should not change substantially relative to present situation (less than 10min).

Impact on users' door to door travel cost

For current public transport users, the impact on travel cost is going to be minimal. Those now travelling on suburban trains are not going to be affected. Those now travelling on the express airport bus would save € 3.65 (according to 2010 fares).

For those changing from taxi (currently having a 39% share) to collective public transport, the saving will be much more important, around € 25 on average. For users of private car, changing modes will include savings in fuel, tolls and parking at the airport.

Initial impact on comfort or convenience

The number of potential users being able to ride straight into the airport by metro with no transfers can be estimated more than 500,000 after implementation of L9 and L2 lines (passengers living within a 500m radius from a station). For these users, convenience increase should be an important issue due to no longer needing to transfer. However, this will only apply to users for whom metro usage will not imply travel time increases with respect to other available modes.

For suburban rail users, comfort would slightly increase, as the rail will serve now both terminals instead of just one. However, current transfer to shuttle buses to connect the rail station and the new airport terminal are easy and well co-ordinated with trains' schedule, so the quality of service could be said to be already satisfactory.

The people-mover would increase convenience mostly for long-distance passengers arriving at the airport with HSR or regional trains at the el Prat de Llobregat intermodal Station. The implementation of a people-mover co-ordinated with rail services would allow long-distance and regional rail users to commute onto the airport without having to do so in Barcelona's main rail station, thus saving some 30min time.

Users' safety and security

As long as rail modes are safer than road modes, enhancing these kinds of modes will increase safety, even if slightly. Security should not be modified.

Region's prestige

As long as having a wide range of collective public transport services to an airport may be considered an element of prestige, the plans here discussed may contribute to increase regional prestige and the international image of Barcelona.

Access for people on low incomes and people with physical disabilities

As public transport is already available to access the airport, no enabling changes can be tracked for low-income users with the increase of public transport services. However, enhancing public transport can be generally considered to favour people with low incomes.

On the other hand, these solutions are unlikely to play a major role in enhancing access to people with physical disabilities.

Mode shift, congestion and GHG emission

Should the interconnection from long-distance and mid-distance rail services to the airport be properly resolved in el Prat del Llobregat intermodal station, some modal shift could be expected from private car to rail. Even if these kinds of traffics are currently not very important (83% origins / destinations currently correspond to Barcelona and its metropolitan area), increasing their weight in the future is a territorially strategic issue for Barcelona. Effects on congestion and GHG would be unlikely to be perceivable.

The increase of rail public transport to the airport, both through the increase of new lines and of frequencies, should increase the modal share of rail public transport with respect to other modes. Some studies have estimated the modal share of access passengers to the airport in 2025 as 40%.

This share would imply around 40,000 daily passengers in 2025 (compared to 6,000 daily passengers in 2010).

Transferability of findings

- Rail access to airports from cities requires important investments, even when airports are located relatively close to city centres.
- Suburban services with adequate travel frequencies are likely to be more competitive in terms of travel time than conventional metro services to connect airports with city centres, even when airports are relatively close (10km). Metro services are to serve other targets of passengers, i.e. non-central core neighbourhoods, business centres, areas of activities.
- Metro services are likely to encourage economic activity in municipalities located close to the airport and linked to it with new metro lines (business parks and activity areas well connected to the airport). The phenomenon from airport to airport city is properly sustained with metro services in big urban agglomerations.
- Proper HSR interconnection with airports can be a strategic territorial issue for cities and regions but as commuting passenger figures are likely to represent relatively low shares of all access travellers to airports, it is important to conceive projects with controlled budgets in order to have economically sustainable services and acceptable cost-benefit ratios.

3.4.4 HSR – Airport Interconnection in Girona and Reus: Tramway Links and Bus Shuttle Services Compared

Problems addressed

Girona and Reus airports have experienced rapid traffic growth over the last 15 years. In 2009, Girona managed 5.3 million passengers while Reus had 1.7million passengers. In the case of Girona, the travel origin or destination of an important share of these passengers was Barcelona (36.2%), some 50% in the whole Metropolitan area, implying that 5,300 passengers are travelling every day from Barcelona inner city to the airport either by private car or bus. Ryanair provides direct bus connections to downtown Barcelona co-ordinated with flights' schedules.

According to AENA, the main trip purpose of users of these airports is tourism: 74% of passengers in Girona are on vacation, while the figure is 83% in Reus.

As soon as HSR will be in service to Girona and to the new Reus rail station, the Catalan administration would like to improve the travel itinerary from Barcelona to these airports by implementing HSR stops nearby the airports. An average car trip from Barcelona to Girona airport takes 1h 5min (1h20 with bus), while HSR services are expected to reach the airport in 30min.

The arrival of HSR to airports is expected to increase regional airports competitiveness with respect to Barcelona's. This is an important issue, as Barcelona's concurrence to regional airports is expected to grow due to its spare capacity since its enlargement in 2009. A relevant matter is how to properly design interconnections between the HSR and the regional airports in order to allow easy and fast transfers.

Both in Girona and Reus, local tramway systems are being currently planned, giving service to both the airports and the HSR stations. In Girona, the tram line reaches the airport to then pursue on a 1.8km track to the HSR station. In Reus, a 1km branch diverting from the main line running through the HSR station will serve the airport.

As the implementation of these networks may not take place within the next 10 years, alternative systems are to be designed in the short term, such as shuttle bus connections. Both solutions are going to be discussed here and further developed in a specific test bed.

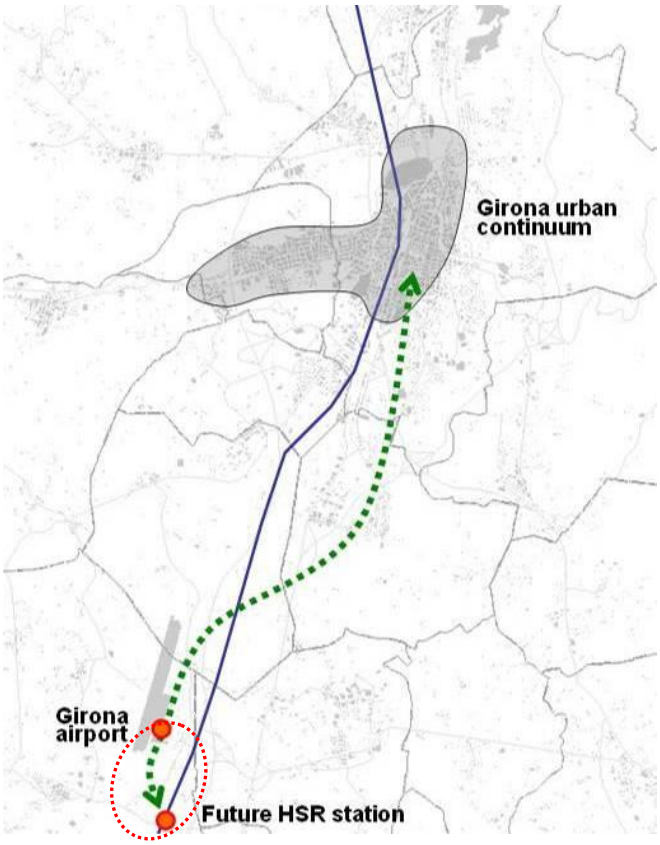
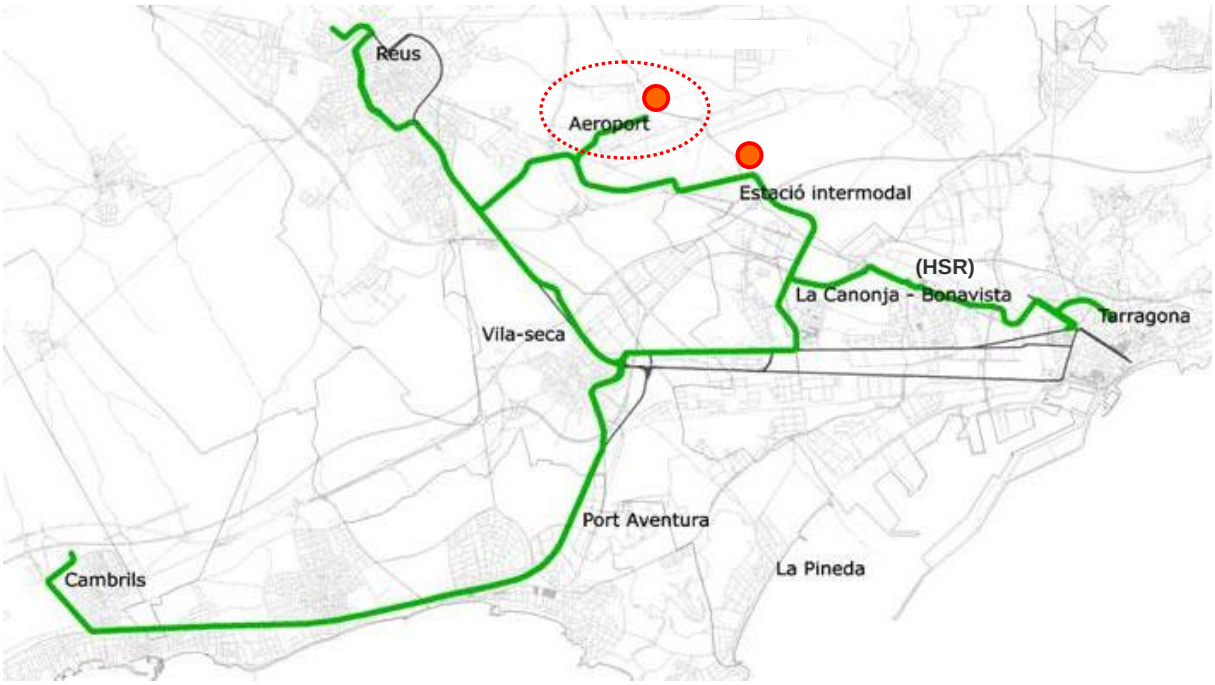


Figure 3-26 Approximate tram scheme in Girona (informative study due 2010). Tram extension from the airport to the HSR station would be 1.8km long



(source: Tarragona-Reus Urban Masterplan, 2010)

Figure 3-27 Planned tram scheme in Reus-Tarragona Metropolitan Area. Tram extension from the trunk line to airport is 1km long

Performance against main toolkit criteria

Cost

A quick estimation of implementation and service costs is provided below to study the order of magnitude of different solutions. Further accurate work would be required to properly evaluate each solution, being a task beyond the scope of this case study analysis.

The cost of construction of a HSR station in Girona airport has not been budgeted in any planning document, but could be estimated between € 10M and € 20M for a very basic station. In Reus, there is not going to be a specific station for the airport, as the new central station for the Reus-Tarragona Metropolitan area (€ 56M) is located 3km from the airport.

The additional cost of extending the future Girona tramway from the airport to the HSR station can be estimated as € 13M considering a hypothesis of standard cost of € 8.5M /km. The additional cost of extending the Reus-Tarragona tramway to the airport could be estimated as € 8.5M with the same hypothesis. No new additional rolling stock acquisition is considered here.

The cost of implementation of bus shuttle services between the airports and the HSR stations corresponds to the cost of acquiring bus coaches. One bus for the Girona service and another for the Reus service would approximately cost € 300.000 each.

Exploitation costs for tramways could be evaluated under the hypothesis of € 7/veh. km. Assuming a minimum service level of 1 tram per direction every 30min (40 trips per day and direction), resulting exploitation costs due to extensions of the implemented network could amount € 0.6M per year in Girona, and€ 0.4M per year in Reus.

Exploitation costs for buses could be evaluated under the hypothesis of € 5/veh. km. Assuming co-ordinated services with HSR arrivals (24 trips per day and direction to Girona and 20 trips per day and direction in Reus), exploitation costs could amount € 0.35M per year in Girona (2km ride), and € 0.6M per year in Reus (4km ride).

Table 3-23 Estimated costs for bus and tramway operation in Reus and Girona airports according to simplified service hypothesis (MCRIT estimations)

	BUS		TRAMWAY	
	Girona	**Reus**	**Girona**	**Reus**
Rail services/day/direction	24	20	40	40
Additional trip lengths due to interconnection (km)	2	4	1.5	1
Total bus daily services in both directions	96	80	160	160
Veh. km per day	192	320	240	160
Cost hypothesis per veh. km	5	5	7	7
Total yearly cost in M€	0.35	0.6	0.6	0.4

Considering an amortisation period for the infrastructure of 30 years, and the need to renovate the rolling stock every 15 years, yearly costs for each solution can be roughly estimated in a simplified manner as follows:

Table 3-24 Estimated costs for bus and tramway service implementation in Reus and Girona airports according to standard parameters (MCRIT, 2010)

		Additional infrastructure to be built (km)	Cost of building infrastructure (M€)	Cost of additional rolling stock acquisition in 30 years (M€)	Yearly amortisation cost (M€)	Yearly exploitation cost (M€)	Total yearly cost (M€)
Bus shuttle	Girona	-	-	0.6	0.02	0.3	0.4
	Reus	-	-	0.6	0.02	0.6	0.6
Tramway extension (*)	Girona	1.5	13	-	0.4	0.6	1.1
	Reus	1	8.5	-	0.3	0.4	0.7

** Costs for tramway consider additional costs to tramway network operation due to interconnection implementation between airport and HSR.*

Technical feasibility

None of the solutions is likely to find important feasibility problems.

Financial feasibility

Financial feasibility should not be a problem in the implementation of bus services.

Financial feasibility for enlargements of the tramway network to enable interconnectivity should not be a problem. However, financial feasibility of the projects of tramway network for both Reus and Girona are more uncertain.

Organisational/legal feasibility

Organisational issues for bus implementation should not be major a problem, as HSR regional services are going to be managed by the Catalan administration, also responsible for bus services. This is to allow an integrated operation of the interconnection scheme.

The tramway network definition in Girona and Reus-Tarragona is a complex process of negotiation between the Catalan administration and all the involved municipalities.

Acceptance by users and other aspects of political acceptability

Acceptance by users is to be expected high in all cases, as long as service co-ordination is adequate. The political acceptability of having airports connected to public transport network is generally high.

Impact on users' door to door travel time

Users travelling to Reus or Girona airports from Barcelona using HSR due to enhancement of interconnection are likely to experience significant travel time savings with respect to those currently using the car or the bus.

- In Girona, the trip to the airport takes 1h 5min by car (without considering parking time and access to terminal), and 1h15min by bus. The HSR trip is expected to take 30min and shuttle services to the terminal are likely to take less than 5min. The key is to either have co-ordinated or high frequency services linking the terminal and the station. Time savings could amount 30min to 40min per passenger.
- In Reus, the trip to the airport takes 1h20min by car and 1h30min by bus. The trip by HSR is expected to take 40min, and shuttle services should take less than 10min. Time savings could amount 30min to 40min per passenger.

Should the rail station in the airport not be implemented, users travelling Girona downtown by HSR and travelling to the airport by public transport / taxi, are not likely to save time with respect to users of car or bus, while the convenience of the trip would be lower.

Impact on users' door to door travel cost

A regional HSR ticket from Barcelona to Tarragona presently costs € 13.30. Regional HSR services to Reus airport should cost approximately the same. Regional HSR services from Barcelona to Girona should cost slightly less due to shorter distance. A round trip would then cost € 26.60.

A bus ticket from Barcelona to Reus airport currently costs € 1 , € 23 for a return ticket.

A bus ticket from Barcelona to Girona airport currently costs € 12, € 21 for a return ticket.

A car trip from Barcelona to Reus airport costs approximately€ 24 (€ 12.60 in terms of gas and € 11.40 in motorway tolls). With an average occupation of cars accessing the airport of 2.9 passengers per car, cost per passenger results on € 8.20, plus the parking fees (€ 7.25 per day). Considering an average stay in the airport of 12.4 days (AENA, 2003), a round trip including parking fees would cost per person € 46.

A car trip from Barcelona to Girona airport costs approximately € 15.30 (€ 8.80 in terms of gas and € 6.30 in motorway tolls). With an average occupation of cars accessing the airport of 2.9 passengers per car, cost per passenger results on € 5.30, plus the parking fees (€ 7.25 per day). Considering an average stay in the airport of 8.4 days (AENA, 2005), a round trip including parking fees would cost per person € 31.90.

Table 3-25 Expected travel cost to Girona and Reus airports from Barcelona

	HSR	**Bus**	**Car** (*)	
			Considering a 3 days stay in the parking	Considering average stay (**)
Girona	€ 24.80	€ 21	€18	€ 31.9
Reus	€ 26.60	€ 23	€ 24	€ 46

** on average, 2'9 occupants per car*
** 12'8 days in Reus airport and 8'4 days in Girona airport*

With current pricing scheme, HSR and Bus services would cost approximately the same. For car trips up to 3 days long and average occupation of cars of 2.9pax/car, this means of transport would be more competitive, but only slightly. For average trip lengths observed by airport operator AENA (8 to 12 days), rail and bus would remain cheaper as parking fees increase.

Considering a standard cost of operation of € 15/train km in a regional HSR service, a ticket price of € 13 per traveller would require at least 100 passengers per train travelling between Barcelona and Girona/Girona airport, or Tarragona/Reus airport stations, to make exploitation financially feasible. This volume of demand looks relatively reasonable on a first approach. Amortisation of the line is not considered here.

Initial impact on comfort or convenience

HSR services are far more comfortable than bus services, or even private car. As the trip takes far less time than other modes, HSR services are expected to be substantially more convenient for inner Barcelona inhabitants, and even some neighbouring municipalities.

Users' safety and personal security

Safety is usually greater in rail services than in road services, both bus and private car ones. Personal security should not be substantially altered by these solutions.

Region's prestige

Having a HSR network connected to airports may be perceived as an element enhancing a region's prestige.

Access for people on low incomes and people with physical disabilities

Analysis of travel costs show that travel cost to users is of the same order of magnitude in all modes. The proposed solution should not have an influence on access to people with physical disabilities.

Mode shift, congestion and GHG emission

As train tickets are expected to cost approximately the same as bus tickets and car trips, but travel times are significantly lower, some modal change is to be expected on trips to regional airports from Barcelona.

It could be stated that as far as this modal change may take place, there will be GHG reductions associated (i.e. for an average traveller accessing the airport from Tarragona -around 100km drive- can save some 12kg CO2 emissions). The overall impact on climate change, however, can be scarcer as this kind of user is only a small portion of the total share.

As for congestion reduction, the implementation of these services is very unlikely to have any perceivable impact on motorway congestion.

Transferability of findings

- HSR access to airports is more competitive in terms of travel time than private car and bus, but only when times to access rail stations and to transfer from rail to airport terminal are competitive enough. It is important that the interconnection between rail and airport is well conceived, with low waiting times.
- HSR access to airports is in terms of travel cost to users, according to current tariffs provided by the Spanish rail operator, within the same magnitude as bus service prices and private car services (AVANT rail services against bus coaches).
- HSR services connecting cities to regional airports should have relatively high demand levels to be economically sustainable to pay for operation costs. While direct airport rail shuttle services are likely to suffer from demand issues, trains serving non airport-related transport demand (i.e. to Girona city) in combination with airport users make it easier to fulfil demand requirements.
- According to simplified evaluation, both bus and tramway could provide similar service quality fulfilling the interconnection between HSR station and the terminals at airports. Exploitation costs would be expected to be lower for bus services than for the tramway, but within in the same order of magnitude in Girona and Reus. Bus services could show more flexibility to adapt better to rail schedules and reduce waiting times for users.

3.5 SUMMARY OF CONCLUSIONS

During the last years, large infrastructure investments in Spain have expanded the capacity of airports, passenger HSR and motorway networks. There is no capacity shortage in airports, passenger long-distance railways and motorways. Broadly speaking Spain's HSR network should be 5,000km in length before 2020. Spain's motorway network has grown from 2,000km to 10,000km between 1990 and 2010. These investments were financially feasible in large part due to Cohesion and Structural Funds. Intermodal connections between these long-distance networks have been planned in some cases, like in Barcelona and the other small airports in Catalonia. The goal is to create a network of specialised airports, with small airports located at approximately 80 km from Barcelona being able to provide the capacity that Barcelona will lack sooner or later. But the interest and feasibility of these rail connections were always under debate and now these are just partially achieved. On the other hand, investments on local rail and road new links to airports were also planned and now (2010) are under construction.

Interconnections in long-distance terminals with relatively low demand require specific ad-hoc solutions to be economically sustainable. Rail-air interconnections must be carefully planned and managed according to the specific characteristics of each case in order to avoid overinvestment in infrastructure. Solutions often require specific public-partnership agreements and organisational schemes (i.e. bus shuttle services partially subsidised by local authorities, buses also serving metropolitan regular routes, people movers from nearby rail stations, extensions of already existing metro or tramway, etc). In large urban areas, suburban services with adequate travel frequencies are likely to be more competitive than building new infrastructure, even when airports are relatively close to city centres.

Increased difficulties in planning optimal solutions. The lack of integrated transport and land-use planning processes leads to extremely long processes to plan complex interconnectivity projects. The design of interconnections in Catalonia was to some extent studied by the regional Territorial Plans, but co-operation between local, regional, and national institutions, at the end responsible for planning, and financing, them was never easy.

There is a need to optimise the institutional framework to manage transport infrastructures. Organisational issues, especially when negotiation involves multiple stakeholders, can become very complex, even if in Spain the airport and railway systems are managed from centralised public institutions. Strong political debate often results in cost increases and substantial delays of project calendars. If interconnections take place in urban / semi-urban areas difficulties can be even more important. New collaborative formulae involving all stakeholders in the planning and implementation process of infrastructure projects need to be considered.

HSR services to regional airports shared with other non-airport related services can pay for their operation. HSR access to regional airports in Catalonia is expected to be more competitive in terms of travel time than private car or bus, but only when times to access rail stations and to transfer from rail to airport terminal are competitive enough. Travel costs to users, according to current tariffs provided by the Spanish rail operator, would be within the same order of magnitude as bus service prices and private car travel costs (€ 10 to € 20 per trip).

Interconnections can provide positive territorial impacts beyond the optimisation of travel times and travel convenience. Metro services connecting Barcelona to its airport are likely to encourage economic activity in closer municipalities to the airport (business parks and activity areas well connected to the airport) besides providing access to downtown. HSR interconnection in Barcelona's airport is strategic for capturing trans-oceanic air routes, as it contributes to enlarge the airport's catchment area - only 3% of its passengers have currently origin or destination outside of the Catalan region. Still, when passenger figures are likely to be modest it is important to take into account the long-term economic and territorial impacts expected from the investment. In order to achieve these potential effects, strategic socioeconomic development plans bringing together public and private institutions can be used.