4. EFFECTS OF RAIL STATIONS AT AIRPORTS

Rail stations at airports[43] are at the hinge any time when considering interactions of (high-speed) rail and air passenger transports and especially both modes as complementary.

That is the reason why this chapter as a whole is devoted to the meaningful role of rail stations at airports.

One has first to take into consideration the common background, that (in Europe) most of the commercial airports of relevance are situated (within or) close to agglomerations, that there is an extended and often dense railway network within (Underground) and around (state railways, some of them becoming privatized), and that train frequencies are rather good.

Rail stations are now operational at several european airports.

First, the concept of rail stations at airports was aimed at relieving local road traffic congestion. That is why the first airport rail links were thought as shuttle services (between the airport and the city centre[44], where connections with the main railway network, as well as the (underground) urban public transport system are supplied.

The concept of airport rail link then developed as (through stations and) as an integrated part of the suburb railway network[45] and the nation-wide railway system[46].

In 1994, even high-speed rail stations at airports (Paris-CDG and Lyon-Satolas) and high-speed rail links between them went into operation.

4.1 General Effects of Rail Stations at Airports

The introductory analysis of rail/air passenger transport development in Europe shows that, few examples excepted[47], rail stations at airports were put into operation after World War II and at a faster pace during the last period of economic development in Europe. This is in line with the following context development:

- air passenger transport developed as a reliable mean of transport since the end of World War II and as a mass transport since the introduction of wide-bodies in the early seventies, adding to the business the booming leisure air travel market;
- rail transport suits to high volumes of transport with regard to its supply ability and cost structure;

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43 Or should we say airports at the rail networks?

44 As for the existing Brussels airport rail link, put into service for the World Exhibition in 1958

45 Being called S-Bahn in Germany, RER in France, etc.

46 IC-trains such as in Germany and Switzerland.

47 Like the U-station at Berlin-Tempelhof or only occasional stops along existing tracks amid the countryside, at some (walk) distance from the airport terminal.

- in the last period of boosting economic development (before the 90th recession), we experienced in Europe often a welcome financial feasibility for costly rail station infrastructures at airports, which had partly to be built underground[48], while track infrastructure costs were eased by the fact that overall classical rail network expansion in Europe had reached maturity, and that rail access to airport was very often provided from already existing (main) rail lines in the airport vicinity[49];

- political issues related to growing welfare and sensibility in the society to environment protection aspects played a role in favour of the advantages of rail compared to airport road access[50] and in some cases to feeder air services[51], whenever feasible.

These statements have in the meantime become obvious, because they rely on facts. Rail stations at airports, for the time being mostly at major airports in Europe (hubs), have clearly improved (rail/air) intermodality, flexibility in airport access (as alternative to road access). More airport rail stations under construction or projected in Europe strengthen the fact that they are worth building them[52]

Last but not least, HSR stations at airports broaden the prospects[53],

rail stations at airports allow beneficial effects
on rail and air transport systems
within their respective field of influence
(Thesis 11),

points out that, even without synergies, rail stations at airports are beneficial ***to rail and air transport systems being taken separately***, ("within their respective field of influence") bearing in mind, this will be anyway the case while involving synergies. This is especially the official view of the German Railways & the ITA-study [2] fully confirms thesis 11 !

In several reports[54], it has already been mentioned, that, if railway companies have increases in transport volumes and revenues and replace some short-haul air feeder

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48 As the open air area had to be reserved for other (land- & air-side) airport purposes.

49 For instance in Brussels, Zurich, Geneva, Paris-CDG, etc.

50 Cited as transport capacity, road congestion avoidance, car parking space saving at airports, reliability, punctuality according to timetable operation, safety, savings in energy consumption and costs, air pollution (and noise), relief in (oil) dependency (see in particular hypothesis 6 outcome & thesis 14).

51 Such as (part of) the Lufthansa feeder services on the german domestic air network (Stuttgart, etc.)

52 Such as next in Oslo-Gardermoen, Stockholm-Arlanda, Cologne/Bonn and Frankfurt (HSR-station). See also Chapter 4.4

53 The survey *"Integrating Aviation and High-Speed Line"* of the Dutch Railways expects beneficial effects in form of facilities for users, railway companies, airlines and airports after opening a high-speed rail station at an airport.

54 So at the DVWG-Seminar „Im Zug zum Flug“ (1990)

services, airlines can concentrate on middle- and long-distance destinations and save operating costs, and (congested) airports get freed slots to allocate.

The rail users' surplus is a most important benefit according to the cost-benefit analyses (Chapter 4.4 related to hypothesis 13) on rail access at the airports of Brussels, Frankfurt, Stuttgart, Geneva and Zurich, as well as in particular of Paris-CDG2 (long-distance rail access with TGVs).

	Rail transport	
Link type	**classical**	**HSR**
City-Centre to airport	Brussels London-Heathrow London Stansted Paris-CDG (RER) Paris-ORY (VAL d'Orly) Rome Stuttgart Munich	**First example** (as of October 1998) Oslo-Gardermoen
Rail system at airport	Frankfurt Zurich Geneva London-Gatwick London-Luton Amsterdam	Paris-CDG Lyon-Satolas
Airport to Airport	Zurich to Geneva &vv	Paris-CDG to Lyon-Satolas &vv

Table 20: Typology of rail access at airports (see also Annex 30)

NB: "City-centre to airport" rail connections had from the beginning some kind of rail system connection, as the city-centre station to the airport **is** often the (main) railway station. In the same sense, a rail system at the airport implies generally the connection to the city-centre (the city-centre rail station remains the main station). A change of train may occur at the city-centre main station, but also elsewhere on the rail system (no difference of attractiveness in this case). Airport to airport link is meant, in this respect, without change of train.

The 5 major London airports have rail connections; with the London Underground (Piccadilly line at London- Heathrow) connecting the BR (British Railways) stations, with a rail line of the BR system (London- Gatwick; Luton airport) or even with a rail service devoted to airport connection (Gatwick Express, London-Stansted to BR Liverpool str. station), with bus shuttle services (Luton & London City airports) to the next rail station, which may be served (London City Airport) by an automatic LRT (Light Rail Transit).

VAL d'Orly (VAL:véhicules automatiques légers) is connected to the RER "B" in Antony.

HSR: TGV services at Paris-CDG and Lyon-Satolas don't serve the city centres respectively, but a HSR link from the Oslo main station to the Gardermoen airport will be in operation from October 1998. As the infrastructure is quite finished, it is no longer a project.

A "Delphi"-survey dealing with hypothesis 12 (Chapter 4.3) reveal interesting aspects in this field: they mentioned the advantages of rail access at airports with regard to, in particular, complementarity, integrated journey, road traffic and car parking relieves, rail service improvement, easiness of use, reliability, time and (for long stays) cost-effectivness, (adequate) frequencies, schedule base, punctuality, speed, safety, especially compared to road access.

The following facts may be underlined, confirming (and strengthening) the thesis' statement.

4.1.1 Beneficial Effects on the Rail Transport System

Rail stations at airport have 3 major operation components, which appeared chronologically as follows:

- **local, urban and city-centre access**, provided by the (sub-)[55] urban[56] rail network

  This context of rail access has taken over from bus lines, among them (non-stop) city centre to/from airport services, mostly run by airlines[57]. As mentioned, rail access to airport, in Europe mostly very close or even within the urban area, was very often provided from already existing (urban network) rail lines in the airport (close) vicinity[49].

  As mentioned, in airport rail access involved public transport companies may benefit from the advantages of rail compared to road access by increased traffic volumes[58] and ticket revenues and by the network effect. They give holders of general tickets[59] the opportunity to take more advantage of their cards and public transport companies to rely more on their customers using their services.

  Apart for air travellers, this mode of access suits very well for airport employees and visitors, as part of them may not rely on car parking place provided for them at

55 Like S-Bahn, RER services

56 Like Underground, Metro, U-Bahn services

57 Starting with the SABENA rail link in Brussels, now run by SNCB, the Belgian railways.

58 Reports from the Swiss Federal Railways (*"Linien-Erfolgsrechnung der SBB 1994/5"*) confirms. The Zurich airport rail station ranks 8 (from nowhere) under the Swiss Federal Railways stations in terms of passenger traffic volumes (7 Mio in 1994; by 185 daily trains and CHF 34 mio in revenues) .

59 Communautés tarifaires ("Regenbogen"-card in Zurich).

a special discount on parking fares, which are increasing, as more parking place is difficult to be supplied.

- **inter-regional access**, provided by the direct IC[60] rail network (of classical trains):

  This context of rail access has been introduced from ***local, urban and city-centre access***, provided by the regional[55] and urban[56] rail network, as in many cases it runs anyway (partly) on the long-distance IC rail network.

  In some cases, the IC rail access to airports was quite at the beginning the main contender of airport rail access: airport and main station in the city may be directly linked[61]. As mentioned, rail access to airport can be very often provided from already existing rail lines in the airport (close) vicinity[49].

  In inter-regional airport access involved railway companies may benefit as already quoted from the advantages of rail compared to road access by increased traffic volumes[58] and ticket revenues[62].

  Air passenger transfer by classical train between two airport (rail stations) does not seem to be an issue to deal with, at least for the time being[63].

- High-speed rail, provided by the direct HSR station at the airport:

  HSR by-passes of the agglomerations of Paris[64] and Lyon had to be provided and having the TGV on them just "stop" at the airports of Paris-CDG and Lyon-Satolas was an opportunity, this without having to interchange (rail station) in Paris between TGV-networks.

  Railway companies may so improve the airport access more than by classical train („train use in order to fly"), as high-speed reduces access time or increases the airport catchment area in distance for the same specific access time compared to classical access modes, such as by road.

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60 Linking the Province capitals or in small countries the main cities (IC stands for Inter-City).

61 Like in Geneva, where even if it is possible to connect at the city-centre main railway station with the urban public transport system, it could be easier due to the urban destination (and even cheaper) to take the public line at the beginning of the ride and stay on the system.

62 The whole railway (and public transport) network effect give holders of general tickets ("abonnement général" or "half-tax" in Switzerland; "carte orange" in France; etc) the opportunity to take more advantage of their cards. Public transport companies may rely more on their customers using their services.

63 As Swissair moved its intercontinental flights, a single excepted, from Geneva to Zurich for cost-cutting purposes, it offered for (inter-) connecting air passengers at the Zurich-hub "feeder" shuttle-flights. The flight between Geneva and Zurich lasts slightly more than half-an-hour; by classical train, it takes more than 3 hours between both airports. There are up-to-now no other example in Europe with shorter distance to study.

64 Interconnecting the TGV-networks "Sud-Est", "Nord" and "Atlantique" without transfers between the Paris rail stations.

As HSR is much more in grade than classical modes to substitute air passenger traffic on specific links, it is consequently in grade to act as alternative to feeder air services (of hubs)[65] („train use instead of flying").

In the last case the location of HSR stations at airports make sense and is beneficial to the rail transport system, both in terms of intermodality role ("flight at level zero") and of providing a welcome surplus in rail passenger traffic volumes and revenues, as network effect, without having (necessarily) to supply extra capacity.

Furthermore, high-speed rail is expected to have economic impacts and other important socio-economic trends[66].

The remaining question regarding air passenger transfer by HSR between two airport(s rail stations) is not to be answered, as with regard to the (single) HSR example in Europe, the Paris-CDG to Lyon-Satolas distance seems clearly to be too long (see Chapter 4.3). One has to bear in mind, that air fare structures as up-to-now would refrain (interconnecting) air passenger from using another mode of transport, if (interconnecting) air services are provided at its convenience. Integrated air/rail ticket may be offered, but the revenues for the railway companies are not expected to be interesting.

4.1.2 Beneficial Effects on the Air Transport System

With air transport liberalisation going ahead in Europe, airport authorities have to look for satisfying the airlines, their main customers, at best attracting new ones, at worst not loosing air services they already have.

This is particularly true for major airports (hubs) with a home base carrier (for the time being still to be found at the busiest airport of each european country), bearing in mind that with fierce competition between airlines (or even between alliances of airlines) taking place, repercussions on the airports future role are expected, as well as competition between airports to take place as a consequence, at least "behind-the-desks".

That is why airports will be keen to improve as much as they can the services they provide, offering for instance the best ground access opportunities.

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65 See examples in the ITA-study [2]. The HSR substitutional function to air transport ***within a one-mode-travel*** lies between 350 and 1000 km, that is on a travel distance on which air passenger transport and HSR are able to compete. The ITA-study highlights complementarity on within a two-modes travel, a part-distance each where HSR (under 350 km) and air transport (up from 1000 km) are considered.

Other sources (*"TGV - Sud-Est studies"*) expect even strong competition to take place in the 500-800 km range.

66 The *"socio-economic impact study of European high-speed rail network"*, published by the EC, mentions the following points as "support for existing trends": dispertion of corporate business activities away from single sites; specialization of regions with particular functions; disminishing influence of local markets and the physical resource base in locating business and people; growth in intra-Community trade stimulated by the European Market and growing demand for leisure travel, as cultural barriers are lowered and wealth increases.

As experience shows, (step-by-step) improvement of airport ground access by rail is greeted by the users, as well as at a large scale by airport authorities and even by airlines.

This because even if air fare structures, as up-to-now, would refrain air passenger from using another mode of transport[67], if (hub) feeder air services are provided at its convenience, it is clear that short-haul air services are for airlines expensive to operate. In this regard hub feeder air traffic operating at marginal costs on short-haul O-D flights will be more acceptable for airlines than hub feeder air services operating at full costs, this because there is practically no short-haul O-D traffic (like for instance Basle-Zurich).

Major (hub) airports would welcome less regional aircraft (with low landing fees), as well as more slots to allocate, this without loosing connecting passengers, thanks to air/rail intermodality.

Airports authorities, like those at Paris-CDG, will be definitely convinced by HSR airport access, as they will experience an impressive airport catchment area, even into the airport catchment area of competing airports, which comes as a significant advantage for the users.

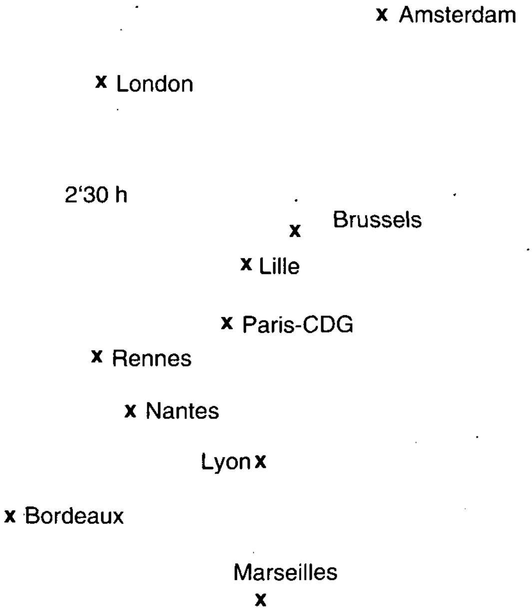

Figure 32: CDG catchment area by TGV (Source: Aéroport de Paris, EURAILSPEED95)

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67 Bearing in mind that hub feeder flights show low or even no additional charge for through-going air travellers, due to the present point-to-point O/D air fare structure applied. This fact, if lasting, unfortunately speaks against the development of a full "combined" network effect associating rail and air networks due to intermodality through airport rail stations, as long as rail and air fare structures are not integrated.

4.2 Multidimensional Effects of Rail Stations at Airports

Multidimensional effects are already incorporated per se in the other (hypo-)theses dealing with rail stations at airports. To be cited are the general effects of rail stations at airports (Chapter 4.1), including in particular flexibility and intermodality; the effects of rail stations at airports on the distribution air passenger transport demand among airports (Chapter 4.3 dealing with hypothesis 12), as airport authorities, airlines, railways, public transport companies, users and the general public (taxpayers and people living close to the rail and airport infrastructures) are involved; the impacts of rail stations at airports on the public transport balance of accounts (Chapter 4.4 dealing with hypothesis 13) being evaluated, whenever feasible, in monetary units, otherwise according to general knowledge as an (obvious) contribution.

As part of the rail transport system, rail stations at airport benefit ipso facto from ***the well-established (multidimensional) (dis-) advantages of rail transport in general***, especially compared to road access and in some cases to feeder air services[68], in particular each time HSR is involved:

- **in technical capability**:
  - high transport volume suitability (at a specific time);
  - speed (HSR & as classical train in the (sub-) urban context);
  - reliability, but depending on potential traffic troubles;
- **in operation**:
  - road traffic congestion avoidance[69], especially in the urban context (at peak hours) [34];
  - punctuality (according to timetable);
  - rail (& urban public transport) network effects (in access& fares);
  - easiness of use as an integrated public transport system;
  - safety record;
- **in environment protection**: [34]
  - air pollution saving;
  - land use saving;

68 See ITA-study [2]. NB: it considers partly and indirectly the reduction of road and (regional) air link costs.

69 A main reason for the existing rail access to Brussels airport having been built.

Bearing in mind airport feeder air services and the HSR alternative, the diagrams in the Annex 31 (see also Chapter 3.4 dealing with (hypo-) thesis 6) aim at mainly establishing, in a pure analytical viewing way, what is to be roughly expected about saving effects of HSR and air transport related to each other:

- time-to-distance spending,
- noise level,
- energy consumption,
- air pollution,
- infrastructure costs
- operating costs.

The aim of the diagrams should be first to ***"show the trends" by air and HSR separately and***, second, ***the "saldi of savings" between air transport and HSR along the ride or flight distance***, that is in each of 3 main phases of ride (acceleration; stage at cruise speed; deceleration) and flight (taxing, take-off and climbing out; flight at cruise level; descent, approach, landing, taxiing). Average values should be set and may show distorted profiles compared to the rough trends.

But what about troubles ***in particular circumstances***:

- Technical reliability of rail transport, but as trouble occurs, such as an electricity supply collapse, the impact may be huge.
- Operational reliability of rail transport, but what about (unexpected) strikes?
- Noise (and in some cases vibrations), especially close to the tracks;
- Comfort, especially at peak hours; no door-to-door service;

As historically rail access to airport was provided first from the city-centre, in most cases from a main railway station and, doing so, by extension from the regions, we simply focus for underlining thesis 14 on the aspects of local, urban and city-centre access provided by the (sub-) urban rail network[70].

the reliability of rail connections at airports allows
overall access costs at airports to be minimised,
waiting time and (parking) space for passengers
being reduced at air terminals,
travel safety to be increased
by the choice of rail transport
(Thesis 14)

points out from the well-established advantage of reliability of rail transport the effects on rail connections at airports.

70 High-speed rail airport access, provided by the direct HSR station at the airport, and interregional access provided by direct IC rail access at the airport, being considered as an improvement and extension of the large-scale network effect.

Overall access costs at airports to be minimised

By the choice of rail transport, the reliability of rail connections at airports allows ***overall access costs at airports to be minimised*** [2];[35].

Taking into account that road access to airports has to be provided anyway (quite at the start of airport operations), ***this is in particular true, when airport access has to be extended in terms of capacity***, according to the specific airport traffic development, and improved, according to political issues (in favour of rail (within the public) transport and environment protection, whenever feasible).

As commercial airports in Europe develop and are usually close to the city centres, that is within the (sub-) urban areas, they have to cope with the extension of their facilities within the airport boundaries. Road access is land consuming and each measure, which is saving space and relieving pressure on land use, is therefore welcomed by the general public and the airport authorities.

Assuming the land use for extension of the landside facilities is no longer available (a real issue in Europe), at least parking space will have to be built underground. At this stage of development, the comparison of construction and operating costs of underground infrastructures appear consequently lower for rail than for (road access and) car parking, when the capacity performance in number of passengers of the rail station is compared to that of (long-time) private car parking facilities. There is with (existing) airport rail access (plenty of) transport capacity reserve (without extension) expected for the future.

Rail access at airports is in grade in some cases to substitute air feeder services at beneficial operating costs for both the railway and airline industry.

Social costs will be kept lower by rail than by air and road access, as:

- with regard to safety, rail transport has a much (more) contributing effect;
- air pollution from electricity power is quite nil[71] compared to oil energy necessary to alternative mode[72];
- noise abatement barriers have to be considered along railways, but as well as along roads.

Last but not least, overall airport access costs may be reduced for users every time airport access by rail is associated with cheap user-friendly season-tickets.

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71 Assuming the safety of hydroelectric & nuclear powerplants last! NB: COST 318 decided to consider the existing infrastructures only.

72 Related seat x km supplied on an average, rail transport is considered by far less energy consuming than air and road transports.

Waiting time & (parking) Space for passengers being reduced at air terminals:

By the choice of rail transport instead of private car[73], the reliability of rail connections at airports allows waiting time and space for passengers being reduced at air terminals, not only for (new) car parking (far from the air terminal).

By fear (of trouble, delay, stress), ignorance (of road network), or simply wise experience, air passengers will arrive at the airport with a (comfortable) time margin. They will spend (much) time in the air terminal as necessary before departure. Areas (shops, etc.) will be accommodated for them.

This is less the case by rail, as users know when they arrive at the airport, according to timetable. Especially when train frequencies are high (assuming unlikely traffic trouble). They will manage a margin of, say, one or two train departure times. Moreover, in case of rail access trouble, it will be easier for them to justify the consequences as they affect many people at the same time. Air passengers going to the airport by rail may be much more used to spend less time in the air terminal[74], at least those not used to go shopping at the airport; the non-commercial waiting space at air terminals can be reduced[74; 75] accordingly.

The average time spent by air passengers before departure is expected to be tighter when airport rail access is provided. This prospect is not expected to boost retail activities, as waiting time at the airport is welcome, if not essential, for their business, and as some of them (as often duty-free shops) even belong to airport owners, if the commercial space is not rented. Waiting time by shopping at the airport has become a significant revenue issue and airport concessions a major position in the financial balance of many airports.

Travel safety to be increased:

By the choice of rail transport, the reliability of rail connections at airports allows travel safety to be increased.

This is quite clear as rail connections at airports benefit from the well-established advantage of rail transport of being quoted[76] safer, in particular compared to road transport. As an overall result, proportionally less accidents causing damage, injuries and deaths will happen.

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73 They may choose „kiss and ride", but related road access traffic will be even double.

74 However, this may be the contrary for arriving air passengers waiting for the train; in this case only if train frequencies are low. ***"Reliability of rail connections at airports" under Thesis 14 should be associated therefore with "high train departure frequencies".***

75 Resulting in less space in particular for waiting lounge and other accomodalities. Less space does not take into consideration reverse trends set at some airports to expand the shopping areas beyond expectation, in order to bosst the revenues of the airports. (In this case not only air passengers, but employees and visitors having nothing to do with the airports activities of the moment are involved.)

76 Taking into account the statistic units related to passenger x km.

Conclusion

By the choice of rail transport, overall airport access costs, as soon as airport facilities extension facing (rapid) traffic growth are hindered, ***are set to be kept low,*** as construction and operating costs of underground infrastructures appear lower and the capacity performance better for rail than for (long-time) private car parking facilities, then as, mainly thanks HSR, some feeder air services can be substituted, and social costs with regard to safety, air pollution, noise abatement will be kept low, as these aspects benefit from the well-established advantages of rail transport. Moreover, there is a better use of public transport season-tickets already owned by the general public, as well as a better load factor of public transport (without supply increase) to be expected. Last but not least, there is with (existing) airport rail access (plenty of) transport capacity reserve (without extension) expected for the future.

The choice of airport access by rail instead of private car ***may reduce non-commercial waiting space for passengers, as time spent (or wasted) in the airport before departure may be managed tighter,*** due to better knowledge of timetable related airport arrival. ***This aspect however should not suit business at the airport,*** which rely on (waiting) time spent by people in the airport for their commercial activities, a significant revenue position in the financial balance of many airports.

4.3 The Distribution of Air Passenger Transport Demand due to Rail Stations at Airports

Many reasons are making access of airports "closer", with the development of rail transport, with HSR of course, but also with IC and (sub-) urban (public transport) network-wide, as train frequencies are increasing and comfort improved, rail fares cheaper with season-tickets, and strikingly with rail stations at airports contributing to an integration of rail and air passenger transports; moreover, with the development of air transport, with (EU)-liberalisation in progress, (very) successful regional air transport (as in Switzerland, Scandinavia, France, for instance) able to feed hubs, but also "by-pass" them; with growing congestion (up to saturation), with more delays in extension and number at major (hub) airports in Europe, which for most of them are not going to be extended (beyond their existing boundaries), with growing environment protection concern and with regionalisation issues.

In this fast-moving context, the question arises whether airports, whenever their increasing catchment areas overlap, will be elected by the consumers like they do it for (a group of) airlines? In particular, whether:

"rail stations at airports allow
a better distribution of air passenger transport demand
among airports"

what impact rail stations at airports have on air transport distribution, considering also the impacts of high-speed rail at airports.

The hypothesis wording suggests that:

- air passenger demand could be distributed in another way that the one taking place actually;
- there is a need of a better distribution of air passenger demand among (more or less close) airports, and
- rail stations at airports are beneficial to this need.

The need of a distribution and of a better one has to be related to the points of view of the users (air passengers), operators (airlines, railways), (airport) authorities and general public (tax-payers, immission areas).

As also mentioned in chapter 2.4, another distribution that the actual one implies that there is another (airport) choice:

- ***with liberalisation***: this has just been (fully) achieved in Europe (third EU-liberalisation package);
- ***with*** (much) ***better*** (time-related) ***ground access***;
- ***within an agglomeration***: this will be more the case for the larger European agglomerations where there are (or there is the need for) more than a single commercial airport to be run;
- ***between agglomerations, especially as HSR is concerned***: this will be especially the case where airport catchment areas overlap;

4.3.1 Compatibility as "complementary" and/or "by substitution"

As already stated in Chapter 2.4 (dealing with hyp. 4), the hypothesis wording implies first that there is a compatibility for users between air and rail (passenger) transport. This compatibility can be regarded as complementary between the two modes of transport, or as the ability to choose one mode in preference of the other mode of transport, which will be called by substitution. This is mainly the case of a (new) challenging service, such as high-speed rail links between airport area[77].

From this historical point of view[77], there is already a compatibility, i.e. a complementarity by substitution, to be found between air and rail passenger transports in Europe. This has also been underlined by outside reports [2], particularly where 3 distinct ranges are cleared up, specifying the influence of air and high-speed rail transport on each other:

- „1st range: until 350 km travel distance (as the crow flies): high-speed train advantages dominate by far;“
- „2nd range: from 350 km to 1'000 km travel distance (as the crow flies): high-speed rail and air transport compete;“
- „3rd range: over 1'000 km travel distance (as the crow flies): air transport dominate per saldo;“

[77] See Chapter 1.2: "Tendences in the world around HSR and air travel";

In this respect, complementarity is defined as follows:

"Two modes of transport will be regarded as complementary for the user when their successive utilisation is either necessary or simply preferred to the utilisation of a single transport mode for a journey between two cities",

focusing on the successive utilisation of high-speed train (as feeder, i.e. substitute to air feeder services) and air transport (on distances where even high-speed train is no longer competitive) resulting from the addition of a part distance within the 1st range (where high-speed rail transport dominates air transport) and a part distance within the 3rd range (where air transport dominates high-speed rail transport)

All this will be of course much more the case if there are HSR stations at airports. The potential (long-distance) role of HSR feeding airports[78;79] is obvious. Furthermore, HSR station at the airport may be considered as one more HSR station (with car parking facilities) in the agglomeration area.

It is to be shown, if it is or will be also the case not only by HSR but by classical trains calling at airports, lower (train) speed being compensated by shorter distances[80], i.e. with roughly the same time spent on trains, and ***whether***, on the contrary, ***under-utilised airports could benefit from a redistribution of air transport demand***[80;81].

Distribution as "free" or "imposed"

As already stated in chapter 2.4 (dealing with hypothesis 4), the "distribution of transport demand among airports" will depend on user location, ground access facilities (a rail station at the airport being an added service value), airline operation concentration (for cost-cutting purpose) and airport operation selection by the authorities (for many reasons).

78 See short mission reports to AdP, Aéroports de Paris:

79 As an example, the rail access routing from Tours to Paris-CDG airport in recent the past meant: TGV to Gare Montparnasse, then underground to Gare du Nord and to the CDG rail station: ***more than 3 hours with 3 breaks*** ! Since June 1996: ***one hour and a half and no break*** !

Out of the total, about 45% are air passengers (at CDG).

However, it is out of question that a TGV line will ever be built for a sole airport; an existing line as to lie in the neighbourhood of the airport in order to have a chance of being carried-out.

80 Typical example of which being (within a sole country) between Geneva and Zurich (classical IC-trains). A new element has come with the fact that, since late 1996, Swissair concentrated all the long-distance flights but one in Zurich.

81 Typical example of which being (within a sole country) between Lyon and Paris (HSR).

The need for a "better" distribution

It has been advocated, "high-speed trains help eliminate the problem of congestion on some high-density sectors with major origin-destination traffic flows"; this may mean a substitution of mainly O-D air traffic to rail from city-centre to city-centre. In this regard, rail stations at airports may not add a lot to this.

More to airport congestion relief is to be offered by rail stations at airports when connecting air passengers are air-train instead of air-air users, discontinuing (non-profitable) air feeder services.

But as mentioned[82], a much more "better distribution among airports" is understood within the Action COST 318 by aiming at diverting a part of the air transport demand from a congested (hub) airport, thanks a rail station at an under-utilised (medium-sized) airport.

Airport catchment area

Diverting a part of the air transport demand from a congested (hub) airport, thanks a rail station at an under-utilised (medium-sized) airport, is given at least from and to locations where the catchment area of both airports overlap[82], as access average speed by train is often (by HSR surely) higher than by other ground access modes, and increases (or even create) the catchment area overlap of both airports.

4.3.2 Rail stations at airports

Not a remote "stopping-place at passenger's request" on a (secondary) railway line in the neighbourhood of an airport, without any shuttle service or system to carry luggage, as it was sometimes supplied in the past[83].

We define a railways station at an airport today as a within the public transport system fully integrated capability in the airport[84], with a level of service comparable to other modes, if not a higher. For the time being, major airports (hubs) in Europe have a ground access rail link. Ground access by rail to medium-sized airports is instead just beginning[85]. According to the AEA, Association of European Airlines:

"it is agreed that **local rail links** should be planned when the airport reaches the threshold of around 2 million passengers and should exist at airports with a traffic volume of around 3 million passengers."

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82 See Chapter 2.4.; see also explaining rough draft in the Annex 17.

83 This kind of railway station got sometimes a shuttle service to the airport, such as from a S-Bahn station to Munich-Riem airport, now out of service.

84 See Annex 32

85 Such as to Geneva airport (about 7 mio air passengers a year), whereas to Basle/Mulhouse (just up from 2 mio air passengers a year) it is considered.

For a link to long-distance rail the limits are not quite clear:

"It is also agreed that links with long-haul rail network should be considered wherever sufficient potential market demand for intermodal travel exists, and acceptable return on investment can be foreseen. This appears more likely at airports with a certain traffic volume: hence, for the purpose of the study, the airports with more than 7 million passengers a year were systematically considered. On this basis, twenty airports should normally be concerned. However, to this initial number must be added ten other airports which, while handling less than 7 million passengers, are identified as already having or planning links with long-distance rail networks. The total number of European airports concerned by links with long-haul rail network is 30."

A list in the Annex 32 describes the state of rail links at airports in Europe in 1992. Rail stations at airports are located mainly in agglomeration with significant business role; main airports without rail links refer to tourist destinations, often islands with no possible railway system. But even there the infrastructure background may change[86].

Role and advantage in this context for airport rail stations

The beneficial role railways (and furthermore rail stations at airports and HSR) may play are to be found under its main advantages: transport capacity, speed, punctuality, safety, environment protection, energy saving and, last but not least, the existence of a dense classical rail network and of HSR (by-pass) lines. At airports in particular:

- ***rail ground access*** (instead of road access) is in grade to:
- improve (ground access) ***time*** saved ***and punctuality***, as operations occur on own tracks and according to schedule (and high frequencies);
- require ***no parking place at airports***;
- give to air travellers ***independence from place of leaving the private car*** (the opportunity to fly back to another (close) airport);
- ***rail feeder service*** (instead of air feeder services) are to be found:
- already ***on short distances***, that is where there is no chance to get an air feeder service operated (no airport; or too short a distance);
- (as HSR) substituting air feeder services, giving the opportunity to free slots at congested airports;
- ***enlargement of the airport catchment area,***
- even in agglomerations, as trains are not subject to (daily) road traffic jams and are able to reduce ground access time significantly, provided that adequate frequencies are offered;
- this particularly by HSR (commercial speed about twice of that on motorways), enlarging the distance by an equal ground access time.

86 A project is being carried on in the island of Mallorca

As in many cases, there is a railway line in the neighbourhood of an airport, it is often possible to build only a station and bridge (London-Gatwick) or a relatively short antenna to the airport terminal (Brussels, Geneva, BR express line to Heathrow being built) or divert an existing line (Frankfurt, Zurich), so that infrastructure costs are kept relatively low; expected (economic) life of the infrastructure is furthermore high.

A special case emerge when the main airport activities of an urban agglomeration are saturated, while other airports in the area have (plenty of) capacity reserves[87].

A further special case of (imposed) distribution could be the scale-down (or even closure) of operations on a secondary (regional) airport, as services of equal quality are provided on rail to the next (hub-) airport.

Will railways lead to another way of distribution ?

That is the main question dealing with hypotheses 4 & 12. Rail stations at airports are improving the role of railways (and HSR) as integrated mode, which is consequently able to offer its advantages where it suits best.

First impressions as preliminary results show that rail stations (and HSR) at airports may lead to further concentration at congested (and going to be saturated) major (hub) airports. Are (in this context) on the contrary, rail stations and HSR at (medium-sized) airports going to play a (major) role in decentralisation of passenger air transport traffic, giving under-utilised (small- to) medium-sized airports a "better" use of their infrastructures, quite as a "renaissance" ?

Practical dealing process of hypothesis 12

The study main task will be to have a complete set of documented arguments aimed at confirming or refuting the hypothesis by, if not quantifying the effects due to a noticeable lack of statistics, at least qualifying and weighing the effects on the base of arguments, which will have to be cleared as plausible.

Apart from an analysis of the development of rail and air transports specially since World War II with regard to the significant aspects, in particular the need of rail stations at airports, examining hypothesis 12 has been done according to 3 approaches:

- Getting the full value of ***outside reports***[88]
- ***Short missions*** in Europe, taking into account the diverse (infra-) structural background;
- ***Questionnaire to experts,*** based on the Delphi method;

87 Such a situation is to be found in the London, Berlin and Rhein-Ruhr area: while the congested airport is connected by ground access with those with capacity reserves, ideas come up to manage the linked airports as a community and balance (partly) air transport demand between them.

88 Among them, a case study on the Geneva airport rail access and its catchment area.

The grade to which a better distribution of transport demand can be effectively achieved between airports, will probably vary sharply according to demand and supply characteristics. A general statement on railways stations at airports improving airport results is of poor value without a background specification.

The dealing process will focus on trying to assess, whether there is a new distribution of air passenger transport demand among airport taking or about to take place, and second, if this new distribution is „better".

Only existing rail stations at airports are analysed, as they offer case studies of different (European) backgrounds in the nature of the rail operations and the airport served.

Preliminary analyses are based on 3 approaches:

- outside reports close to the issue;
- specific case studies: on the Geneva airport access, carried out on behalf of the Geneva airport and on the „Direttissima" with a simulation programme[89]
- short missions within the Action COST 318, based on local meetings;

4.3.3 Evaluation of outside Reports

- **ITA-study:**

In the ITA-study aspects high-speed train contributes to force a hubbing system at (big) airports, most at the expense of both hub feeder and "hub by-passing" air services.

The ITA- study does not examine the inverse opportunity: demand redistribution from a busy (and congested) airport to (existing medium-sized and regional) airports with poor traffic.

- **TR News report** (Nr.181) [36]:

The article compares US and European airport access patterns, in particular the integration of air transport and airport access by rail. Although the author is promoting "the intermodal and the congestion management systems", there is no indication on a new distribution of air passenger transport demand between congested and under-utilised airports.

- **Eurailspeed 95**, Lille (November 95):

AdP set at the Eurailspeed 95 conference the catchment area limit base for the Paris-CDG airport at 2h30' TGV access time, while limits beyond this value were quoted as "very hazardous".

89 A computer-based simulation model "Decision Support System for National Strategic Planning", using a 1993-databank input, calibrated and validated on Italian networks for every transport mode and steadily improved with the Centro Studi sui Sistemi di Trasporto, Rome.

Paris-CDG is set towards complementarity through integration of airport access: TGV, RER, ownsite people mover linking terminals 1 & 2 and P&R facilities.

Mr. Duret, AdP General Manager, asked about the future of regional airports: "Regional airports will next suffer; they are expected to recover in a further phase, depending however on the adequation airport-airline-ground access supplies.

Mr. Veldkamp, Director Airport Affairs, KLM, sees HSR as feeder for air traffic; some reduction of congestion at airports (ATC) are expected; various fields for co-operation are to be defined to create synergy effects: performance, scheduling, frequencies, capacity, reservations, code sharing, pricing and product concept.

- **Enquêtes Passagers, AdP** (1986-87; 1993-94):

AdP surveys on departing air passengers gives quite interesting results, in particular related to travel origin in the Paris area and airport access mean used.

Overall 1993-94 survey results by district (arrondissement) on air passenger origins show often values by all means slightly above average from Northern Paris districts to CDG airport and from Southern Paris districts to Orly airport (and of course values slightly under average for Southern Paris districts to CDG airport and for Northern Paris districts to Orly airport). ***This shows***, in spite of the context at the time of the survey of a still largely regulated airline operation distribution between both airports of Orly and CDG (imposed distribution = authorities choice), ***catchment areas*** existing around each airport and ***related to distance***.

Airport access results by rail are also given in the 1993-94 survey (airport rail access in 1986-87 achieved only by last-leg airport shuttle bus) and it appears that airport rail access contribute catchment area extension of each airport, as modal split to airports is higher for rail in Southern (29.3%) than in Northern (22.6%) Paris to CDG, and vice-versa (higher in Northern (11.6%) than in Southern (8.9%) Paris to Orly airport) .

- **2nd Forum on Air Transport DVWG** (March 95)[37]:

The forum was devoted to "integrated air/surface transport concept" and related to the relationship between agglomeration and belonging airport, the catchment area of which being extended by the integration of long-distance rail transport, but understood as feeder service

- **London (Strategies) Conference** (April 96)[38]:

The Conference dealt with "interaction" as an "integration" of rail & air transport with regard to a specific airport; the case of a new distribution of air passenger transport demand towards under-utilised airports is not addressed.

Although "Crossrail" & "Thameslink 2000" will be part of "new railway routes to provide greater accessibility into and through the Capital" linking together London airports "directly or with one interchange only", no particular mention is made about a new distribution of air passenger transport demand among (the London) airports, except the fact, that the (British) government "has set up ***a special committee under the Public Transport Minister to look at*** the effects on London and consider possible solutions, including ***the potential for inter-airport connections***".[90]

- **Colin Buchanan & Partners Report** [34]:

Key features are assessed as a "pro memoria" basement (recommendations) when approaching a specific issue[91] on optimising rail/air intermodality. Related to "Rail/Air interchanges", this report does not focus directly on whether "rail stations ***airports allow a better distribution of*** air passenger transport demand among airports", although some aspects would have been in the sense of the hypothesis wording[92].

4.3.4 Case studies

- **on the Geneva airport access**

The case study on Geneva is a particular one, best suited for dealing with hypothesis 12, as the rail access to its medium-sized commercial airport was put into service seven years after the rail access to the major airport of Zurich-Kloten.

Surveys and studies were undertaken in the recent years on behalf of the airport authorities, focusing on the airport catchment area shrinkage in the years during which the Zurich airport had a rail access and the Geneva airport not[93].

The limits of the catchment area are quite precise, as the origin of ground access to the airports is well-defined by the rather tiny cantons (Swiss side) and départements (French side).

Recent surveys [39] on behalf of the Direction de l'Aéroport de Genève and dealing with 5'000 passengers departing from Geneva Airport, show that the French side attracts 18% of the air passengers, most of them come from the neighbouring French départements of Ain (Jura-side) and Haute-Savoie (Alps-side).

90 Seen (only) as help for flight diversions due to bad weather conditions, and replacing short-haul air (feeder) services as "local and inter-city rail travel, plus air travel". "Formation of the committee may have been prompted by environmental concerns, but it certainly represents an opportunity for rail to expand its market penetration". "Rail operators traditionally have had a myopic view of passenger demand", but "as train operations are progressively privatised over the coming months, there will be no lack of desire by the new owners to seek out ways of tapping into the fast-growing air travel market".

91 Such as "Rail/Air interchange design".

92 Such as under 7.3.6.: "The airports with high passenger flows and large local urban catchment areas, e.g. Gatwick, CDG and Frankfurt, concentrated on the provision of good airport to city centre links initially and then long distance links. The airports with smaller local catchment areas and therefore more longer distance trips, e.g. Amsterdam, Manchester, Geneva and Zurich, focused on the provision of longer distance services that also serve the local urban area".

93 After Swissair decided to move all its overseas flights but one from Geneva to Zurich for cost-cutting purpose, it would be interesting to see the impact on rail access figures.

The catchment area on the Swiss side, even with a railways station at the Geneva airport[94] is not far-reaching either, only a little farther than the cantons of Geneva and Vaud, which account for two thirds of the airport passengers. The other French-speaking cantons and the Canton of Berne share the rest percentage.

Out of ten reasons, the first for choosing Geneva Airport is given by closeness (75%), the second by access (only 20 %)[95]. 78% of the asked persons within the catchment area, declare using systematically the Geneva airport (94% in Geneva; 82% in Vaud, but only 57% the Swiss peripheral regions of the catchment area).

There is still no rail access (SNCF) from France to the airport and it should be interesting, comparing French and Swiss side to see if the railways station at the airport has provided an extension of the catchment area of the Geneva airport[96].

According to the survey [39], taking into account the outgoing market[97], the share under outgoing passengers is the biggest for non-professional purpose and the overall mean journey[98] until back home lasts consequently longer than for business purpose[99]. This should be in favour of a relative less significance of ground access time and for a potential extension of the catchment area of the Geneva airport.

Asked about airport choice opportunities for users just as airline choice, AIG (Marketing director) is divided between a yes, considering the business community as well as long-haul flights, and no, as "proximity is fundamental". ***Airport rail access should enhance the proximity factor.***

In the AIG view, "passengers are beginning to avoid "hubs"". Concentration will have a limit. For medium-sized airports "more traffic is needed". "Hub-by-pass" flights will not be relevant in terms of air passengers, but in aircraft movements yes, and under this aspect relieving major airports. The most important factor for both air travel purposes (business & private) is airport access, while air services supply (destinations, frequencies) is even more important for business trips only and air transport fares for private journeys.

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94 There are about 185 trains a day from the Swiss Federal Railway network; one air passenger in five used it, but 55% from the city of Lausanne

95 The other reasons are not significant (infrastructure; efficiency; air services; reception; parking; image; shops; prices).

96 This does not seem to be the case up to now as the survey states, at least for businessmen, who complained about the difficulty to reach the airport by train to catch early flights.

97 The outgoing market is defined as passengers living in the region and leaving for a stay elsewhere. This market accounts for 39% of the air passengers (incoming market: 49%; transfers: 12%).

98 Journey out of GVA lasting:

Journey out of GVA lasting:	1 day or less:	11%
	2 to 3 days:	20%
	4 to 7 days:	31%
	8 to 14 days:	15%
	14 days or more:	23%

99 GVA air passengers for professional purpose: 56%;

GVA outgoing air passengers for professional purpose: 43%.

An interesting specific aspect is underlined from the experience made in Geneva: people are not aware of the opportunities they have to reach the airport (from France, for instance): they are believed to think in terms of distance.

Another interesting (financial) aspect is underlined by increasing airport catchment areas: more communities could be committed if they take advantage of airport infrastructures.

Railways will lead to a new way of distribution of air passenger transport demand between airports, in particular as a modal redistribution and with the extension of catchment areas along railway connections. Rail transport (within an integrated multi-mode transport system) suits very well for ground access to airports, due to congestion of roads and parking; it is easy and cheaper for long stays abroad.

Medium-sized airports will have even more opportunities by rail access than major airports, as the role of "secondary" airports in the future will be more important and the extension of so far smaller catchment areas is very much expected to occur. However, it is not "vital" whether the airport is connected to high-speed rail, "because of the substitutional function".

- **on the "Direttissima" & close airports' rail access**

The case is an extension of the "Direttissima" case study without airport rail access (see chapter 2.4). As soon as the Milan-Bologna-Florence legs are HSR, one should speak about TAV (Treni ad Alta Velocità) and consider that travel time by rail is diminishing once again.

Results have been provided on passenger traffic modal split (air/ car/rail, see table below). Figures with rail stations at airports show that modal split shifts are quite sensitive; there is a competitive effect coming up, as the results provide a substitution shift in mode shares clearly in favour of HSR (see also for comparison Chapter 2.4) .

Rail station at Rome (FCO) airport only

Link		Passengers	"Direttissima" operating		
		per day	Car (%)	Rail (%)	Air (%)
Rome	Florence	2900	18.2	68.5	13.3
Rome	Milan	4500	2.2	24.3	73.5
Florence	Milan	1800	23.4	74.2	2.4

Rail stations at all airports

Link		Passengers per day	"TAV" operating		
			Car (%)	Rail (%)	Air (%)
Rome	Florence	2900	13.3	74.8	11.9
Rome	Milan	4500	1.4	53.0	45.6
Florence	Milan	1800	11.5	86.7	1.8

Table 21: Modal split (in %) to hypothesis 12 (Rail Station at Rome airport only and at all airports)

Calculations on a new distribution of air transport demand between airports (Florence & Rome) close to the "Direttissima" line, by concentration ("Direttissima" feeding the Rome airport hub) or decentralisation[100] of air passenger traffic volumes (see Annex 19) have been provided, assuming unchanged user costs:

- feeding the Rome (FCO) airport hub from the Florence area:

  22,2% by TAV (and FCO airport rail link) and 77,8% still by plane;

- feeding regional airports in the Florence area from Rome to Paris as example:

  23,8% by TAV (and airport rail links) and 76,2% still by plane directly to Paris from Rome-Fiumicino airport

According to the simulation results, ***a (significant) new distribution of air passenger transport demand is taking place as soon as congestion, expressed by delays[101] at the major (hub) airport of Rome (FCO), is occurring.***

4.3.5 Short missions

The short missions carried out have quite a good completing factor:

- on the one side, the London area airports, with the major commercial airports within Europe's largest agglomeration area (and looking at the "Eurostar" HSR link with the other major agglomeration area of Paris);
- on the other side, a major European (HSR) transport axis between agglomerations from Amsterdam to Lyon, where regional (Antwerp-Deurne; Lille-Lesquin) to medium-sized (Lyon-Satolas) airports alternate with major (hub) airports (Amsterdam-Schipool; Brussels-Zaventem; Paris-CDG/Roissy & -Orly), which all

[100] "TAV" feeding the regional airports of the Florence area, as the programme is a simulation tool and "results" of hypothetical connections may be shown. This is in phase with the case study aim, which is to assess passenger traffic volume shifts towards the one or the other mode of transport.

[101] Average delay set at about 15 minutes (20% of the flights coming from Florence) and at about 40 minutes (35% of the flights to Paris).

have rail (and even HSR) stations in or close to the airports; a case study line for Action COST 318 which makes sense in this European context.

Hereafter some (meaningful) arguments with regard to hypothesis 12 (see Annex 33 for full arguments).

- **London area airports**

The London area analysis is ***a case within agglomeration*** (see rough drawing & description in Annex 34).

The London area airports case study give the opportunity to examine the influence of rail access on the distribution of air transport demand between the airports within the largest agglomeration in western Europe: that are major (Heathrow & Gatwick), medium-sized (Stansted, Luton), as well as small-sized (London City) airports.

According to British Airport Authority, the two main determinants for passenger airport choice are frequency of flight departures and accessibility (journey time and cost each a factor).

There is a "very clear airport catchment area sectorisation" of the London area, due to cost and reliability. However, two thirds are using Heathrow airport. Majority is still running by car: Heathrow airport is too close (to the city centre) to have a good rail attraction. Rail links "are not powerful enough to have a more significant share".

Rail links are comparatively (much) more used at airports by people from abroad, much more dependent on (semi-) public transport than air passengers living spread in the agglomeration (and without direct rail access).

Without rail links the volume of passenger traffic at the Stansted and Gatwick airports would be (much) less. That's what can be said about catchment area extension due to rail links at the airport.

Direct links between airports should not be worth considering. The influence of the London Underground is, from the nature of service supplied, not relevant.

- **Antwerp's Chamber of Commerce & Industry**

The Antwerp case study give the opportunity to examine the influence of rail access on the distribution of air passenger transport demand with regard to a regional airport.

Antwerp lies between two European major airports (hubs) Amsterdam and Brussels. Antwerp has nevertheless a regional airport with a very close rail station, which should become, in a not too far future, the HSR Antwerp stop (TGV-Thalys) between Brussels and Amsterdam.

The airport ground access times by rail to airports should improve, as the Brussels airport is reported to be linked from Antwerp by IC trains directly at the new through-going airport rail station. It remains to be seen what impact HSR will have on distribution, as in this case rail access time to the Amsterdam airport will be reduced (significantly) according to present classical trains.

The Antwerp airport plays the role of a working regional airport, going to be much more involved in the overlap of the catchment areas of two major (hub) airports; a HSR station in Berchem will be beneficial to the Antwerp area and to the Antwerp regional airport (with its regional airline). There is a need felt for a better distribution of air passenger demand among airports and that rail stations at airports are beneficial to this.

Airports will compete between them. Concentration in air passenger traffic will last or not, depending on the number of years necessary to implements the new airport aims (and with regard to the development of feeder services).

For the very next time), there will be even more concentration in air passenger traffic, but it is not thought that the use of improved technology will (finally), with more concentration, avoid saturation (at hubs).

There will be in regional air transport more "hub-by-pass" flights. The future of regional airports lies in (more) intra-European air services, whereas major airports will have to cope first with overseas traffic. Many regional airports are in grade to offer a 10' check-in dead-line time, major airports are not.

Rail stations at airports extend the catchment area of an airport; however, it depends on the frequencies supplied. Airport catchment area for businessmen is set within a 2 hours ground access limit.

Generally speaking, a rail access to the airport causes a new distribution of air transport demand within an agglomeration with more than one commercial airport, as well as between a hub and a medium-sized airport, but not between major airports (hubs). Because of flexibility, (non-stop) high-speed rail between airport rail stations makes in any way sense.

- **Brussels airport**

Cities like Antwerp are clearly in the catchment area of both Amsterdam & Brussels airports, but it is difficult to estimate the shares: Amsterdam offers much more long-distance flights, whereas Brussels is nearer (in distance, if not in time and comfort).

High-speed trains could also lead to loosing traffic for the benefit of challenging airports. It seems that Paris-CDG (via Lille) is already on the way to attract a higher share of the Belgian air passenger traffic (see AdP address at the Eurailspeed 95 conference in Lille).

For BATC however, there is a clear distinction between "business" and "budget" travellers: the (full-fare) "business traveller" will not choose the airport because of its structure or his favourite airline, but because of the flight departure (and arrival) times; the "budget traveller" instead will follow the choice imposed by the tour operator, which will (try to) minimise costs against comfort, time spent and accessibility.

- **Lille airport**

The Lille case study give the opportunity to examine the influence of rail access on the distribution of air passenger transport demand with regard to a regional airport within a much populated area and the first HSR-crossroads in Europe (see rough drawing attached), two major (hub) airports (Paris-CDG & Brussels-Zaventem) being within one-hour ride reach.

Considering air passenger demand distribution, flight frequencies supplied at Paris-CDG are, of course, overwhelming. That means for the business air traveller more opportunities and flexibility, according to his work. Furthermore, he is able to check-in at the TGV station in Lille (if flying Air France).

Whether an airport has to be connected to high-speed rail is "indispensable". Only HSR stations at airports extend the catchment area of an airport like Lille.

A regional airport like Lille-Lesquin "has to use its strength: proximity" is seen as strength.

The idea of Lille-Lesquin becoming a "reliever" airport (for both close hubs) is familiar, but depends on "a strong airline". Air passengers would have to change their reflexes.

More generally, rail access does not cause a new distribution of air transport demand within an agglomeration with more than one commercial airport. More important are frequencies of public transport access to the airport.

- **Paris area airports**

Orly airport is connected to the RER station of Antony by a fully-automated new technology guided light transit (see rough drawing & description attached). Paris-CDG plays a future role, taking into account the influence of the new HSR station at the CDG-airport. In this respect, the catchment area extension of the Paris-CDG airport by HSR as a ground access is worth considering (see also rough drawing attached). Expected consequences are set as follows:

- People living in towns without a significant regional airport will use CDG more frequently;
- People living in towns with a regional to medium-sized airport (such as Lille) will continue to use it for the main destinations ("Lille airport" will not disappear);
- People living in towns with major airports (such as Brussels) will choose among several opportunities (from their town or from CDG);
- For people switching from CDG to Brussels for instance, very few opportunities are expected;
- Induced (new) traffic is hard to (fore-)see; no data is available.

New developments are expected, since Air France started the operation of a hub-and-spoke system in CDG in the Spring of 1996. A new distribution of air passenger transport demand towards the still under-utilised airport of Lyon-Satolas is not going to happen.

AdP are familiar with the idea, that, first, feeder air services to CDG will be restricted to a strict (commercial) necessity (relieving slot congestion by more hub-by-pass flights).

As AdP stress, Paris airports may not be saturated in terms of technical capacity (at CDG), but in terms of maximum movements authorised per year (already the case in Orly).

Discussions on a 3rd (major) airport (on grounds of environment protection around the existing ones) are not welcome by the AdP. It cannot be said whether it will be necessary. AdP encourages the regional airports rather than a 3rd airport for Paris.

Whether air passenger use the rail links (RER "B" + VAL d'Orly) between both Paris airports to transfer from flights in ORY to CDG and vv., the answer, RATP believes, is no, as, even having to take into account road traffic jams, people are expected to prefer the appreciated direct airport-to-airport coach service comfort (having put their luggage in the appropriate place for the whole ride).

- **Lyon airport & "TGV-Sud-Est after** airport rail stations" (Paris-Lyon)

NB: a European case, where there is also an opportunity to compare the air transport distribution ***before*** the introduction of HSR rail stations at both airports (see chapter 2.4)

Air passenger traffic between Lyon and Paris, "TGV is a very powerful competitor!" (see Figures in Annex 34).

However, air passenger traffic is now increasing again, due to the introduction of the Air France hub-and-spoke system in Paris-CDG last year. This fact speaks against HSR access to airport instead of feeder air services; but due to the air fare system, one has to consider overall ticket costs in many cases still cheaper by air than by rail access.

When necessary, a new distribution of air passenger transport demand works quite efficiently thanks HSR (see rough description in Annex 33 & 34).

However "one is hub or feeder". There is a strong belief that Lyon-Satolas will develop as France's second hub, because it is well-located and well-connected at the cross-roads from the Mediterranean arc, the Western Alps and Italy, the North-Western Europe regions and from (Scandinavia and) Germany (if the TGV Rhine-Rhone link is built), as well as within the Rhône-Alpes region, France's second economic region. EU-liberalisation of air transport would help in this respect. "A second big airport in France will not be a competitor to Paris."

Whether Lyon-Satolas (and its rail station) will be in grade to cause a new distribution of air transport demand by attracting air passenger demand from other sites, and doing so, a new pole in the French airport system, HSR is believed to take its part by better ground access to enhance air traffic development in Satolas and, doing so, to economic development in the region, being even an alternative to other airports, at least for travel origins and destinations lying between them and Satolas, and relieving air traffic congestion in the long-term at some neighbour airports, where extension capability is lacking or makes less sense.

- **ADV, Stuttgart**

ADV, Arbeitsgemeinschaft Deutscher Verkehrsflughäfen, as stated by the title, represents the community of German airports and is located at the Stuttgart airport. ADV deals also with airport access issues in Germany. Its point of view must not necessarily be in phase with the whole European scene, as the background elsewhere in Europe may be different.

Air travel destination (intercontinental, with an expected stay of many days vs. Europe, with an expected stay of may be only few hours), that is connecting at one of some few hubs or taking direct (non-stop) flights at one of several airports may lead to different airport access choices for air passengers. Air travel purpose distinction business/ private, that is mainly between "few time left" (as "time is money" and travel costs may be not so relevant) vs. "time is laying ahead" (private spending considered as an important issue) are also leading to different choices (flight arrival (& departure), access time).

Both aspects cited may coincide: "more time left" for a "stay of many days" at an "intercontinental destination" after a "feeder service to a hub" on the one side; "European destination" for a "short stay (of a few hours)" after a "direct (non-stop) flight (from the most convenient airport)".

The catchment area extension of the Frankfurt airport by rail ground access is worth considering. Significant reductions in air feeder services, such as from Stuttgart, Cologne/Bonn and Hannover, have been consequently reported. This could lead to further easing (slot) pressure of feeder flights at Frankfurt airport and freeing airport (slot) capacity for other (inter-continental) flights.

Will it lead (in the second phase) to relieve the airport from some air passenger traffic in favour of other airports, as ground access by (high-speed) rail will also be provided in the other way towards under-utilised medium-sized up-to-date airports, such as Hannover or Cologne/Bonn?

Dealing with hypothesis 12, ADV sees, as background, 70% of the airport users within an airport access area of less than 1 hour airport access time, but widespread in the area, which is not what rail transport requires (demand concentration). ADV does not think that airport choice opportunities will increase just as those on airline choice; air passengers made their choice with airport in the vicinity.

That is why access by car remains usually more convenient. However, when parking constraints come up, rail transport suits very well for ground access to airports: this may be the case at major airports; the convenience of car access prevails at medium- to small-sized airports if enough (parking) supply is available. When considering a rail station at airport, traffic saturation and airport parking area issues may play a boosting effect.

ADV thinks, air passenger demand among airports (in Germany) could be distributed in another way than the one in place, but small-scaled only.

Not for short-haul flights, but for long-haul flights, rail stations at airports enlarge the airport catchment area (and even much more when served by HSR). Note that, for ADV, this is not the case without rail stations at airports!

ADV has some doubts over the ability of (high-speed) rail to distribute (on its own) air passenger demand among airports.

A new distribution of air passenger demand among airports (in Germany) is seen by ADV only in the long-term, if forced to, and railways are set to play then a role. Whatever, it does not make sense to have (non-stop) high-speed rail between airport rail stations: "we don't need it!".

Air traffic concentration at hubs up to saturation will last in the meantime. Regional air transport will develop further, especially with "hub-by-pass" flights, but it will not be relevant in terms of air traffic volumes relief at major airports (hubs).

Prospects for medium- to small-sized airports are quoted by ADV as a "difficult issue" considering scheduled air transport, but "easier" when considering charter air traffic. But ADV stresses that no development is 100%-foreseeable!

When airport catchment areas overlap, the air transport demand is increasing; the direction of the journey may play a role for airport choice.

Nevertheless it is important to have an airport connected to high-speed rail, as (ground access) demand is to switch from car to HSR, leading to less intra-air passenger transfer traffic, that is less feeder flights. Only the region has to be linked by rail (to the airport).

Given a rail link to the airport exists or is feasible, its traffic volume share has to be increased. The most influent factors aiming at achieving this goal are "no change, adequate frequencies (every 15'), available seating". In order to expect changes (of habits) by users in favour of public transport, infrastructure must be provided in the long-term ("for the next 100 years" ....!).

Although ADV considers the passengers' airport choice for given, airport access in general and flexibility (rail vs. road) is regarded as very important for business travel, less for private travel. Whereas ground transport costs and air transport fares are important for the traveller on private purpose, this aspect is respectively less and not important for the business traveller. Air services supply (destinations, frequencies) is quoted as "important" for businessmen and as "not important" for private purposes. An integrated (public) transport (with no change) and information system is regarded as very important for the choice of the airport access transport system. High-speed, comfort and fares are regarded as less important by ADV.

4.3.6 Delphi-Survey

Introduction to the survey (with regard to the full report [40])

Due to EU-liberalisation, fierce competition, cost-cutting constraints, hubbing of major European airlines at their home base, airport catchment area extension by existing (high-speed) rail access at most of the major European airports, lead to air traffic congestion, whereas a number of other (medium-sized) airports are under-utilised. Once, saturation and fading trust (repeated delays) in air transport could emerge.

Moreover, most of the European airports can't be extended (close urbanisation, noise and air pollution concerns). The idea comes up that, at least where the catchment area of several airports overlap, even much more when airport (high-speed) rail access is provided, users have the choice to shift to other airports.

As statistics related to this evolution are (still) not available, the issue suits to an expert questioning based on the "Delphi" method (Annex 35), meaning the statement of personal convictions in several questioning rounds, after having read the arguments put forward by the other experts the round before.

More on the Questionnaire, the results and their evaluation (including by professional groups) in the special report [40], as well as under chapter 4.3.3.

Context assessment

The "Delphi"-Questionnaire is assessing the hypothesis' context too, the evolution of which is well to the fore.

- **Wording meaning**

According to the Questionnaire's answers related to the hypothesis (to be confirmed or refuted) on whether *"rail stations at airports allow a better distribution of air passenger transport demand among airports"*, there is a quite unanimous agreement among experts that the hypothesis wording suggests that ***"air passenger demand could be distributed in another way than the one taking place nowadays"***. However, for a minority (which may be right), the hypothesis does not suggest, that "there is a felt need of a better distribution of air passenger demand among (more or less close) airports". But when felt, quite unanimous experts agree, that "rail stations at airports are beneficial to this need" is another hypothesis suggestion.

- **Air passenger transport trends**

Considering air passenger transport trends, boosted in particular by air transport liberalisation (in Europe), "airport choice opportunities for users will increase (just as present airline choice opportunities)" as, unanimously stated by the experts, ***"airports will be keen to offer new services according to flexibility and market opportunities*** (just like airlines are doing it)", "competing between them": ***this speaks for airport rail link whenever (economically) feasible!***

However, "concentration in air passenger traffic will last (even up to saturation), but a qualified expert majority is trusting the use of improved technology (surprisingly only one third of those coming from research institutes and universities believe in an improvement), as well as of airport and airline management, to be able to cope with more concentration without a saturation to intolerable levels"; some experts are expecting concentration in air passenger traffic even without effects of hub-and-spoke systems operated by the airlines (on some airports). ***As large airports in Europe are*** (about to be) ***first served by rail operations, this speaks (for the time being) against a new distribution of air passenger transport demand towards other airports (by rail):*** this has been already mentioned in the COST 318 Interim report.

Underlining this, it has been acknowledged as "correct, that more traffic gives an airport the opportunity to be more cost-effective and more profitable", if not quite congested. ***Passenger transport supply by rail***, occurring first at large airports, offers new service opportunities (advantages of rail transport, such as punctuality, transport capacity, car parking supply relief and in some cases, feeder air services alternatives) ***is capable to enhance air passenger traffic concentration.*** That means that the actual situation will continue to prevail at least for the (very) next future: air traffic growing (tremendously) at some airports.

- **Large (hub) airport constraints**

As air passenger traffic is concentrating at large (hub) airports, constraints come up, such as long walking distances and delays. Until now, although often predicted, no lasting air passenger transport collapse occurred in Europe (which should not mean, such an event is out of question). ***Rail stations at large airports are in grade to provide some relief to air traffic congestion, as passengers at rail stations are*** related to air passenger transport, ***for some of them*** (part of feeded air passengers) ***relieving the airside by reducing flights.***

The facts however are that ***most (large) airport areas in Europe*** (a few excepted), some of them close to the city-centre, ***cannot be extended outside their present boundaries, due to (dense) urbanisation and*** environment protection. Moreover, ***only a slim expert majority think, "people from airport neighbouring communities will protest against more air traffic concentration, but finally accept (after political concessions), as they did in the past".*** Three quarters of the experts, who don't agree, believe "they will (even) be in grade to stop the process" (of air traffic concentration). ***This means that a potential reallocation of air traffic lies ahead*** (without or with air passenger transport liberalisation) to (more or less close) airports, which will have to be competitive (and rail access at the airport being, without doubt, one key element of attractiveness).

In this respect, it is confirmed, that airport access in general & air services supply are more important for people travelling for business purpose, whereas ground transport costs & air transport fares are more important for private purpose. For both, ground access time is more relevant than ground access distance.

- **Airport catchment areas**

On whether rail stations at airports, that means airport ground access by rail, extend the catchment area of an airport, a clear majority agrees, and that this would not be the case at major airports only.

That means also that ***catchment areas of airports being linked by rail are consequently to extend, giving the opportunity of a "better" distribution of air passenger transport demand, at least within areas where the catchment areas of several airports overlap*** (and are extending due to airport access by rail).

Almost unanimous is the conviction that the airport catchment area will extend surely much more when high-speed rail stops at the airport.

Additional effects of increasing catchment areas are cited as: increasing airline choice; direct flights; more competition between airlines; accelerating concentration at large airports; air passenger flexibility; effects on area planning, urbanisation development, more benefits for users.

- **Airport rail access features**

Rail ground access distance/ time ***range suitability to airports set*** by the experts vary significantly from an expert to the other, as probably the background in their respective countries may be (quite) different: airport access ***by underground up to 50 km; by local train up to 100 km; by Intercity train/ HSR up to 450-500 km***, whereas the true substitutional function of HSR (to air passenger transport) is quoted up to 800 km.

Relying on railways leading to a new way of distribution of air passenger transport demand between airports and on rail transport suiting very well for ground access to airports, all experts stress, ***"it is important for an airport to be connected to high-speed rail". However***, for half the experts, ***"it does not make sense to have high-speed trains between airport rail stations"***. This would mean according to the expert majority, that ***no new distribution of connecting air passenger demand is expected*** (or even wishful) ***between airport lying*** (too far) apart (in the HSR present usual distance range, that is for instance Lyon-Satolas airport being consequently not to be considered as a potential reliever for the Paris airports).

A large expert majority agrees that the traffic volume share of a given rail link to the airport has to be increased (enhanced compared to airport road access) "by every possible mean" (integrated rail-air services, improvement of transport supply and services (frequencies, quality, fares), profitability of rail links, framework of EU transport policy and long-term development).

Further enhancement conditions cited: service points; integrated supply of services; communication centres at airports; policy of growth and awareness; logistic facilities (check-in and luggage handling); environmental and economic aspects; more attractive rail stations; network morphology; software issues. These are issues, which public transport could match.

Values set for access transport system characteristics vary significantly from one expert to the other, except the "frequencies" value for the choice of an airport access transport system for business travel purpose, set thoroughly as "important" to "very important". As rail transport supplies per unit a significant transport volume, this means that transport volumes by rail at airports should be important in order to achieve high frequencies without empty trains.

This is also why ***rail access is in grade to perform better at large airports.***

Other quantitative and qualitative opportunity matters within the transport supply to look at: transfer; check-in; reliability; punctuality, modal integration; time; information. These are aspects, rail management to airports is in grade to manage successfully.

4.3.7 Comparisons (according to typical Backgrounds)

As the existing context with regard to hypothesis 12 is manifold (within or between agglomerations; influence of major (hub), medium-sized and regional (small-sized) airports between them; airport catchment areas; "free", "imposed", "neither-free-nor-imposed" air passenger transport demand distribution; airport "liberalisation" prospects; (bilateral) accords; the influence of EU- and national policies, such as those regarding environment protection, and their effects), a comparison should take place ***according to typical backgrounds***, taking into account the different approaches and sources (outside reports, case studies, short missions, "Delphi"-survey) considered.

- among airports **within the agglomeration**

Answering to a questionnaire [40] experts seem to trust less in the adequacy of rail accesses to airports to cause a new distribution of air passenger transport demand within an agglomeration than between agglomerations.

Related to the Paris area, both major airports are linked by rail from the city area: AdP survey [41] results by district (arrondissement) on air passenger origins and access mean to airport terminals show catchment areas related to distance around each airport, in spite of a context of still largely regulated airline operation distribution between both airports at the time of the survey. Whether airport catchment areas within the agglomeration have been enlarged by airport rail access is not specifically assessed by the survey results, but one expects it, as airport rail access modal share results are higher for the farthest part of Paris.

Considering a noticeable rail link use between both Paris airports by air passengers transferring from one to the other airport, the answer is however believed to be no.

Related to the London area and according to BAA, there is a "very clear airport catchment area sectorisation" of the London area, due to cost and reliability, but rail links "are not powerful enough to have a more significant share": Heathrow airport is too close (to the city centre) to have a good rail attraction; without rail links the volume of passenger traffic at the Stansted and Gatwick airports would be (much) less. That's what can be said about catchment area extension due to rail links at the London airports.

Direct links between airports should not be worth considering. The influence of the London Underground is told, from the nature of service supplied, as not relevant.

- airport catchment area extension **beyond agglomeration boundaries**

  - **major** vs. major **airport**

    AdP set at the Eurailspeed 95 conference ***catchment area limit for the Paris-CDG airport*** at 2h30' TGV access time: already within the limit, Brussels, as a major airport, is to be found.

    The contrary (Paris-CDG being in the 2h30' hours catchment area limit of the Brussels airport) is effective too, but it is only efficient if air transport supply match the air travellers expectations; indeed, very few opportunities are expected by AdP for people switching from CDG to Brussels.

    "Delphi"-Questionnaire answers show that "airport rail access is" believed "to cause a new distribution of air transport demand from an agglomeration with a major airport (hub) to another major airport.

  - **medium-sized** vs. major **airport**

    With regard to medium-sized airports, ***"Delphi"-Questionnaire answers of an expert majority*** report, "rail transport access could provide the same opportunities as to major airports". This statement implies among other things, the airport catchment area being extended. Expert expectations are quite high, that "airport rail access is going to cause a new distribution of air passenger transport demand from an agglomeration with a major airport to a medium-sized airport".

    The case study on Geneva is best suited as the rail access to its medium-sized commercial airport was put into service seven years after the rail access to the major airport of Zurich-Kloten.

    Some of the air passengers (at peripheral regions) of its catchment area went lost as they found the Zurich airport more convenient, thanks to rail access.

    The Geneva airport, having got its rail access in the meantime, is struggling to recover at least part of the traffic it lost (at the peripheral regions of its catchment area).

    "Proximity is fundamental". Airport rail access should enhance the proximity factor.

    Railways will lead to a new way of distribution of air passenger transport demand between airports, in particular as a modal redistribution and with the extension of catchment areas along railway connections. Rail transport (within an integrated multi-mode transport system) suits very well for ground access to airports, due to congestion of roads and parkings, is easy and cheaper for long stays abroad.

Concentration will have a limit. For medium-sized airports "more traffic is needed". More communities could be committed if they take advantage of airport infrastructures.

Medium-sized airports will have even more opportunities by rail access than major airports, as the role of "secondary" airports in the future will be more important and the extension of so far smaller catchment areas is very much expected to occur.

Only a minority of travellers ***using the TGV-station at Paris-CDG*** are air passengers. The new Air France hub-system operating in Paris-CDG attracts since last year much more passengers from Lyon on air feeder services. Paris-CDG is not going to be saturated in the next future, so the present strategy of Air France having air feeder services from Lyon-Satolas and concentration in Paris-CDG may last, at least several years. There is a reason to be found in air+rail tickets not taking account the advantage of mileage flown by the air passenger; on some (long-haul) flights, the transfer flight may be at no charge (for the air passenger). This is occurring up to now without the influence of TGV access.

On the contrary, HSR is not expected to significantly attract air passenger demand from a major airport, like Paris (except on special situations like the Air Algérie case described).

Not so if Lyon-Satolas is going to be France's second hub airport (thanks to a group of airlines, or even Air France). At least as a secondary hub. The chances of development seem quite good in every respect, as already described.

The Lyon-Satolas airport is likely, like Paris-CDG, thanks best access connections, especially by rail and TGV, to extend its catchment area significantly, and attract more air traffic from an extended zone of influence and from medium-sized airport areas going to be saturated in the future due to a lack of extension capability. The Lyon-Satolas case described shows even at its early stage of development clearly, that HSR "allows a better distribution of air transport demand among airports".

- **regional** vs. **major airport**

With regard to regional airports and ***according to the "Delphi"-Questionnaire results***, air traffic reallocation from large airports to regional airports (outside an agglomeration) would be expected as slow by the experts, as an overwhelming majority of them mean, "there will be a further development in regional air transport, especially with "hub-by-pass" flights", but a clear majority think, "it will not be relevant in terms of air traffic volume relief at major airports". A "better" distribution of air passenger transport demand among airports by the expected development of regional air transport, if better stands for relieving congested airports, is according to the expert majority not lying ahead.

Lille and Antwerpen may be defined as agglomerations. However, their ***airports are clearly regional*** as air traffic volume growth rate has been impressive, but total per annum is not exceeding 1 mio. air passengers (Lille may be regarded as medium-sized from the airport infrastructure side). Moreover, they are ***both located between the major (hub) airports of Paris-CDG, Brussels-Zaventem and Amsterdam-Schiphol, as well as on the TGV-"Thalys" axis.***

Lille has a regional airport working and is getting quite much more involved in the overlap of the catchment areas of both close major (hub) airports Paris-CDG and Brussels, but (for the time being) has no very close rail station (yet). Whether an airport has to be connected to high-speed rail is "indispensable; it makes sense" to have (non-stop) high-speed rail between airport rail stations. Only HSR stations at airports extend the catchment area of an airport like Lille.

Strong marketing is needed, as well as a strong airline. A regional airport like Lille-Lesquin "has to use its strength: ***proximity" is seen as strength.***

Distribution of air passenger transport demand is given by the context. Flight frequency supply in Paris-CDG gives the business air traveller opportunities & flexibility. Opportunity to choose its airport is a convenient (high-frequency public transport) access.

The Antwerp airport plays the role of a working regional airport, going to be much more involved in the overlap of the catchment areas of two major (hub) airports , especially as access time to the Amsterdam airport will be reduced (significantly) according to present classical trains.

The Antwerp's Chamber of Commerce and Industry is confident that a HSR station in Antwerp-Berchem will be beneficial to the area and to the Antwerp regional airport, extending its catchment area.

Airports will compete between them. The future of regional airports lies in (more) intra-European air services, whereas major airports will have to cope first with overseas traffic. Many regional airports are in grade to offer a 10' check-in deadline time; major airports are not.

Regional airports, like Antwerp, are not dependent on subsidies and have means to provide resources.

There is a felt need on both airports for a better distribution of air passenger demand among airports and that rail stations at airports are beneficial.

- **airport access railway network** (see list attached)

Underground, as well as suburb trains (RER, S-Bahn), are to be mainly considered, while dealing with airport rail access and distribution of air passenger transport demand among ***airports within an agglomeration. Advantages of rail transport*** may be then those of safety, punctuality, high-frequency, cheap fares and relative speed, but ***most probably not those of comfort***, as many airport access rail link are extensions or stops on usual (in rush hours overcrowded) lines of the suburb (underground) network. There are no high-speed link between an agglomeration airport and its city-centre.

Rail access by IC (classical trains), as well as by HSR, are to be considered, while dealing with airport rail access and distribution of air passenger transport demand among airports ***between agglomerations. Advantages of rail transport may be then those which lack to intra-urban rail transport,*** in particular comfort: low noise level, (reserved) seat and other on board services (catering, telecommunications). However, frequency, especially on HSR airport access remains (for the time being) rather low.

The type of airport rail access (local, shuttle service, IC-network, HSR line or network, direct or with interfaces) may have an influence on the customer (air passenger) behaviour.

- **saving effects** (hypothesis 6 results)

When dealing with "better" distribution of air passenger demand among airports, the word "better" should be also related to indirect effects, which are not to be perceived primarily by people as users or operators, but as tax-payers and living part of the society; that are investments, energy consumption and dependency, air pollution and its effects, among other things. These aspects are mainly the topics of chapter 1.4 (hypothesis 6).

4.3.8 Conclusions

First "impressions" from some case studies written as "preliminary results" ***at the stage of the COS-318 Action Interim report*** showed that Hypothesis 12 is probably to be refuted at a first stage, but could be confirmed at a second stage.

As a matter of fact, airport rail access has been supplied first at major (hubs) airports (see listing of airports in Europe with rail links), because investments are justified first there (where the need is expected to be more significant and therefore the financial risk of failing should be minimum). The airport ground access catchment area increases, given access and railway network improvements, while high-speed trains are even able to replace (some) feeder air services at hubs. An additional air traffic concentration will/ is occur(ing).

At a second stage however, major (hubs) airports, dealing with incoming/ outgoing traffic as well as significant (intraline home carrier) transfers, will get real difficulty to allocate new slots (for new comers), as runway systems will probably reach maximum extension because of lack of space, except some exceptions. Regional, medium-sized, under-utilised modern airports could recover (with rail stations) "some ground lost" (to other close airports) from peripheral regions of their natural catchment area and even pick-up traffic from "saturated" airports. This trend could take place at other places.

- **according to outside reports**

Outside reports read do not tackle specifically the issue of distribution (in volume) of air passenger transport demand among airports related to the quality of airport ground access, out of the common road access & car parking supplies.

- **according to the Geneva and Direttissima case studies**

The same evolution took place with "classical" airport rail stations, such as at Zurich-Kloten (put into service in 1980), where the catchment area of the Zurich airport first extended to catch people at the boundaries of the Geneva airport catchment area (Swiss cantons of Neuchâtel and Fribourg for instance).

Since the Geneva airport hat put in 1987 its railway station into service, the Geneva airport authorities are keen to get the "lost air travel consumers" back into the (former) catchment area of the airport.

According to the simulation results on the "Direttissima", ***a (significant) new distribution of air passenger transport demand is taking place as soon as congestion, expressed by delays at the major (hub) airport of Rome (FCO), is occurring***. This new distribution is shown as HSR substituting part of the feeder air service to/from the Rome hub airport, or, within the meaning of hypothesis 12, as a simulated traffic "near-collapse" situation is able to divert by HSR part of air passenger transport demand from Rome to the regional airports of the Florence area.

- **according to the short missions**

Airport experts visited overwhelmingly agree, airport ground access by rail will lead to a new distribution of air passenger transport demand among airports, however and a little bit surprising not within a specific agglomeration.

"Proximity" is quoted as "strength" for medium-sized and regional airports and has been mentioned by visited airport practitioners thrice on their own independently. "Proximity" can be realised by airport ground access time being tight short, therefore by rail access, as (high-speed) rail allows more and more the access time to be reduced or, more interesting, for a specific access time threshold a longer distance, i.e. an extended airport catchment area.

- **according to the "Delphi"-survey**

Airports will be keen to offer new services according to flexibility and market opportunities: this speaks for airport rail connection whenever (economically) feasible!

As almost unanimously stated, railways will lead to a new way of distribution of air passenger transport demand between airports and rail transport suits very well for ground access to airport!

This evolution does not concern air passenger connecting service between two airports, but airport ground access by rail at the origin or destination areas by air, especially from areas where the catchment areas of several (large to medium-sized) airports overlap, even much more due better ground access time by high-speed rail, whereas regional airports (outside agglomeration) are not set to be involved; there, a development by "hub-by-pass" flights, relieving congestion at large airports, is expected.

The attractiveness of further (medium-sized) airports getting their own rail access will improve compared the large airports whenever more people have a choice, opening a new way of distribution of air passenger transport demand among airports.

The contributors to the Action COST 318 understand a "better", more wishful distribution by decentralisation of the air transport demand, with less airport congestion and more opportunities for the users, and, last but not least, more economic activities for the European regions.

- **A new way of distribution could be a better distribution**

Rail stations are (about to be) provided at large (hub) airports. Extending the airport catchment area, ground access by rail is enhancing air traffic concentration (at some few airports). This development appears for the present free market players to make sense (to be "better")[102].

"First impressions" expressed in the Interim report are confirmed. There are still no (meaningful) air passenger transport demand flows back to medium-sized (or regional airports), non-lasting events excepted showing anyway that it is possible. That is why, ***hypothesis 12 has to be refuted in the present stage***, if "better" stands for diverting a part of the air transport demand from a congested (hub) airport, thanks a rail station at an under-utilised (medium-sized) airport.

However, due to the (new) context coming up[103], at the latest when airport traffic congestion (whatever the causes) and its consequences give no other choice, a new way of distribution of air passenger transport demand among "not only large (hub) airports" may lie ahead, as the (new) context's constraints cited[(39)] at large (hub) airports may very well have to be relieved by (part-) decentralisation of the activities towards (under-utilised) airports. Then, ***in a second stage hypothesis 12 is to be confirmed.***

102 For cost-cutting purposes of major (former state-owned) airlines "hubbing" mostly at their home base and because, according to the experts, "it is correct to state, that more concentration gives an airport the opportunity to be more cost-effective and profitable".

103 EU-liberalization in air transport, airport management self-conciousness, fierce competition (between airports), cost-cutting constraints, hubbing of major european airlines (at their home base), airport catchment area extension by existing (high-speed) rail access at most of the major european airports, lead to air traffic congestion, whereas a number of other (medium-sized) airports are underutilized. Once, saturation and fading trust (repeated delays) in air transport could emerge. Moreover, most of the European airports cann't be extended (close urbanization, noise and air pollution concerns).

It is hard to see, according to all the expert opinions expressed, why a new distribution of air transport demand among airports by airport rail access should not take place in a second stage, as airport ground access time by rail makes "proximity" extended and achievable, to new areas and for not only a single airport, provided that it is feasible. In this regard, as one expert mentioned, extension of the catchment area of an airport means, more communities could be committed when taking advantage of airport infrastructures.

A new way of distribution will then mean better distribution by airport choice, traffic congestion (delays, costs) and spot environment impact relieves, better use of existing (medium-sized airport) infrastructures, flexibility, more competition, better chances for the regions, regional economy improvement (decentralisation).

We will then have in fact extended the move from an airport concept with direct (high-speed) rail network access to a (high-speed) rail network concept with direct airport „network" access.

4.4 The Impact of Rail Stations at Airports on the Public Transport Balance of Accounts

At a time where deficits in the society are much more under scrutiny than in the past, due to trade liberalisation, globalisation, competition, all this associated with privatisation (of state-owned public transport companies), it should be shown, to what extent rail stations at airports contributing to an integration of rail and air passenger transports, whether:

rail stations at airports have
an important impact
on the public transport balance of accounts
(hypothesis 13)

Existing railway stations at airports may account for a high volume of passenger traffic; railway companies operating at the airport are expected as beneficiaries, but not necessarily other (public) transport companies, nor other activities related to airport (ground) access, which will be challenged.

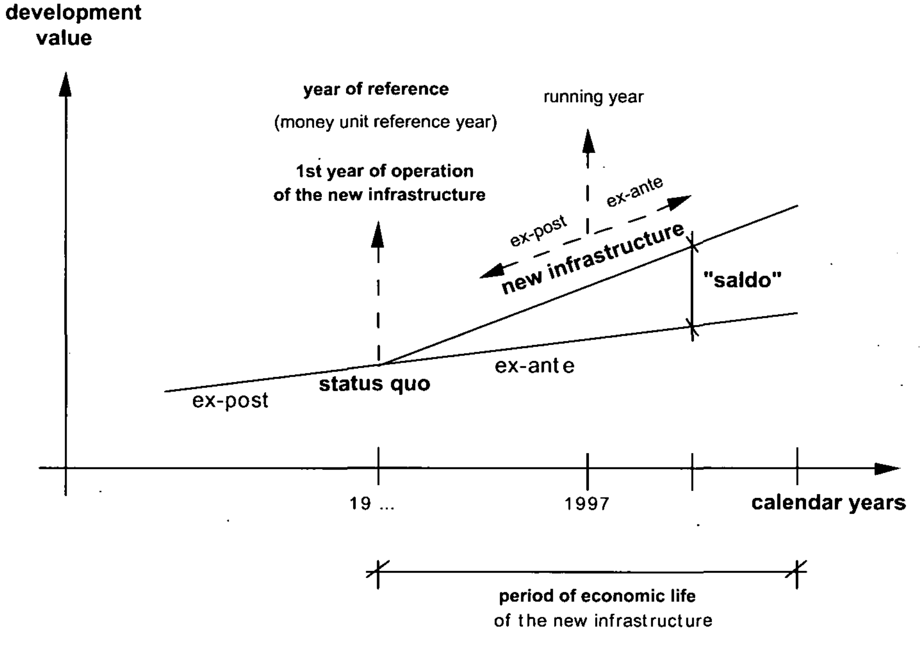
Involved are also the general public, as taxpayers and beneficiaries (of transport improvements & environment impact relieves) of the new infrastructure.

The study is limited to airport ground access. The welcome-if-feasible substitution effect of rail on air feeder services is not taken into account in the calculations.

4.4.1 Practical Dealing Process of Hypothesis 13

The assumption (to be confirmed or refuted) suggests that, beyond the development of an integrated system of public transport, there is an important improvement of the public transport balance of accounts and therefore relief for the tax-payers.

The cost-benefit analysis is a useful tool to evaluate transport projects, in our case airport rail access infrastructure. The notion of cost-benefit analysis implies that costs and benefits of an analysed subject will be put into comparison (see explaining graph[104] hereafter & flowchart attached in Annex 36):



[104] Each position of the costs or revenues is valuated as a saldo (a difference value) between the situation with the new infrastructure operating on the one side, and the "status quo ex-ante" on the other side, that is the situation which would have prevailed if the new infrastructure had not been built. That means, the saldo value makes sense. An example to a development value: if the new infrastructure works well, taxi earnings (as well as taxi costs) are expected to fall compared to the situation which would have prevailed if the new infrastructure had not been built.

Costs and benefits of an analysed subject put into comparison each year within the period of economic life of the new infrastructure (as well as during the construction period) will be discounted (or uprated) according to a rate, which normally applies for public works, and expressed in monetary units of a year of reference set for the analysis. The final result as capital value is the addition of the positive or negative "mainpart saldi" as follows:

- **investments:**
  - investment ***costs*** by calendar year ***of construction***;
  - ***and costs by element*** of the new infrastructure in order to assess the period of economic life time (by the cost share weighted average of the renewal period set for each infrastructure element type;
- **operators' surplus (or shortfall):**
  - ***investment costs*** before and ***(cost savings)*** within the period of economic lifetime of the new infrastructure;
  - ***operating costs*** before and ***(cost savings)*** within the period of economic lifetime of the new infrastructure;
  - ***revenues*** before and ***(revenue shortfalls)*** within the period of economic lifetime of the new infrastructure;
  - ***energy tax shortfalls***;
- **users' surplus:** (supported by a special programme)
  - ***users' O-D distribution*** by mean of airport ground access, traffic volumes and travel time;
  - ***time savings*** due to the new infrastructure;
  - ***conversion of time savings in money values***; necessity of having travel purpose shares (professional/ non-professional); for air passengers and non-passengers (employees, visitors, accompanying persons);
  - ***transport cost savings***;
- **external effects (cost savings):**
  - ***noise***;
  - ***air pollution***;
  - ***accidents***;
  - others (hard to express in money value);
- **socio-economic data:**
  - (socio-economic) ***discount rate***;
  - ***inflation***;

The cost-benefit analysis includes both the socio-economic costs and benefits of the project when national economy is considered. It determines whether the construction of a new infrastructure produced (or is about to produce) gains or losses for society, that is, whether the new infrastructure was (is) worth being constructed. When considering with corporate economy the influence on public transport (accounts), only parts of the analysis are required.

4.4.2 Case Studies

Given the European background of COST Actions and therefore the opportunity to get data much more easily by involving the help of COST members, the following case studies[105] have been carried out:

- Brussels
- Frankfurt
- Geneva
- Stuttgart
- Paris (CDG2 & Orly)
- Zurich

According to the aims cited, results of the airport rail access case studies are structured in 3 batches in progress

- Investment costs;
- Revenue & cost saldi of rail operations;
- ***Effects on rail transport*** (operator);

- Revenue & cost saldi of other airport access operations;
- ***Effects on public transport*** (operators);

- Users benefits;
- Avoided external effects;
- ***Effects on national economy***;

Results of the Cost-Benefit-Analysis Zurich (ZRH) [42]

The new built (most underground) 6 km rail link from Zurich-Oerlikon to Winterthur via Zurich airport was put into operation in 1980 with local and Intercity train connections. The Swissair bus between the city main rail station and the airport was then put out of service. The Zurich airport rail station, with about 7 mio passengers a year, now ranks 8th among the Swiss Federal Railways in terms of revenues and traffic volumes and offers 185 train departures a day, covering most of the Swiss Federal Railways network.

105 According to the document "Optimising rail/air intermodality in Europe" by Colin/Buchanan and partners, on behalf of the European Comission DG VII, it seems that few quantitative approaches have been carried out up-to-now.

Fields	Discount rate 4%	Discount rate 5%	Discount rate 6%
Investment costs	-452.44	-470.59	-489.47
Saldo revenues - costs rail	969.34	754.12	592.66
Effects on rail transport	**516.90**	**283.53**	**103.19**
Saldo revenues - costs (other operators)	-670.02	-541.41	-442.58
Effects on public transport	**-153.12**	**-257.88**	**-339.39**
Users' benefit	925.42	741.63	603.27
Avoided external effects	84.58	67.96	55.43
Effects on national economy	**856.88**	**551.71**	**319.31**

Table 22 ZRH rail access capital value (in million CHF of 1980)

Comments

Discount rates of 4 to 6% taken into account in the calculations are usual in Switzerland for public work investments. Considering rail operation results and investment costs, the results remain positive anyway. The outcome for public transport (including taxi-cab rides and parking fees) is negative, due to the shift from other modes, as their costs remain the same or fall less than earnings. Users' benefit (from time and ticket price savings) is quite strong; external effects (noise, air pollution and accident avoidance), in phase with the advantages of rail transport, make their positive contribution. Capital value in socio-economic terms related to the period of economic life of the new infrastructure is quite positive.

Results of the Cost-Benefit-Analysis Geneva (GVA) [43]

The new built 2.5 km and the upgraded 3.5 km of the 6 km long rail link from the Geneva main station to the Geneva-Cointrin airport were under construction between 1982 and 1987 and put into service in 1987 with Intercity trains. The Swissair/PTT bus link between the Geneva main rail station and the airport, as well as a bus link from the airport to the city of Lausanne, were then cancelled.

Fields	Discount rate 4%	Discount rate 5%	Discount rate 6%
Investment costs	-326.20	-333.80	-341.60
Saldo revenues - costs rail	490.91	396028	323.61
Effects on rail transport	**164.71**	**62.48**	**-17.99**
Saldo revenues - costs (other operators)	-465.31	-388.08	-328.01
Effects on public transport	**-300.60**	**-325.60**	**-346.00**
Users' benefit	345.00	286.90	241.80
Avoided external effects	35.90	31.20	27.50
Effects on national economy	**80.30**	**-7.50**	**-76.70**

Table 23 GVA rail access capital value (in million CHF of 1987)

Comments

Discount rates of 4 to 6% taken into account in the calculations are usual in Switzerland for public work investments. Considering rail operation results and investment costs, the results are rather positive. The outcome for public transport (including taxi-cab rides and parking fees) is quite negative, due to the shift from other modes still existing, as their costs remain the same or fall less than earnings. Users' benefit (from time and ticket price savings) is quite strong; external effects (noise, air pollution and accident avoidance) are in phase the advantages of rail transport and make a positive contribution. Capital value in socio-economic terms related to the period of economic life of the new infrastructure is balanced regarding the discount rates applied.

Results of the Cost-Benefit-Analysis Frankfurt (FRA) [44]

The new built 6 km track of the 11 km long rail link to the Frankfurt airport was under construction between 1969 and 1972 and put into operation in 1972 with a local train connection and was extended to Intercity operation in 1985. The express bus link between Frankfurt city and the airport was then cancelled. The throughgoing rail link connects Frankfurt with Wiesbaden and Mayence; between Frankfurt main station and Frankfurt airport there are 176 trains per day in the average.

Fields	Discount rate 4%	Discount rate 5%	Discount rate 6%
Investment costs	-115.90	-117.66	-119.45
Saldo revenues - costs rail	125.77	92.97	69.28
Effects on rail transport	**9.87**	**-24.70**	**-50.17**
Saldo revenues - costs (other operators)	-266.09	-214.13	-175.06
Effects on public transport	**-256.22**	**-238.83**	**-225.23**
Users' benefit	829.70	667.51	545.72
Avoided external effects	58.56	48.78	41.25
Effects on national economy	**632.04**	**477.46**	**361.74**

Table 24 FRA rail access capital value (in million DM of 1972)

Comments

At a discount rate of 3% usual in Germany for public work investments, the results considering rail operation and investment costs would be slightly positive (and may be explained (partly) by the fact, that airport access in Frankfurt had long no direct nation-wide rail access at the airport, but a S-Bahn direct access only). The out-come for public transport (including taxi-cab rides and parking fees) is negative, due to the shift from other modes, as their costs remain the same or fall less than earnings. Users' benefit (from time and ticket price savings) is quite strong; external effects (noise, air pollution and accident avoidances), with the advantages of rail transport, are making their positive contribution. Capital value in socio-economic terms related to the period of economic life of the new infrastructure is quite positive.

Results of the Cost-Benefit-Analysis Stuttgart (STR) [44]

The new built 8 km track of the 20 km long rail link from the Stuttgart main railway station to the airport was under construction between 1983 and 1993 and put into operation in 1993 as a dead-end railway line and as a local train connection. The bus link between Stuttgart city and the airport was then cancelled. As the new built airport rail link connects also the suburbs with the city of Stuttgart, an incorporation of full infrastructure costs and part of them have been considered separately (see Tab. 25 and 26).

Fields	Discount rate 4%	Discount rate 5%	Discount rate 6%
Investment costs	-449.65	-474.10	-500.00
Saldo revenues - costs rail	12.33	8.43	5.48
Effects on rail transport	**-437.33**	**-465.67**	**-494.51**
Saldo revenues - costs (other operators)	-108.88	-92.69	-80.02
Effects on public transport	**-546.21**	**-558.36**	**-574.53**
Users' benefit	228.02	194.81	168.73
Avoided external effects	34.09	29.65	26.15
Effects on national economy	**-284.10**	**-333.90**	**-379.65**

Table 25 STR rail access capital value, full infrastructure costs incorporated (in million DM of 1993)

Comments

At any discount rate above 3%, the latter usual in Germany for public work investments, the results of rail operation and full investment costs would be quite negative and worse for public transport (including taxi-cab rides and parking fees), due to the shift from other modes, as their costs remain the same or fall less than earnings; this according to an airport link with full assignment of the infrastructure costs (Tab. 26). Considering infrastructure part-costs only (the new rail airport link is also providing rail access to the city centre for suburbs on the line), the results are still negative. Users' benefit (from time and ticket price savings) is positive, but with external effects (noise, air pollution and accident avoidance), the advantages of rail transport making their positive contribution, not enough to overturn the socio-economic results (as far as aspects, which may be set in money units are considered).

Fields	Discount rate 4%	Discount rate 5%	Discount rate 6%
Investment costs	-210.82	-222.28	-234.42
Saldo revenues - costs rail	12.33	8.43	5.48
Effects on rail transport	**-198.49**	**-213.85**	**-228.94**
Saldo revenues - costs (other operators)	-108.88	-92.69	-80.02
Effects on public transport	**-307.37**	**-306.54**	**-308.96**
Users' benefit	228.02	194.81	168.73
Avoided external effects	34.09	29.65	26.15
Effects on national economy	**-45.26**	**-82.09**	**-114.08**

Table 26 STR rail access capital value, infrastructure costs partly incorporated (in million DM of 1993)

Results of the Cost-Benefit-Analysis Brussels (BRU) [45]

The new built 3 km dead-end track of the 18 km long rail link from the Brussels main railway station to the airport was put into operation in 1955. From the beginning of the World Exhibition in 1958, the train service was fully operating as a shuttle service. Until 1960, the existing bus link to the airport was operated parallel to the railway service from the city-centre rail stations. In the first years, the link from the central station to the airport was operated three times an hour, with a bus service in the late evening; later on and until last year twice an hour; the frequency now is once again trice an hour.

Fields	Discount rate 4%	Discount rate 5%	Discount rate 6%
Investment costs	-176.69	-180.07	-183.52
Saldo revenues - costs rail	215.26	235.88	249.77
Effects on rail transport	**-391.95**	**-415.95**	**-433.29**
Saldo revenues - costs (other operators)	-17.00	33.61	72.22
Effects on public transport	**-408.95**	**-382.34**	**-362.09**
Users' benefit	51.33	40.69	32.78
Avoided external effects	31.13	24.93	20.27
Effects on national economy	**-326.49**	**-316.72**	**-309.04**

Table 27 : BRU rail access capital value (in million BEF of 1955)

Comments

At any discount rate, the operation results of the existing, old rail shuttle service between the airport and the main rail station is quite negative, based on data from the old document "Etude de la liaison ferroviaire entre l'aéroport de Bruxelles et le Centre de la Ville" by UIC, Union Internationale des Chemins de fer, and EARB, European Airlines Research Bureau, and of which the Belgian delegation stressed having no means to verify the underpinned hypotheses and data in the 50s and early 60s, that are over the construction period and during the first years of operation. However, estimates of order of magnitude by SNCB have shown, that values displayed may be plausible. The results are not worse or even better for public transport (including taxi-cab rides and parking fees), as the shift from other modes to rail did not really take place. Users' benefit (from time and ticket price savings) is positive, but very low compared to other case study results. External effects (noise, air pollution and accident avoidance), the advantages of rail transport making a modest positive contribution. Consequently, socio-economic results (as far as aspects, which may be set in money units are considered), are negative. The poor cost-benefit results are to be explained as follows:

- the airport rail access was put into service at a time period as air transport was not yet a mass transport, but generally used by few (wealthy) passengers; compared to those of bus service, rail operating costs were high with regard to low passenger traffic demand;

- as the existing rail service is a (two-trains-per-hour) shuttle to the city-centre, time savings (as users' surplus) by rail, including change and waiting time while connecting in the city-centre, are not significant compared to other modes;

- produced rail revenues were/are (very) low, too low to challenge the costs of airport rail access.

The new Brussels airport rail access concept (see Annex 34 to Chapter 4.3) to be put into service progressively as of 1998, will offer for users not only time savings and attractive fares, but direct links to the cities of Liège (and Cologne), as well as of Antwerp (and Rotterdam). It will also supply meaningful operating advantages and flexibility of rail system in the Brussels area.

Results of the Cost-Benefit-Analysis Paris (CDG2) [46]

The Charles de Gaulle (CDG) airport is situated in Roissy, 26km North-East of Paris, and is characterised by terminals 1 & 2, the latter being in phase of extension.

The CDG airport is connected by the motorway A1 Paris-Lille (and beyond) to the long-distance road network, as well as to Paris.

From the city-centre of Paris directly to CDG there are two Air France coach lines, which are quoted as quite comfortable, and as well as a bus line operated by RATP as "Roissybus".

Besides, a RER-link ("B" line underground trough the city of Paris) exists; it terminated between the terminals 1 & 2 before the new rail station (called "CDG2") under airport terminal 2 (and its extension) was built. At that time, the passengers could use a bus-shuttle service between the (former) RER station (now called "CDG1") and airport terminal 2.

The new rail station at terminal 2 (CDG2) is situated on the Paris agglomeration by-pass TGV-line linking the TGV "North", "South-East" and "Atlantic" networks, and offers also direct connections with the RER "B" extension. The bus-shuttle service from the former RER station to airport terminal 2 has been closed down as a consequence, but it still operates to airport terminal 1.

The RER "B" stretch between the Paris city-centre and the CDG airport is consequently divided in an "old" part to Roissy "CDG1", and since November 1994 a "new" part between Roissy "CDG1" & "CDG2", which is 4km long and double-tracked. The RER trains operate about every 8 minutes.

The TGV at CDG2 started to operate in November 1994 with 9 pairs of through-going high-speed trains, and since June 1996 (TGV "Atlantic" connection starting) with 18 pairs of trains on a workable day, underlining an increasing tendency.

This cost-benefit analysis is limited to those rail passengers having the airport as rail destination or origin.

Fields	Discount rate 4%	Discount rate 5%	Discount rate 6%	Discount rate 8%
Investment costs	-2043.50	-2074.20	-2105.20	-2168.30
Saldo revenues - costs rail	2817.37	2367.98	2017.17	1517.87
Effects on rail transport	**773.87**	**293.78**	**-88.03**	**-650.43**
Saldo revenues - costs (other operators)	-1257.69	-1056.25	-898.98	-675.17
Effects on public transport	**-483.82**	**-762.47**	**-987.01**	**-1325.60**
Users' benefit	1839.15	1537.09	1301.60	967.19
Avoided external effects	529.97	453.47	393.39	306.99
Effects on national economy	**1885.30**	**1228.09**	**707.98**	**-51.42**

Table 28: CDG2 rail access capital value (in million FF of 1994)

Comments

At any discount rate under 8%, the latter usual in France for infrastructure projects, the positive results of rail operation are quite impressive, as the new rail station is situated on an existing TGV by-pass line connecting all the TGV (long-distance rail) networks. The results for public transport as a whole are still positive. ***No shift*** towards RER is expected to have occurred ***from other public transports***, considering that existing coach lines to the city-centre are quoted as quite comfortable: shifts to rail access have been set to come from cars. Earning shortfalls have been considered from taxi-cab operations and from (airport) car parking fees. Before the CDG2 rail station was in service, travellers by (high-speed) rail had to change at one of the Paris downtown stations and take the (underground and) RER or a taxi-cab to the CDG airport. That is why ***users' benefits (from time and ticket price savings) are high***, reflecting savings magnitude in the long-distance rail transport. External effects (noise, air pollution and accident avoidance), as expected from the advantages of rail transport, are making their positive contribution. No "structuring effects" and resulting prospects of boosting traffic volumes and activities in the future could be taken into account.

Results of the Cost-Benefit-Analysis Paris (ORY) [46]

The Orly (ORY) airport is situated 14km South of Paris and has characterised by two terminals "South" and "West". The airport is under an aircraft movement limitation rule, which affects its evolution.

The ORY airport is connected by the motorway A6 Paris-Lyon (and beyond) to the long-distance road network, as well as to Paris.

From the city-centre of Paris directly to CDG there is an Air France coach line, which is quoted as quite comfortable, and as well as a bus line operated by RATP as "Orlybus".

Besides, the RER "C" line is connected as "Orlyrail" with a bus-shuttle service.

The new rail infrastructure operating since October 1991 is "ORLY-VAL", an automatic rail (VAL-) system (like that operating as public (underground) transport system in the cities of Lille and Toulouse) linking both airport terminals to the RER "B" station of Antony. The double track is 7.3 km long and the double-cab trains operate about every 8 minutes.

The economic duration of life of this "non-conventional" has been set as between 15-20 years; this uncertainty however does not affect the results very much.

Fields	Discount rate 4%	Discount rate 5%	Discount rate 6%	Discount rate 8%
Investment costs	-1243.30	-1249.50	-1255.60	-1268.00
Saldo revenues - costs rail	106.26	92.66	80.51	59.90
Effects on rail transport	**-1137.04**	**-1156.84**	**-1175.09**	**-1208.10**
Saldo revenues - costs (other operators)	-309.56	-287.78	-268.8	-235.67
Effects on public transport	**-1446.60**	**-1444.62**	**-1443.89**	**-1443.77**
Users' benefit	-372.95	-347.69	-324.91	-285.71
Avoided external effects	143.26	134.42	126.42	112.54
Effects on national economy	**-1676.29**	**-1657.89**	**-1642.38**	**-1616.94**

Table 29: ORY rail access capital value (in million FF of 1991)

Comments

At any discount rate under 8%, the latter usual in France for infrastructure projects, in the case of VAL d'Orly, the results (as "calculable") are negative, except for rail operations and, of course, for external effects. This may be according to the specificity of the non-conventional rail system, such as reduced volume supply in size (with scarce luggage space) and in transport capacity and to its operating features (high fare level with no season ticket admittance). The airport rail link with Paris occurs with change at a RER-station, with no significant travel time advantage expected compared to other modes of transport; moreover, the (direct) coach & bus links (by Air France and RATP) are quoted comfortable enough, so that particular conditions only, such as ***punctuality (road traffic jam avoidance)*** stated as the prime advantage of VAL d'Orly, may be of meaningful value when choosing this connection. This advantage ***is however not included in the calculation***, although a factor of "convenience", set by the operating company RATP at 27 FF a trip, should incorporate "all the non-quantifiable reasons for choosing VAL d'Orly". In this case, users' benefit should be positive, as having a still negative result in this respect would mean users make the wrong choice, which is not plausible.

Avoiding car parking space extension thanks to VAL d'Orly operations has, for the time being, not been estimated.

Case study result synthesis

	ZRH	GVA	STR	FRA	BRU	CDG	ORY
Investment costs	-	-	-	-	-	-	-
Revenue & cost saldi of rail operations	+	+	+	+	-	+	+
Effects on rail transport (operator)	+	+	-	+/-	-	+/-	-
Rev. & cost saldi of other airport access operators	-	-	-	-	+	-	-
Effects on public transport (operators)	-	-	-	-	-	-	-
Users benefits	+	+	+	+	+	+	-
Avoided external effects	+	+	+	+	+	+	+
Effects on national economy	+	+/-	-	+	-	+	-

Taking into account the discount rate applied (4 to 6%[106]) conclusion steps from the general to the particular outlook are:

- ***overall results*** (capital value in terms of national economy) ***are mixed***: major (hub, national airline home base) airports show up a positive overall results, except BRU & ORY for particular reasons, whereas medium-sized airports results are balanced or negative;
- the obvious expectation that ***rail network access at the airport*** (ZRH, GVA,FRA,CDG) *performs better than airport rail stations with only shuttle service* to the city or the next public transport station (STR, BRU, ORY) is confirmed, even if the rail terminal in the city centre is a main rail station.
- ***avoided external effects*** (noise, air pollution, accidents) have ***thorough positive*** contributions in phase with the advantages of rail;
- ***users' benefits***, as far as those set in money value are considered (time & travel expense reductions), are positive, except for ORY;
- ***effects of airport access on other public transport*** activities show negative values; the reason being in particular when other public transport modes loose traffic demand (earnings) to rail without saving costs (on a same supply);

106 In the Paris case study 8% as usual discount rate for infrastructure projects in France.

- effects on ***rail transport*** show ***positive*** values ***as far as operating results are concerned,*** except in the BRU case for particular reasons. Investment costs of the new infrastructure included, they show positive results comparing the TGV rail station in Paris-CDG & the Swiss cases; they are balanced in the FRA case. A (much) contributing factor is of course when, like often in Europe, a rail (network) operation close to the airport exists.
- ***the Brussels case is a specific one***, as the existing airport rail access was the first on the European continent[107] and the period of economic life of the existing rail access infrastructure is coming up to an end. A new concept is coming up;
- ***the ORLY airport case is another specific one***: rail access is operating according to a „non-conventional" rail system

Summing up 7 case study results of airport rail access in Europe (Belgium; France; Germany; Switzerland) with a large spectrum of operating system backgrounds, that are city-centre to airport shuttle, (through-going) suburb and IC railway network, and even HSR network access at the airport, as well as of technologies (classical train, HSR, non-conventional system like VAL):

- ***the effects on national economy taking into account the investment costs and on the railways are positive for major (hub) airports***, except for particular reasons (BRU & ORY), ***and balanced or negative for the analysed medium-sized airports***.
- the results show not only the impact of airport size, but also that of the distance in airport access by rail, as users' benefit in time and ticket savings has a significant role.
- the effects on public transport as a whole (all public transport companies at the airport, including taxi and parking operators) is negative.

[107] The very first underground station Berlin-Tempelhof excepted.

5. COMPREHENSIVE DESCRIPTION OF RESULTS

5.1 Adjustment between Supply and Demand

The first element to recognise is that, as usual for „new technologies", the question of adjustment between supply and demand for high speed transport has to be addressed in a dynamic way. This is not only relevant for high speed train because of the significant proportion of creation of traffic that has occurred in most cases as compared with the situation ex ante. This is also true for the development of air transport considered apart, the progressive extension of the network, increase in frequencies and reduction of fares having generated new needs that couldn't be satisfied before. Considering that perspective, high speed rail is nothing more than a step, although a quite substantial one, in the life cycle of the product „high speed", which may approach the turn from initial diffusion to maturity growth.

Addressing the problem that way allows to formulate as a first element of answer that the success of the high speed system, illustrated by a steady rhythm of growth even in a context of global economic stagnation, is the best evidence that supply is meeting demand continuously better. The real question becomes thus to know whether a better allocation of the resources on the supply side could be reached, and in particular whether there is at present an optimal balance and articulation between the air and high speed rail system.

A first contribution, and a positive one, to this question lies in the recognition that both the substantial transfer of air passenger and the global increase of the market on corridors where HSR is introduced suggest that the introduction of a new mode improves the attractiveness of the whole system. This is all the more true as the cut in the air market share most often do not prevent this mode from a further growth on the O-D concerned. This means more or less that a reallocation has been produced to the benefit of consumers, the magnitude of the modal shift being likely to vary between relations served according to such factors as the time of travel by high speed rail (with a maximum around two hours), the respective accessibility of air and rail terminals, the potential of high speed users dwelling closer from an airport than from a HSR station, the respective structure of fares in relation to the purpose of trip of travellers, and the frequencies offered on both modes.

This last criteria introduces to an additional dimension of complexity of the problem. Indeed, the frequencies are not determined only according to the potential of the market between the origin and the destination considered. The main reason for that is, on the air side, that it can be important to maintain a relation as a feeder service to a major hub, even with times of departure/arrival that do not fit the need of travellers from origin to destination, and, on the rail side, that other destinations on the line may be more important and allow for the profitability of the service. This means that, more generally, optimisation of supply and demand on a specific O-D cannot be appreciated independently of the structure of the network, taking into consideration the other stops and links that may have an influence.

Although it is granted that a better adjustment to the consumers needs will be produced by a new high-speed project; it is therefore not so easy to forecast to which new split between competing modes it will lead, considering the number of parameters to introduce, not all of them being mentioned above. Indeed, the models applied in different European countries lead to rather different estimates of the diversion and induction of traffic, without making easy to understand whether the gaps between them are the consequence of the content of the projects themselves, of different methods of surveys used for the calibration of the model, of different values of the parameters, of different structures of the models or of different behaviours of the populations concerned. The assessment is all the more difficult as very few before and after studies exist that could be used to check the predictive capability of the model. There is clearly here a matter for further investigation, on the basis of the elements already gathered within the action.

But would the reallocation of demand be estimated with a great accuracy, it would not guarantee a better adjustment between supply and demand is produced as a consequence. The fact is that considering up to now the extension of the high speed rail network, the destinations served are minor part of the traffic of the airport for the biggest of the two cities linked, so that the diversion of traffic from air to rail can only release the airport congestion, if any, by a small percentage. In addition, when the high speed rail link would allow for a transfer of the air traffic to a less congested airport, it seems that in most cases no significant effect arise, or even a reverse effect, the biggest airport reinforcing its attractiveness based on better frequencies thanks to the high speed rail link.

Of course, the situation analysed within the action mainly concern direct links between cities, and not between cities and airports, where different behaviour could be found. The hypothesis of a high speed network providing good connections at airports between high speed rail and air offers a much higher opportunity for adjustment between supply and demand, by introducing the possibility of a real complementary. It would certainly be highly profitable to simulate the impact of scenarios established according to this hypothesis, with such underlying questions as the possible level of fare integration between air and rail operators, according to the kind of parameters proposed in the report.

5.2 Level of Services

Concerning the types of services and the level of services which the travellers appreciate and demand for, they are to some extent depending on the mode in view. And it also depends on if you are travelling as a private person or in business missions.

Generally as a business traveller the common most important factors are the time related factors as travel time (speed), frequency and time schedule. Very decisive for the modal choice is mostly the distance and thereby the actual travel time. Hourly departures, and in peak time maybe even more than that, are what most of the business travellers are expecting for main connections. ***As a private person you often give higher priority to the ticket price.*** For business trips, your company i.a., will pay for your expenses. And of course you have your mission to fulfil and the differences in prices are of lesser importance than other factors in this respect, which will affect your work. Sometimes you have no choice either. Comfort and possibilities to work during trips are such important factors which business travellers appreciate more and more.

Looking at the supply of services at HSR and air, there are two different aspects one can have in mind. The first to appear perhaps is the competition relations between the modes. ***If HSR wants to compete in a successful way the rail system must give at least comparable services of the same sort as air offer.*** Concerning other area of services, where the train has advantages, the rail system has to exploit them even more. It is the case when it comes to offer travellers better space than air for instance, to be used for seat comfort, moving around, calling, working possibilities onboard etc.

On the other hand when it comes to factors where HSR is worse as compared to air, the mode must work hard to achieve a better position. That is especially valid for travel time, for instance. But there is a couple of other factors too, maybe of somewhat lesser importance, that yet belongs to the overall opinion of the airs good service.

For the air system the general strategy to improve its competition, must be in principle, the other way round compared to what was pointed out for HSR.

The other aspect concern the concept considering the two separate modes as complements creating one effective transport system, with the best travelling opportunities for the travellers as the leading thought. To this concept naturally belongs the overall view in creating a better co-ordination between the two systems. Some first steps we already can registrate when it comes to the connection of rail (HSR) and air at the airports. An other initiative refer to different plans to release capacity at crowded airports and in the starting and landing corridors by substituting shorter flights by HSR.

In these cases there are necessary to offer general services on both co-operating modes which do not differ too much in the levels of quality. Otherwise the system will not function as an "unitary transport system", seen especially from the travellers point of view.

If we look closer to the co-ordination thoughts of course it requires a lot of adaptations between the HSR system and air system. It concerns check in routines, ticket handling, price strategies, luggage handling, time schedules and many other factors.

An over all better co-ordination between the two systems must be of great advantage, not only for the travellers which it must be meant for, but also for the general public, thereby all the tax payers concerned. And of course a co-ordination will strengthen the two modes competition power in relation to other modes too.

5.3 Socio-economic Profitability

It seems from what has been studied in the action that the introduction of high speed rail can result for sure in an increase of socio-economic profitability for such factors as energy consumption and air pollution, whereas for other aspects like noise emissions or time savings the result is more dependent on the specific conditions of the O-D considered such as the distance or the location of the neighbouring population.

Reversibly, it looks as if the flexibility of air transport allows for important savings of investment costs as compared with high speed rail, although it is not easy matter upon which to conclude. On the one hand, the possibility to use air transport on O-D, not justifying a high speed link on the basis of the rate of socio-economic profitability, may be dependent in a context of growing congestion at airports on the ability to organise the air services in such a way as to develop supply in regional medium-size airports. On the other hand, a link that could be considered as non profitable by high speed rail, could become profitable if associated with other destinations along a corridor.

As a consequence, it seems advisable to establish comparative analysis of socio-economic profitability of high speed rail and air services at the scale of a corridor or of a network of independent origins and destinations, rather than at the level of a specific O-D. It will anyway consist in a difficult exercise, for at least two reasons:

- some important parameters are difficult to evaluate in physical and moreover monetary terms, such as the real impact of air pollution on health, or the noise disturbance to neighbouring populations,

- the impact of further technology progress is uneasy to forecast, although it may be determinant of the magnitude of some impacts and consequently alter substantially the result of the comparison.

Considering the example of HSR at airport rail stations, there is clearly a socio-economic profitability shown by the case study on Paris-CDG2 (see Chapter 4.4), as the users' benefit contribution on long-distance access to the airport provides significant time savings, as well as in this particular case, travel ticket savings compared to the status quo expost of TGV arrivals in the city of Paris (and further airport access expenses with underground and RER or taxi-cab transport). Moreover, investment and operating costs for CDG2 are at the lowest, as the Paris-CDG2 TGV station is situated on the Paris by-pass TGV line linking all the three TGV operating sectors ("Sud-Est", "Atlantique" & "Nord"). Not included in the analysis are furthermore the use of the CDG2 rail station as additional O-D rail station in the Paris area, connecting to the RER "B" (and the busy locations of the Parc des Expositions, Villepinte and even Le Bourget, without having to go through the city of Paris).

5.4 Rail Stations at Airports

Dealing with rail stations at airports within the Action COST-318 implies the description of theses 11 & 14, as well as confirming or refuting the wording of hypotheses 12 & 13. These issues have been long developed in Chapter 4: "Effects of rail stations at airports".

As mentioned in Chapter 4.1, rail stations at airports are, even without synergy, beneficial to rail and air transport systems taken separately.

Beneficial effects on the rail transport system

Rail access to airports, in Europe mostly very close or even within the urban area, is very often provided from already existing (urban network) rail lines in the airport (close) vicinity. So investment costs are kept relatively low; access can be provided from several directions, thanks to the dense railway network in agglomeration areas.

Advantages of rail compared to road access are to be found in increased traffic volume capabilities without having (necessarily) to supply capacity in addition while improving load factor (with a same supply); then, in the rail (& public transport) network effect and in (long-distance) ticket revenues. Users have the opportunity to take more advantage of their season-cards and rail transport companies to rely more on their customers using their services. This fact is enhanced by the lack of cheap car parking facilities at the airport. Last but not least, there is with (existing) airport rail access (plenty of) airport access capacity reserve (without extension) expected for the future.

Especially by HSR, airport rail access is in grade to act as alternative to feeder air services (of "hub" airports): that is "train use instead of flying", underlining much more the intermodality role: "flight at level zero".

Safety and environment protection issues are best suited by the "image" of rail compared to other modes of transport.

Beneficial effects on the air transport system

With air transport liberalisation going ahead in Europe, airports will be keen to improve as much as they can the services they provide, offering for instance the best ground access opportunities.

As experience shows, (step-by-step) improvement of airport ground access by rail is greeted by the users, as well as at a large scale by airport authorities and even by airlines.

Air transport liberalisation is associated with competition and operations at the lowest costs. It is quite clear, short-haul air services are for airlines expensive to operate. In this regard, hub feeder traffic by rail at airports is seen as beneficial, as it helps to shut down (or at least downscale) not profitable air links, as far as in airlines' mind, this move is not going to be beneficial to their competitors (at other hubs). Major (hubs) airports would welcome less regional aircraft (with low landing fees), as well as more slots to allocate, without loosing connecting passengers, thanks to air/rail intermodality.

Environment protection advantages by rail are also best suited for the "image" of air transport, as it shows that, with inter-modality, air transport takes also care of these aspects.

As mentioned, Chapter 4.2 points out other effects of the well-established advantage (of reliability) of rail transport.

By the choice of rail transport, as soon as the extension of airport facilities facing (rapid) traffic growth is hindered, construction and operating costs of underground infrastructures appear to be lower and the capacity performance better for rail than for private car (long-) parking facilities.

The choice of airport access by rail instead of private car may reduce non-commercial waiting space for passengers at the airport, as time spent (or wasted) in the airport before departure may be managed tighter, due to better knowledge of timetable related airport arrival. This aspect however should not suit business at the airport, which rely on (waiting) time spent by people in the airport for their commercial activities, a significant revenue position in the financial balance of many airports.

As mentioned in Chapter 4.3, rail stations are (about to be) provided at large (hub) airports. Extending the airport catchment area, ground access by rail is enhancing air traffic concentration (at some few airports). This development appears for the present free market players to make sense (to be "better").

"First impressions" expressed in the COST 318 Interim report are confirmed. ***There are still no (meaningful) air passenger transport demand flows back to medium-sized (or regional) airports***, non-lasting events excepted showing anyway that it is possible. ***That is why, hypothesis 12 has to be refuted in the present stage, if "better" stands for diverting a part of the air transport demand from a congested (hub) airport***, thanks a rail station at an under-utilised (medium-sized) airport.

However, due to the (new) context coming up, at the latest ***when airport traffic congestion*** (whatever the causes) and its consequences give no other choice, a new way of distribution of air passenger transport demand among "not only large (hub) airports" may lie ahead, as the (new) context's constraints cited at large (hub) airports ***may very well have to be relieved*** by (part-) decentralisation of the activities towards (under-utilised) airports. Then, ***in a second stage, hypothesis 12 is to be confirmed.*** A new way of distribution will then mean a better distribution by airport choice, by relieves in traffic congestion (delays, costs) and spot environment impact, by a better use of existing (medium-sized airport) infrastructures, flexibility, more competition, better chances for the regions, as regional economy improvements (decentralisation).

We will then have in fact extended the move from an airport concept with direct (high-speed) rail network access to a (high-speed) rail network concept with direct airport "network" access.

Beneficial effects on the public transport balance of accounts

At least, as mentioned in Chapter 4.4, while rail stations at airports are contributing to an integration of rail and air passenger transports and at a time where deficits in the society are much more under scrutiny than in the past, due to the effects of trade liberalisation, globalisation, competition, associated with privatisation (of state-owned public transport companies), there is the issue of (relief in the) public transport balance of accounts.

Existing railway stations at airports may account for a high volume of passenger traffic; railway companies operating at the airport are expected to be beneficiaries, but not necessarily other (public) transport companies, nor other activities related to airport (ground) access, which will be challenged.

Involved are also the general public, as taxpayers and beneficiaries (of transport improvements & environment impact relieves) of the new infrastructure.

The study is limited to airport ground access. The welcome-if-feasible substitution effect of rail on air feeder services is not taken into account in the calculations.

This issue has been dealt using cost-benefit analyses and many case studies of airport rail access within Europe (Brussels, Frankfurt, Geneva, Paris (CDG2 & Orly), Stuttgart and Zurich) taking into account the extremes of rail access at airport, as a direct access in CDG2 to the whole TGV-network and the non-conventional VAL d'Orly system.

According to the aims cited, results of the airport rail access case studies are structured according to 3 batches in progress, reflecting rail transport results (with or without investment costs), public transport results (taxi-cab operators and airport authorities as car parking operators included) and finally the socio-economic outlook (users' benefit and external effects, that are safety as accident avoidance, noise and air pollution avoidance, as far as estimations and results can be quantified and set in money values).

Taking into account the (usual) discount rate applied for public works, ***conclusion*** stepping from the general to the particular ***outlook*** is in general that:

- ***socio-economic*** overall ***results are mixed***:
  - comparing ***major*** (hub, national airline home base) ***airports*** show up a ***positive*** overall result
  - whereas ***medium-sized airports*** results are ***balanced or negative***,
- ***avoided external effects*** (noise, air pollution, accidents) have, as expected, ***thorough positive*** contributions, in phase with the advantages of rail;
- ***users' benefits***, as far as those set in money value are considered (time & travel expense reductions), ***are positive***;
- ***effects on public transport activities as a whole show negative value***, the reason being in particular other public transport modes loosing traffic demand (earnings) to rail without saving costs (same supply);

effects on rail transport show positive values as far as operating results are concerned. Investment costs of the new infrastructure included, they show positive results comparing the TGV rail station in Paris-CDG & the Swiss cases; they are balanced in the FRA case.

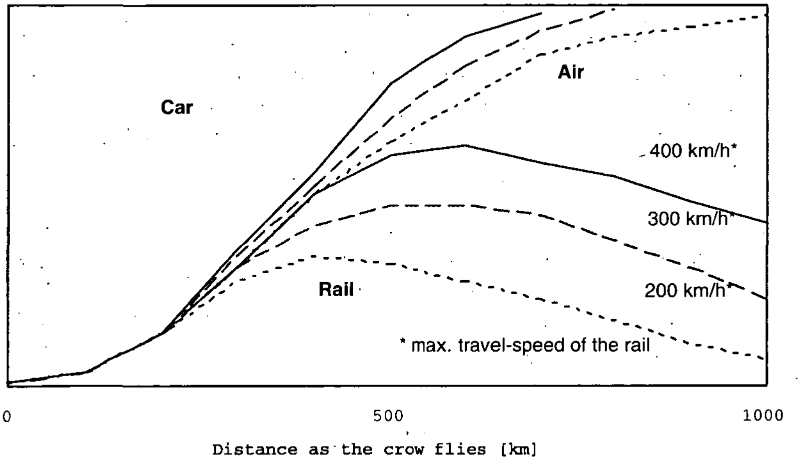
A (much) contributing factor is of course when, like in Europe and so in all the case studies, a rail (network) operation exists close to the airport.

For particular reasons ***the cases of Brussels, Paris-Orly and Paris-CDG2 are (still) specific ones*** (see Chapter 4.4)

5.5 Balance of the Transport System

As a general result can be emphasised that the area of influence of road, rail and air transport will alter significantly if HSR are realised for all connections with high traffic load. Best effects result if both HSR and APT-networks are connected by efficient railway stations at all important airports.

While travel distance of more than 400 km are declining for conventional railways, for HSR this only applies for travel distances of 600-700 km. But APT will still predominate in the future for longer travel distances.



Source: Model by DLR (Deutsche Forschungsanstalt für Luft- und Raumfahrt)

Figure 33: General Influence of Speed on Modal Split for Road, Air and Railway

A consequence of this shift at the area of influence is, that air traffic is reduced for certain relations up 50% if HSR connections provide an outstanding alternative. But also with a fully accomplished HSR network in Europe of about 30.000 km the medium air transport reduction in modal split will probably not exceed 15-20%.

There are also important effects on the reduction of environmental damage (especially on air quality and reduction of congestion at the airports).

The consequence of all these modifications is a new and more sustainable balance of long distance trip distribution between road, rail and air transport.

6. FORMULATION OF FINAL THESES AND HYPOTHESES

In this chapter for each thesis and hypothesis the final result and formulation is presented.

6.1 Conclusion for each Hypothesis

Hyp. 2 High speed rail (HSR) transport is enjoying its best time, but its development is limited in the future.

Considering the different possible understandings of such concepts „best time", „limited" or even „high-speed" it appears impossible to give an unique answer to the hypothesis neither positive nor negative. Without doubt there is a high potential for HSR in the future. But determining the period of best time depends on a lot of different definitions and different points of view and may vary from country to country.

For these reasons ***Hypothesis 2 can neither be accepted nor refused at this time.***

Hyp. 3 HSR transport allows a better co-ordination and utilisation of rail and air system capacities.

The conclusion that can be raised from our analyses of different case studies and reports, most of them based on modelling exercises, is ***that a significant contribution of HSR to a better co-ordination and utilisation of rail and air capacities is likely to be effective***. But certain conditions must be gathered as appropriate times of journeys by HSR, high potential of traffic between conurbations served and at least one of these suffering from air traffic congestion.

However, ***some differences in results between these studies remain unexplained and would justify some additional modelling on totally comparable basis***. Moreover, nearly all these studies are only addressing the question of creation of traffic and substitution in an air/HSR competition context. ***To better highlight the question of co-ordination, scenarios of complementarity should be tested through appropriate modelling tools.***

Hyp. 4 HSR transport allows a better distribution of transport among airports.

Considering the past and the time being (underlined by the French experience of TGV-South-East and the Swedish „X 2000") and as long as no airport collapse does exist, HSR is expected to have an influence and a contributing effect to the concentration at major (hub) airports.

This hypothesis has to be ***refuted as long as the situation is still sustainable.***

Simulation carried out along the Italian „Direttissima" show however a shift to less congested airports as soon as significant delays are lasting at major airports. ***In future hypothesis 4 could, under certain conditions, be confirmed.***

Hyp. 5 Extended „air" services on train: what level of services is needed?

Travel time and frequency appear to be two key elements to make HSR transport able to compete successfully with air transport and to focus desirable improvements of the overall service.

Just as short trip times and frequency emerge as the greatest advantages for airlines, they are also the areas in which improvements can have the greatest marketing significance for HSR. Another major conclusion of the present analysis is that there are no physical conditions preventing trains from fully measuring up to the service and comfort offered by planes. On the contrary, the physical prerequisites for rail to excel in this area does not confront the same limitations with regard to space. Empirical studies also indicate that HSR has good possibilities of developing very attractive service concepts.

The question treated in Hypothesis 5 can now be answered as mentioned above.

Hyp. 6 HSR transport has meaningful saving effects of time (on distances up to 500 - 800 km) transport and operating costs, consumption and dependency, air pollution and noise, airport infrastructure investments.

The investigations proved that meaningful saving effects can be attributed to HSR for air pollution and energy consumption, in nearly any case. The hypothesis can be accepted for these parameters.

Considering time savings, the advantage of HSR appears significant for a large proportion of customers between 1 and 2 hours of HSR travel time, and rapidly vanishes beyond.

The noise impact comparison is especially difficult to assess, because of the very different nature of the impact in the air (disturbance to dense populated areas around airports) and in the rail case (disturbance very dependent on the density of areas through which the infrastructure in built, and on the distance of buildings to it).

Concerning operating costs, the unavailability of information for confidentially reasons makes difficult to conclude, but it could also be recognised, that significant changes may happen in the future in relation with different operating conditions. Eventually, the saving of airport infrastructure investment is very much depending on the structure of demand on the considered O/D (see hypothesis 10)

Hyp. 7 Air transport represents for high-speed rail transport a forerunner and a model.

Extensive studies show that air-transport in Europe has a clear forerunner function for high speed rail transport referring to development vehicles, services to passengers, design of future terminals, pricing policies and the development of the form of companies.But in case of the network development there is no forerunner function identifiable.

For the future it can be expected that there is a mutual influence between HSR and APT.

Hyp. 10 Air transport is more flexible than HSR transport and allows the saving of important investment costs.

It has been shown that the air transport system is able to react immediately to new transport demand situations and has a high flexibility in adapting supply (new service price structures). Building new routes for HSR transport lasts to 10-20 years with cost of several billions ECU.

Therefore ***the first part of the hypothesis is accepted.***

Based on existing APT infrastructure in Europe, where airports are continuously expanded, it can be shown that the extension of existing regional airports will offer in short run an additional supply within short delay and without high expenses. It is not quite clear, how to answer the question if APT allows to save important investment costs.

The second part of the hypothesis can be accepted only for low and medium traffic volume, ***for long time period and with high and increasing demand it is possible that APT needs also important investment costs, so that it could be cheaper in general economic terms to build a HSR.***

Hyp. 12 Rail stations at airports allow a better distribution of transport demand among airports.

The „first impressions" expressed in the Interim Report are confirmed by different case studies and a „Delphi" survey. There are still no meaningful air passenger transport demand flows to medium-sized (or regional) airports.

That is why ***this hypothesis has to be refuted at the present stage.***

However, due to the context coming up (EU-liberalisation and significant delays, at the latest when airport congestion up to saturation will become reality) these large airports will have to be relieved by decentralisation of activities towards medium-sized and under-utilised airports. Then, ***this hypothesis is to be confirmed in the later stage.***

Hyp. 13 Rail stations at airports have an important impact on the public transport balance of accounts.

The case studies of 7 airports in Belgium, France, Germany and Switzerland showed that there are important impacts in terms of the national economy. In the cases of major airports the impacts are normally positive. In 2 cases there are negative impacts, although due to particular reasons. The results for medium-sized airports are balanced or negative.

The effects on the rail companies alone show normally positive results as far as only operating costs are concerned. If the investment costs of the new infrastructure are included, results varied depending on the different cases.

The result of the investigation shows also that the impact of rail stations on the balance of accounts of the whole public ground transport involved at the airports is negative.

6.2 Final Formulation of all Theses and Hypotheses

After research work and investigations of the members of COST 318 the initial theses and hypotheses have to be formulated as follows:

1st group: About the effects of HSR on Air Transport

Thesis 1: HSR transport is able to compete successfully with air transport demand.

Hypothesis 2: HSR transport is enjoying its best time, but its development is limited in the future. This hypothesis is neither accepted nor refused at this time.

Thesis 3a: HSR transport should allows a better co-ordination and utilisation of rail and air capacities (but certain conditions must be gathered, as appropriate travel times by HSR, high potential of traffic and one at least among the conurbations served suffering from air traffic congestion).

Hypothesis 3b: The magnitude of the competing effect can vary according to the concept (this has to be better explained by comparing the results of different modelling experiments). The complementarity effect could be very sensitive to specific parameters (this should be checked by testing various scenarios through models).

Hypothesis 4: HSR could allow a better distribution of transport demand among airports in the future, although this did not happen yet.

Thesis 5: Extended „air“ services on train are important for HSR. One has to take into account travel time and frequency as key elements. To compete successfully with APT, there are no physical conditions preventing HSR from fully measuring up or excel to service and comfort offered by planes.

Thesis 6: HSR transport has meaningful saving effects of time (between one and two hours of HSR travel time), primary energy consumption and air pollution. The effects of HSR on operating costs, infrastructure investments and noise depend on the singular situation.

2nd group: About the reverse effects of APT on HSR

Thesis 7: Air transport represents for HSR in many aspects a forerunner and model. In future it can be expected that there will be a mutual influence between HSR and APT.

Thesis 8: APT is well placed in relation to HSR on routes with poor or medium demand.

Thesis 9: Within the high-speed transport system as a whole APT and HSR transport are complementary.

Thesis 10a: APT is more flexible than HSR transport

Hypothesis 10b: APT allows the saving of important investment costs. In the short run the extension of existing regional airports offers additional supply with little expenses. But over a long time period and with an increasing demand it is possible that APT also needs important investment costs. Therefore Hypothesis 10b can not be generally proved.

3rd group: About the effects of rail stations at airports on rail and air transport

Thesis 11: Rail stations at airports allow beneficial effects on rail and air transport systems within their respective field of influence.

Hypothesis 12: Rail stations at airports could allow a better distribution of transport demand among airports, although this has not been the case up to now.

Thesis 13: Rail stations at airports have an important impact on the public transport balance of accounts. The result of different case studies shows the effects on the rail companies alone are normally positive as far as only operating costs are concerned. If the investment costs are included, the results vary depending on the singular case. If the financial effects of the whole public transport are considered the results are negative.

Thesis 14: The reliability of rail link at airports allows to reduce overall access costs, waiting time and (parking) space for passengers; travel safety is increased by an increase of the rail market share.

COST 318 started with 6 theses and 9 hypotheses which were elaborated by the former Technical Subcommittee. After finishing the intensive working programme of this action most of the hypotheses are answered positively or negatively. There are 11 theses and 5 new or reformulated hypotheses which need further time for to observe the development or more research work.

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Annex 1:

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Annex 2: Theses and Hypotheses

1st group About the effects of high-speed-rail transport on air transport

Thesis		Hypothesis	
Th 1	high-speed-rail-transport is able to compete successfully with air transport demand	Hyp 2	high-speed-rail-transport is enjoying its best time, but its development is limited in the future
		Hyp 3	high-speed-rail-transport allows a better co-ordination and utilisation of rail and air system capacities
		Hyp 4	high-speed-rail-transport allows a better distribution of transport demand among airports
		Hyp 5	extended „air"services on train: what level of services is needed?
Th/Hyp 6 - high-speed-rail-transport has meaningful saving effects of time, (on distances up to about 500-800 km), transport and operating costs, energy costs, consumption and dependency, air pollution and noise, airport infrastructure investments			

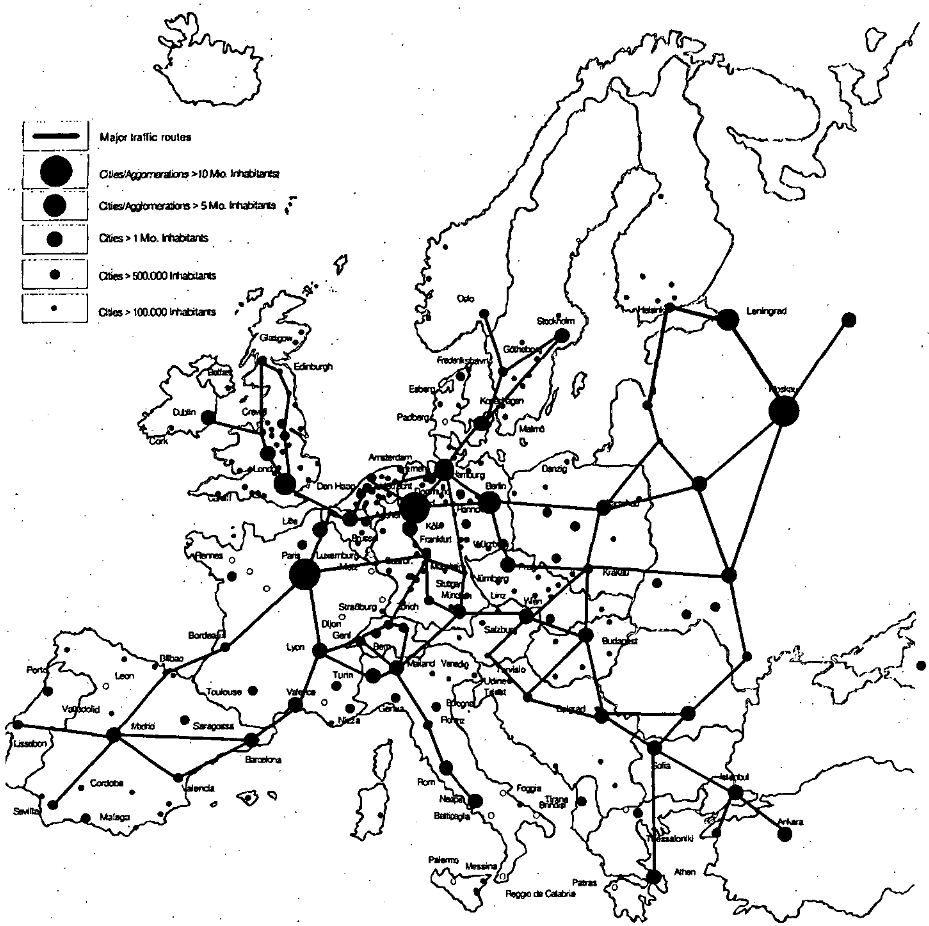
2nd group About the (reverse) effects of air transport on high-speed-rail transport

Thesis		Hypothesis	
Th 8	air transport is well placed in relation to high-speed-rail on routes with poor demand	Hyp 7	air transport represents for high-speed-rail a forerunner and a model
Th 9	within the high-speed-transport system as a whole, air transport and high-speed-rail transport are complementary	Hyp 10	air transport is more flexible than high-speed-rail transport and allows the saving of important investment costs

3rd group About the effects of rail stations at airports on rail and air transport

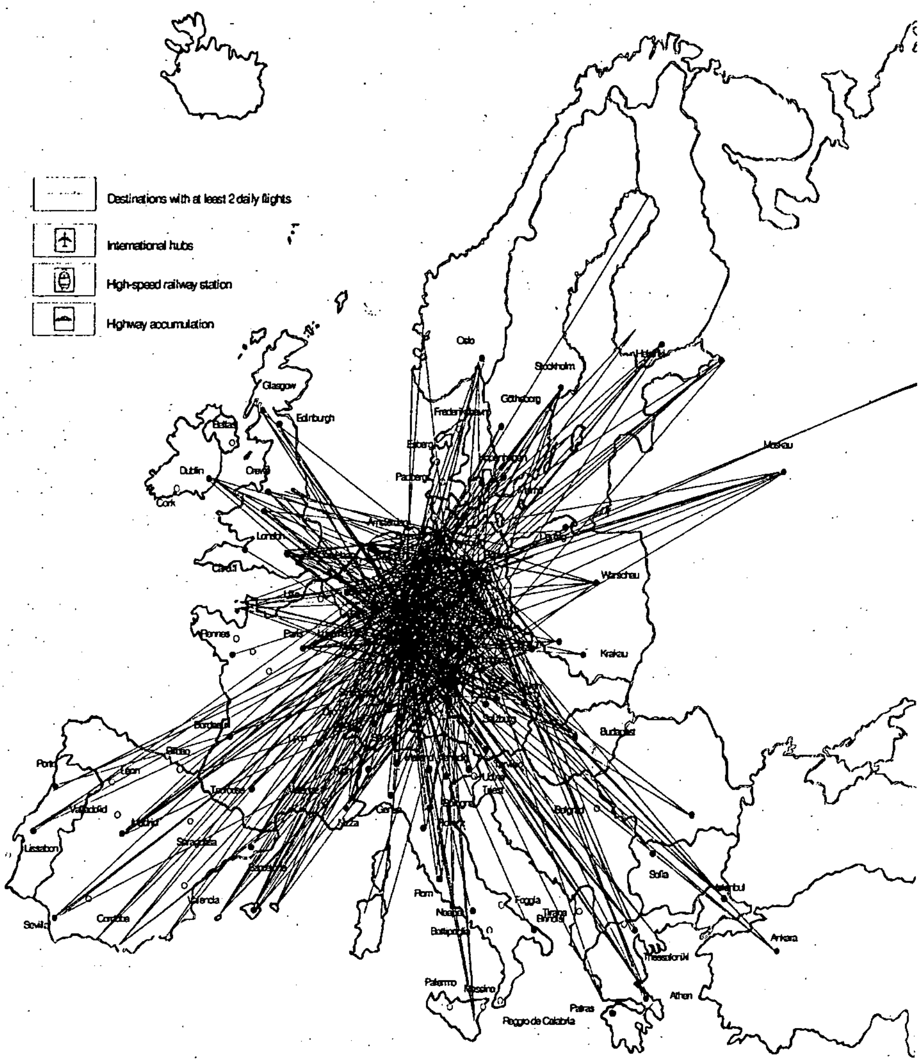
Thesis		Hypothesis	
Th 11	rail stations at airports allow beneficial effects on rail and air transport systems within their respective field of influence	Hyp 12	rail stations at airports allow a better distribution of transport demand among airports
Th 14	the reliability of rail link at airports allows overall access costs at airports to be minimised, waiting time and (parking) space for passengers being reduced at air terminals, travel safety to be increased by the choice of rail transport	Hyp 13	rail stations at airports have an important impact on the public transport balance of accounts

Annex 3: Population Distribution and Major Transport Routes

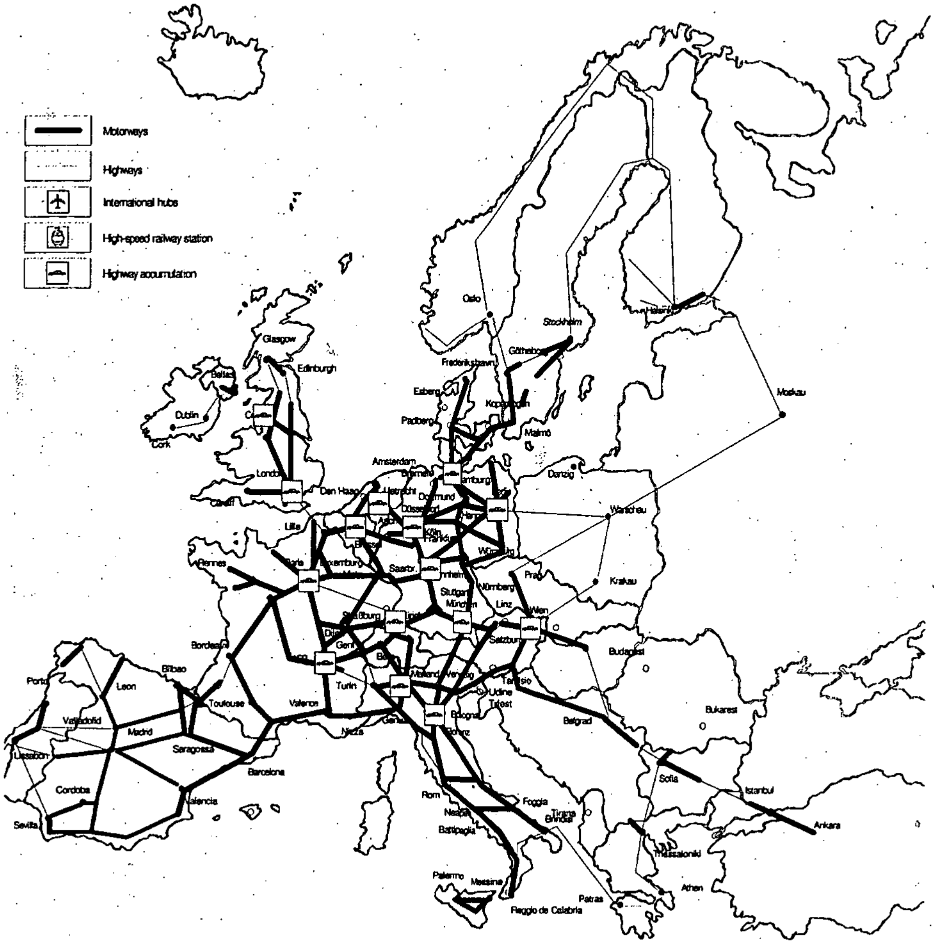


ource: Several country reports, Alexander Weltatlas, UIC

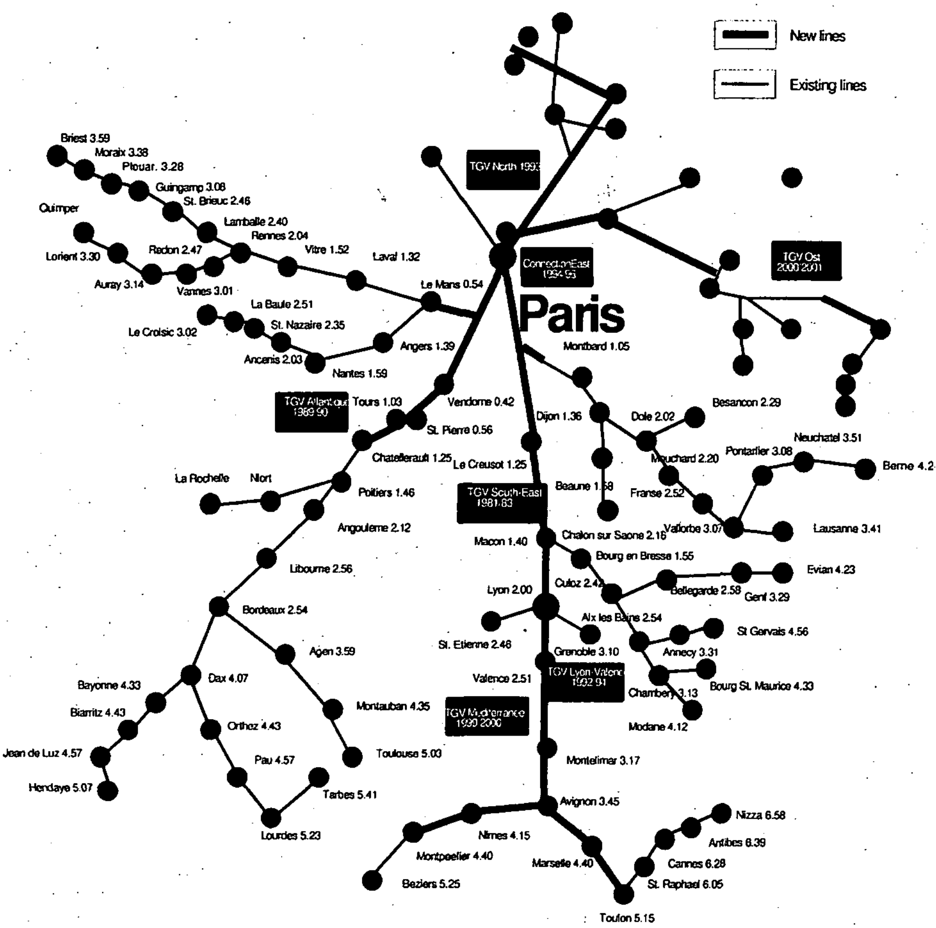
Annex 4: European Air Traffic Links from Germany 1994



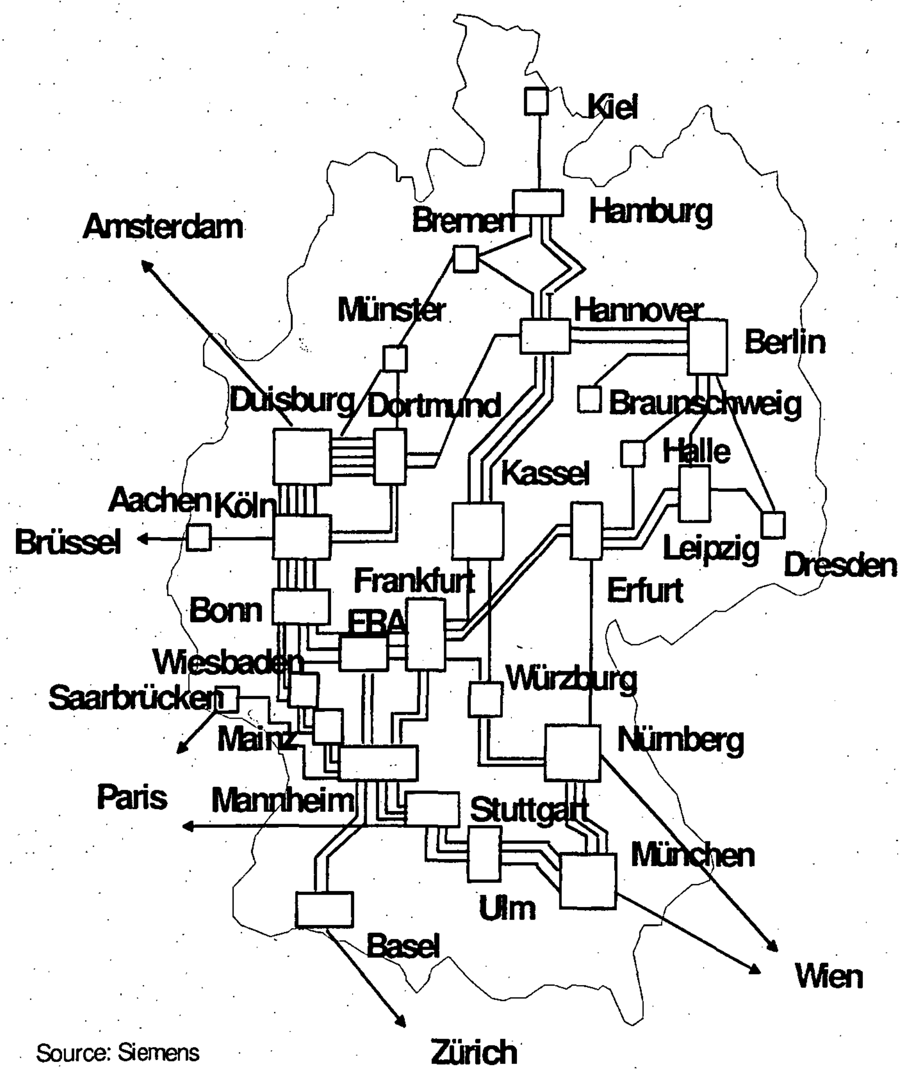
Annex 5: European Motorway and Highway System



Annex 6: The TGV Sud-Est and TGV Atlantique 1991

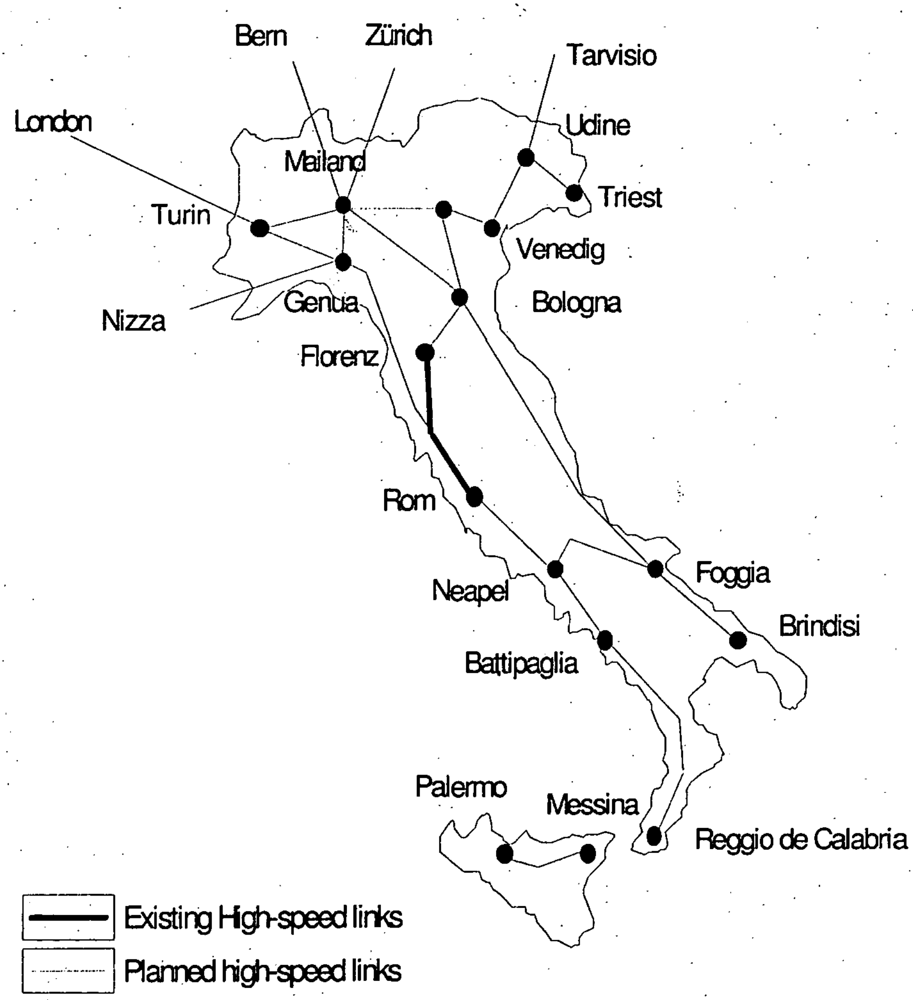


Annex 7: The ICE in Germany in Service 2005

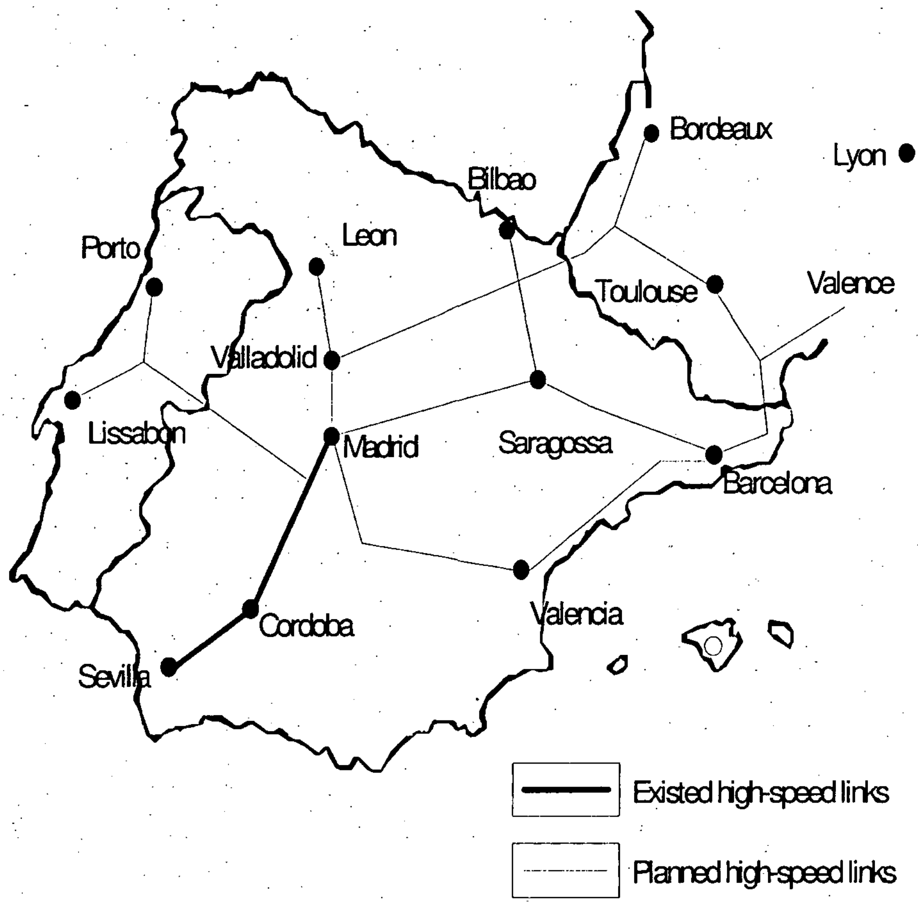


Source: Siemens

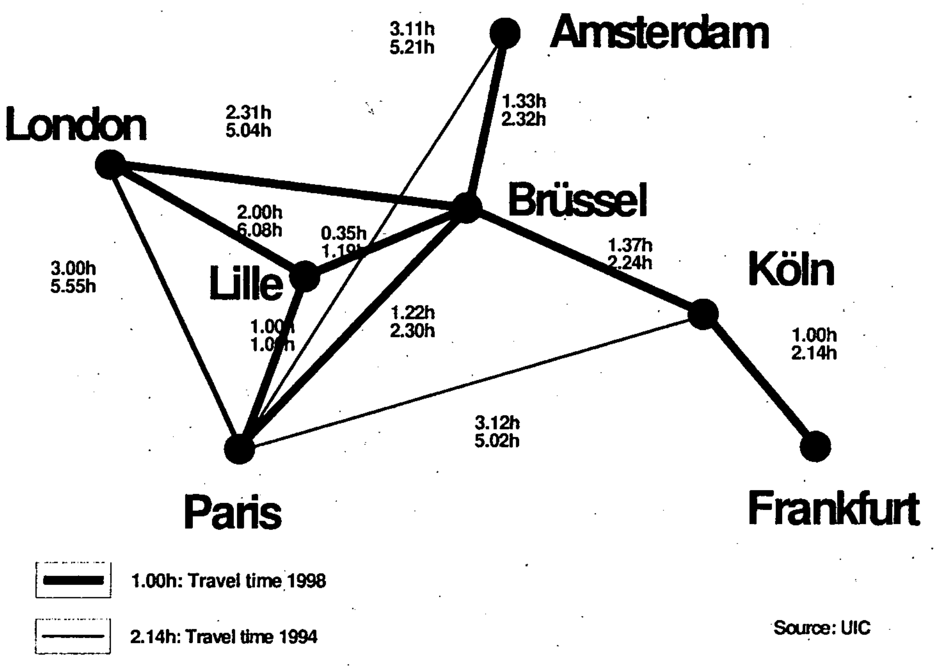
Annex 8: The High Speed Rail Network in Italy



Annex 9: The High Speed Rail Network in Spain (AVE)

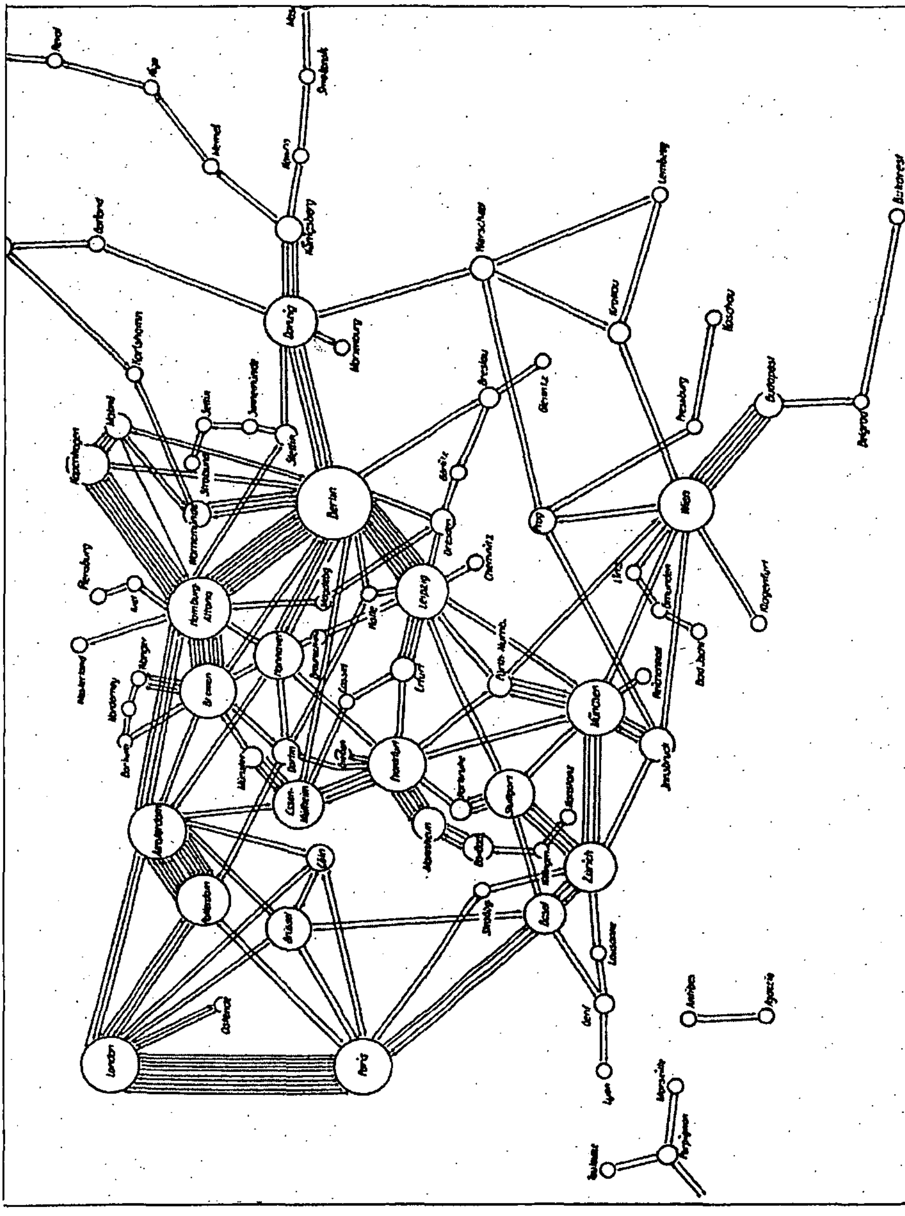


Annex 10: Core of the European High-Speed Rail Network



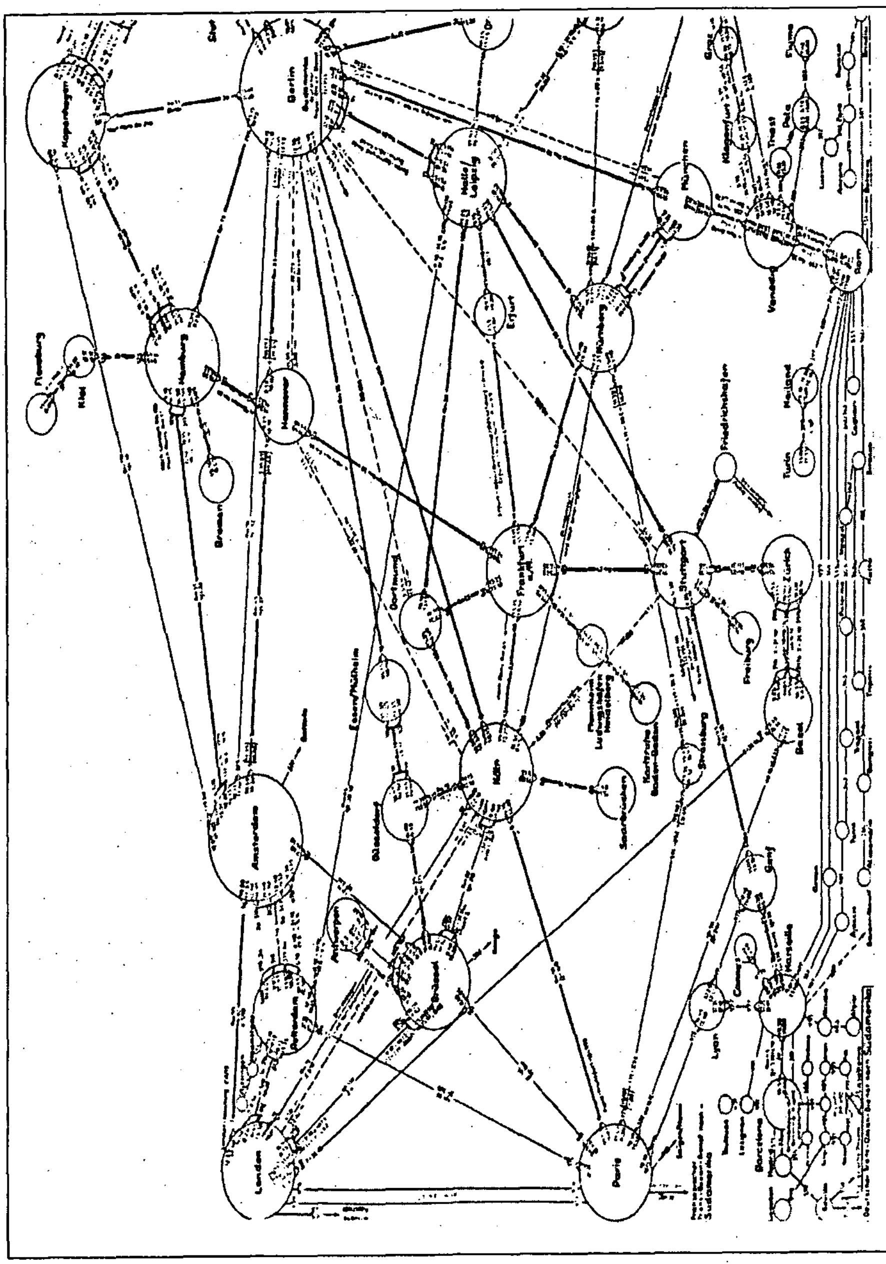
Source: UIC

Annex 11: European Air Traffic Network 1925



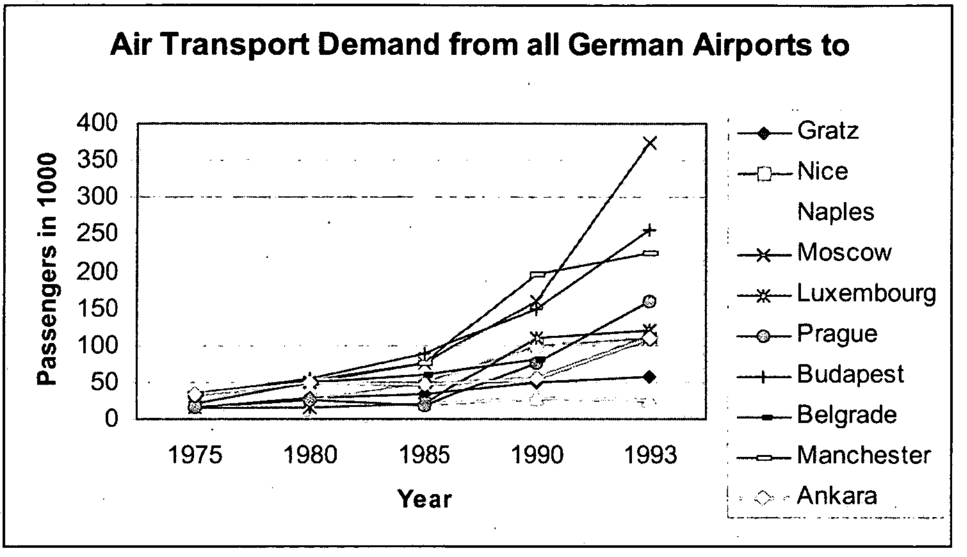
Source: Treibel, W.: Geschichte der deutschen Flughäfen

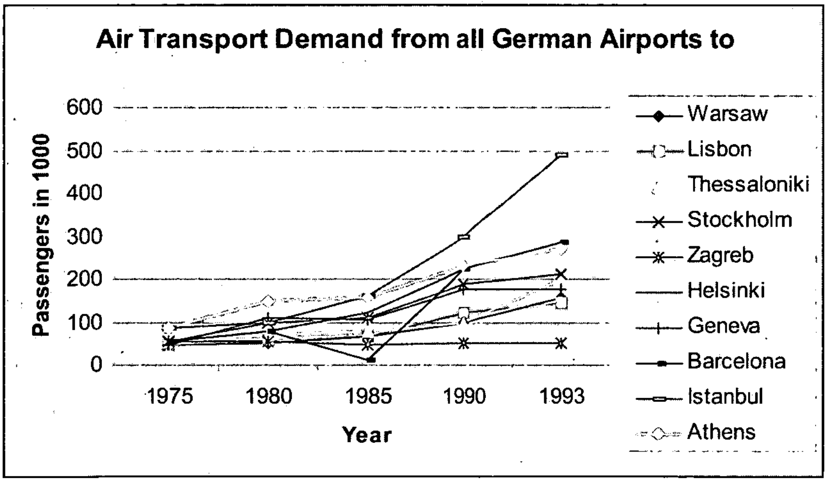
Annex 12: Lufthansa Timetable Winter 1956



Source: Deutsche Lufthansa

Annex 13: Development of Air Traffic Demand on Different City Pairs





Annex 14: Studies about Interactions between Air and High-Speed Rail

A. Dutch studies about substitution from air to HSR concerning Schiphol airport

The three studies are dealing with traffic forecasts.

A.1 The PASO study[108]

The PASO study uses a model predicting at year 2015 shares of air and rail on the basis of previous forecasts made by Schiphol airport on potential demand for air transport within a maximum of 10 hours travel time. The modal share model is of linear logit type, whereas the potential demand forecasts use mainly income and prices elasticities.

According to the scenarios with introduction of HSR, the substitution from air to HSR varies from 8% to 45% of total demand. 8% corresponds mainly to a reference scenario of basic HSR network, increase of 25% of business rail fares and constant 1990 non-business rail fares, minor expansion of Schiphol air-network, constant 1990 business air fares and decrease by 35% of non-business air fares, and comparable air and rail quality and punctuality. 45% corresponds to constant 1990 air fares, either business or non-business, maximum possible HSR network and integrated air-rail operation.

The most effective substitution factor appears to be keeping air fares constant (more than 20% of total demand, coming from non-business travellers). Other significant factors are integration of air and rail services (about 10%, coming from transfer passengers), maximum rail network (a bit less than 10%, mainly coming from 500-1000 km distance band), modified rail-fare structure (business and non-business fares respectively 90% and 50% of air fares coming to a 9% of total demand additional substitution), reduced air punctuality (7,5%), air fares increased by 10% (7,5% also), and rail fares reduced by 10% (5%).

Answer to hypothesis 3 would be, assuming that limitation of Schiphol airport traffic in favour of HSR means a better utilisation of air and rail system capacities, that HSR contribution to this goal is rather modest in the expected situation but could be much more substantial if tariff trends were differing a great deal from the reference or if strong policy measures were taken.

108 PASO : Plan van Aanpak Shipol en Omgeving

A.2 The IEE study[109]

The IEE study differs by the use of a more sophisticated substitution model, consisting of an incremental logit model coming after a growth module, and applied to the demand for London, Paris and Frankfurt, with an extension to 43 other destinations. The parameters are prices, journey-times and services for air, rail (including HSR) and car.

The three main scenarios are called Global Shift - GS - (Europe in recession and Far East plus USA flourishing, with increase of 2% of air fares because of stop in liberalisation and HSR fares 20% lower)), European Renaissance - ER - (Europe flourishing, USA in recession and Far East on a good trend, with decrease of air fares within Europe by 10%, HSR fares 18% lower and extended HSR network) and Balanced Growth/Global Liberalisation - BG - (with decrease of air fares at the scale of the global market by 14%, HSR fares 4% lower and more limited HSR network). Variants according to prices and levels of services are introduced.

The level of substitution varies in 2015 and on the three main destinations from 1,1 millions of passengers in GS reference situation to 4,7 million in BG with maximum HSR level of service and airfares 38% higher than in reference situation (to be compared to the 1,3 to 4,8 mio. of the previous study for a broader geographical scope). The study confirms that business travellers are mostly sensible to journey time whereas non-business are much more concerned with fares.

The additional answers to hypothesis 3 are that :

- **a strong European integration combined with a liberalisation of air-transport market within Europe and an extended HSR network (ER) could be more favourable to substitution than a world-wide economic growth combined with a global liberalisation of air-transport market and a less extended HSR network (BG),**
- **when policies affecting fares or level of service are imposed, BG gives a higher substitution because of the higher level of air travellers,**
- **the substitution percentage for O/D passengers is only slightly higher than for transfer passengers.**

A.3 The high substitution scenario study

The third study used the same methodology as the IEE one and concentrated on a scenario of maximum substitution, applying ten variants of policy measures to the BG scenario. Those variants consist in additional HSR services, like direct services to London or fast connection to Berlin and diverse increases in air fares (from 24% to 36%) linked or not with increases in rail fares (from constant 1990 to + 4%) and improvement in HSR level of service. A last variant makes travelling by HSR compulsory for destinations within 500 km from Schiphol, with reversely no possible substitution above.

109 IEE : Inventorisation Economical Effects

Substitution results varies from 2,6 millions of passengers to 15,1. Most of it comes from passengers with Schiphol as their origin or destination, but a significant part comes also either from passengers who have Schiphol as their origin or destination but transfer to another airport (negative transfer) or from passengers who don't have Schiphol as their origin or destination but choose to transfer in this airport (positive transfer), positive transfers being twice as big as negative ones.

The main complementary element for hypothesis 3 is that the destinations generating the biggest substitution are those with a large number of passengers or within a short distance from Schiphol.

B. French studies about HSR corridors

B.1 Before and after study about the impact of TGV Sud-Est on traffic

The methodology of the study has consisted of co-ordinated traffic surveys (same days and same questionnaires) on air, road and rail carried out in September 1981 (just before starting operation) and September 1984, one year after the opening of the 2h travelling time services between Paris and Lyon.

The total traffic increase appears to be very important, around 30% as a whole, and up to more than 40% for specific O/D zones. In the case of the Paris- Lyon relation, a total increase of 37% leads to a creation of traffic of 27% after taking into account the estimated trend of growth in the reference situation.

The modal split has changed considerably, the rail share increasing from 40% to 72% between Paris and Lyon and from 28% to 52% on the overall links between Paris region and south-east. The main counterpart affects the air, its market share collapsing from 31% to 7% as a whole, with huge differences according to the zones : -75% for relations between Paris plus inner belt and Lyon plus Departement du Rhône, to be compared with only -15% between the outer belt of Paris and Lyon, and even +30% between Paris region and Provence. Although road traffic has slightly decreased between 1981 and 1984, to be compared with an expected 2% year growth in the reference situation, the diminution of the modal share remains very limited, and is only noticeable where the initial road market share was the highest.

As a whole, the rail traffic has been multiplied by 1,9 between Paris region and south-east, and by 2,5 between Paris region and Lyon region, with a roughly equal contribution of transfer and creation of traffic to this growth, transfer coming essentially from air in the last case whereas it concerns more significantly road and night trains in the first case.

It appears from those results that a significant impact has occurred on the air traffic between Paris and Lyon, with some release to the congestion of Orly airport. At the same time, it appears that this impact mainly concerns flows with origin and destination rather close to the city centres, and that the impact is much less sensible for more distant flows with longer TGV travel time.

B.2 Before and after study about the impact of TGV Atlantique on traffic

A similar study has been undertaken about TGV Atlantique, with surveys in September 1989, just before the opening of the West corridor, and September 1993. Questions were more detailed about the purpose of the trip, either leisure or business, and the personal or professional determinants of travels. For that reason, an original way of mailing back the questionnaires was chosen for car users stopped at the toll barrier on the motorway.

Because "before" surveys were made in a growth period whereas "after" surveys happened during economic crisis and coincidated with the perturbation due to the new SNCF ticketing system Socrates, the small increase in mobility (even the decrease for certain categories) is difficult to analyse, the reference situation being uneasy to estimate.

Commuting is the only purpose of trip with significant growth, whereas journeys for a short (return within a half day) or long (over a week) period decrease substantially.

The evolution of the modal split appears anyway unfavourable to the rail. During weekends, rail decreases over the period from 43% to 39% whereas air is stable to 6% and road increases from 51% to 55%. During week-days, all modes are rather stable (rail : 50%, air: 14%, road : 36%).

The decrease of rail share is verified as well for business (from 50% to 46%) as for leisure (from 38% to 35%) or for commuting (from 83% to 79%).

The decrease of rail traffic during the period (-9% at weekends and -13% at week-days) is especially important for short distance traffic without competition of air, time of access and egress being particularly sensible in this situation for the competition with car (+10% for weekends and +2% for week-days).

Situation is much better for rail (+20% at weekends as well as week-days) in cases of high competition with air (relations with Rennes, Nantes and Bordeaux), air traffic being more significantly affected (-18% at weekends and -23% at week-days) than road traffic (+19% at weekends and -4,5% at week-days).

For long distances (relations with time of travel by high-speed train over 3 hours), the effect of high-speed train is again rather limited, rail decreasing by 15% at weekends and 7% at week-days while air traffic keep growing by 15% and 11% respectively, the situation being more contrasted for road (better score than rail at weekends with +8% but worse score at week-days with -7%).

The first contribution of this study to hypothesis 3 is probably that the order of magnitude of the creation of traffic due to high speed train is not necessarily always greater than the impact of economic recession on mobility. The second is that TGV do not necessarily leads to a better utilisation of capacities in so far that the modal share of air may remain stable and the decrease of rail modal share is balanced by an equivalent increase for road. The third is a confirmation that the most positive impact is to be expected from competition with air for relations with HSR journey time between 2 to 3 hours, whereas road remains more attractive under this threshold, as well as aviation over it.

B.3 Longitudinal survey of potential users of TGV Nord

To monitor the impact of north European high speed train, a panel of residents of Ile de France and Nord Pas de Calais has been launched in October 1992, one year before the first opening of the new line between Paris and Lille, and kept in activity up to September 1995, one year after the opening of Eurostar services through the Channel Tunnel.

The main results about impact of high speed train on air traffic coming from this study obviously apply to the corridor Paris-London. Between the second (October 1993-September 1994) and the third (October 1994-September 1995) year of the panel, the air market share has evolved from 72% to 39%, the rail market share moving from nearly nothing to 32,5%.

However, the volume of air flows only decreases by approximately 5%, reflecting the strong creation of traffic by the HSR.

The panel reveals that a majority of Eurostar users in year 3 that were mobile on the corridor in year 2, are coming from the air. Road travellers using ferries in year 2 more likely remain ferry users or shifts to Le Shuttle services. This corridor illustrates clearly that air and high speed train are competing on the same market.

The structure of the customers in year 3, significantly evolves in favour of private purposes of travel, old people and high social classes

C. Italian study about the Milan-Naples and Turin-Venice corridors

The study of evaluation of the two high-speed line projects Milan - Naples and Turin - Venice has been driven in 1988/1989 according to a breakdown of Italian territory in respectively 68 and 110 zones, with an analysis of demand by mode and by type of relation in 1987 (cross - tabulation of distance categories and of large or medium size O/D cities). As a whole, the modal share was in 1987 27% rail, 72% road, 1% air and 32% rail, 68% road respectively.

High and low scenarios have been elaborated according to demography, economy and land-use, and models of generation of traffic have been developed on this basis distinctly for four different purposes (work, study, business, others).

On the corridor Milan - Naples, the model predict 103.000 passengers per day in 1996 with the new line (as compared with 1.750.000 for the total matrix of 68 O/D) with an average distance of 287 km and with 81% coming from the existing rail line, 15% diverted from road and 4% from air. This leads to 10,8 billions passengers x km, among which 1 billion for night traffic.

On the corridor Turin-Venice, in the hypothesis of a new line plus an increase of capacity of the existing line, and no extra-fare for high-speed train, the model predicts 106 000 passengers per day in 1996 with an average distance of 97 km.

An updated forecast study has been conducted more recently. Assuming an opening of the high-speed line in 2002 with progressive increases in services up to 2004, the traffic would be 10,5 billion passenger x kilometre in 2002 and 17,5 billion in 2004, among which 77,6% coming from the existing line, 14,3% from road, 1,6% from air and 6,4% being creation of traffic. The transfer from air to rail has been calculated according to two different fares hypothesis, on the basis of a price elasticity for 57 airlines likely to compete with the high-speed rail.

As a whole, those studies reveal that it gives corridors with HSR projects where the initial air modal share is so low that the influence on air traffic can only be very limited, most of the patronage of high speed trains coming from existing rail traffic, and diversion from road is much more substantial than diversion from air. It would be necessary to get more detailed information about the impact of HSR on such O/D as Milan-Rome or Milan-Naples to check whether those project studies refute hypothesis 3.

D. Spanish studies about new HSR corridors

D.1 Madrid-Seville

The AVE, opened in April 1992, has reduced the rail travelling time between Madrid and Seville from 6h30 to 2h32, making total journey time comparable with air. The available data show that the modal split between 1991 and 1994 has changed substantially for public modes, from 16% to 51% for rail, from 40% to 13% for air and from 10% to 5% for coach, the impact on car being moderate (from 34% to 31%). Even considering the importance of creation of traffic in those figures, this still means a very severe cut in air traffic, by more than 2.

Forecasts with a PERAM-type model for the year 2000 have been made according to three scenarios : A (current fare structure and reduction of 12 minutes of HSR travel time), B (decrease of 5% of air fares), C (decrease by 5% of air fares and increase by 10% of air fares). As compared with 1994 situation, these forecasts lead to an increase of the market share of the air (17% to 19% according to the scenarios) and of the road (38% to 40% for car and coach altogether), with a corresponding decrease of the rail share (45% to 41%).

Main contribution to hypothesis 3 and 6 may be that a substantial substitution from air to HSR do not necessarily lead to an important impact on airport congestion and environmental impacts. The bigger impact on traffic concerns the Seville airport (decrease by nearly 12% of aircraft movements) in a situation where the improvements made for the Expo'92 provides an important reserve of capacity. On the other hand, impact on aircraft movements of the more congested Madrid airport reaches less than 2% of the total.

D.2 Madrid-Barcelona

The projected HSR between Madrid and Barcelona should reduce the average rail journey time door to door from 8h03 to 3h54, to be compared with 2h38 by air.

Forecasts according to the same methodology (PERAM-type model) indicate for the Madrid-Barcelona route a shift in the modal split at the year 2O22 due to the HSR from 10% to 33% for rail (23,5% in 1990), and reversely from 56% to 40% for air (45,5% in 1990), and 34% to 27% for road (31% in 1990). If we consider the total routes concerned, the shift becomes from 15% to 30% for rail, and reversely from 26% to 20% for air, and 59% to 50% for road. Taking into account the creation of traffic, the corresponding reduction in air traffic is in both cases by approximately 13%.

Although target period for forecasts is not the same than for Madrid-Seville, this clearly confirms the influence of travel time thresholds on the relative importance of diversion from air to rail. To a limited degree, infrastructure investments on the specialised air terminals in Madrid and Barcelona could nevertheless be postponed.

D.3 Madrid-Lisbon

A preliminary study has been also undertaken about connections by HSR between Spain and Portugal. The main route analysed is Lisbon-Madrid, with an hypothesis of 4h09 rail journey time considerably shorter than at present, to be compared with an air journey time of 3h15. Forecasts according to a scenario with the choice of the best HSR route and a 30% decrease in air fares gives a modal split in the year 2012 of 35% for rail (19% in 1989).

It is difficult considering the information available to derive any contribution to the hypothesis.

E. International studies

E.1 PBKA study[110]

PBKA project has been studied between 1984 and 1986 by a group with representatives of the four countries served. Forecasts have been made for year 2000, both in a reference situation and in a scenario with high speed rail. Results show first that the creation of traffic due to high speed train is mainly coming from relations between big cities (+33% as compared with the reference situation, instead of +2,5% for other types of relations). It shows in addition that the increase of the modal share of rail is maximum for these relations between big cities (52% instead of 31% in the reference situation) with a counterpart mainly on the side of road modal share (44% instead of 63%) considering the weakness of air traffic on the corresponding corridors. For other types of relations, rail modal share remains much more modest although growing significantly (from 11% to 17% for relations in the vicinity of TGV stations, and from 15% to 19% for other relations).

110 PBKA : Paris Brussels Köln Amsterdam

An evaluation has been done of the profitability of several variants of the project. In the option with an integral network of high speed lines, the internal rate of profitability reaches 5,7% (and 3,8% more than in the reference situation) as a whole, with a huge contrast according to the countries, from 10% for France to 1,2% for the Netherlands.

The main contribution to hypothesis 3 seems to be that in general terms high- speed trains have a maximum and quite significant effect on traffic between big cities with major airports, and should contribute to a better distribution of demand, although on the specific corridors studied (which excluded at that time relations with London) air traffic is marginal because of too short distances.

Regarding hypothesis 6, it can only be said on the basis of the information provided that high-speed train has a profitability of its own, which is very dependant at national level on the respective volumes of the flows (with an advantage to France considering the important domestic relation Paris- Lille).

E.2 European scheme for high-speed rail

CCFE and CCE have ordered a study of the impact of a European scheme of high-speed rail on traffics for years 2000 and 2010, according to two scenarios of mobility evolution and different steps of development of the HSR network.

The modal share of rail in passengers as a whole at year 2010 increases from 12% in the reference situation to 17% in the scenario of maximum extension of the HSR network, with a greater impact for business than for leisure traffics.

The growth of rail modal share is also more sensible for international traffic (22% in the scenario with reduction of the boarder effect to be compared with 9% in the reference situation) than for domestic traffic (26% instead of 18,5%).

Considering international traffic, air and road are affected in the same proportions (decrease from 41% to 35% for air and from 50% to 44% for road), whereas the impact is mainly on air for domestic traffic, road remaining the dominant mode.

The profitability of the different variants has been evaluated. It appears much more sensible to rail tariffs than to air tariffs or road restrictions of use.

E.3 Lyon-Turin

For the Lyon - Turin project of high-speed rail, a predictive model has been calibrated on the data coming from a boarder survey on road, rail and air made during two periods of one week (sampling rate of 2,5%). The survey shows a split of the total market of 32,8 million passengers between mainly car (57%) and air (24%), rail and busses accounting only for 11% and 7% respectively. However, the situation differs widely according to the origin/destination country, rail being more important than air for relations with France (16% and 14% respectively) whereas it is almost neglectible for relations with UK, Benelux and Iberian countries.

The methodology for forecasts refers to previous models used by SNCF for the projects of Channel Tunnel and connection between French and Spanish HSR networks. These models are especially adapted in case of physical or technical barrier and of high competition with cars and busses. They use a traditional profit price-time model for air-rail modal shift, a logit generalised cost model for road-rail modal shift, and a unimodal gravitary model for creation of traffic. Value of time for passengers is estimated from stated-preference surveys.

A behavioural survey concerning travellers by rail, air and road has allowed an insight in attitudes toward HSR. People travelling by conventional rail would divert to HSR much more likely than air travellers, and even more likely than car drivers.

About the split between night and day HSR, it appears that only 20% of the travellers prefer night trains under 6 hours of travel time whereas 80% choose alike over 8 hours of travel time. Air travellers have the greatest preference for night trains over 6 hours of travel time and the greatest interest for comfort of sleeping.

No evidence about hypothesis 3 can be derived from this study without access to the results of the forecasts. Considering the very significant market share of air on this corridor, those results would be of major interest for the COST action.

Annex 15: COST 318 Internal Seminar - 27 June 1997, Brussels about models

COST 318 Internal Seminar
27 June 1997, Brussels

From Competition to Complementarity between Air and High Speed Rail : are Models all telling the same Story

8h30 welcome of participants

9h00 presentation of the seminar in the context of COST 318 action (M. Houée)

First part : The Kaleidoscope

9h15 main elements of method and results arising from dutch studies (M. Kroes and Van Ommeren)

9h45 main elements of method and results arising from spanish studies (M. Archilla and de Quiros)

10h15 main elements of method and results arising from italian studies (M. Frondaroli and Cascetta)

10h45 break

11h00 main elements of method and results arising from french studies (M. Chopinet and Houée)

11h30 main elements of method and results arising from belgium studies (Mme Gayda)

12h00 main elements of method and results arising from european studies (M. Schubert)

12h30 general discussion

13h00 lunch

Second part : Present Comparability and future Relevancy

14h30 **do models say the same thing about high speed competition up to now?** (general animation : M. Gaudry)

How models'results are influenced by the availability of data required for calibration?

To what extent models are sensitive to variations in the level of parameters fixed for scenarios?

What is the consequence of choosing the specifications of a model?

To what extent differences of context and travel behaviour explain the gaps between forecasts?

16h15 break

16h30 **will models be able to tackle with the future of high speed?** (panel of experts)

The competition with road in the extension of high speed rail networks

The new context of rail deregulation and air open market

From competition to complementarity between air and high speed rail

17h30 general discussion and closing speech

Key Substitution-Complementarity Features of Travel Demand Models, with Reference to Studies of High Speed Rail Interactions with Air Services

by
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COST 318 « Interactions Between High-Speed Rail and Air Passenger Transport »

Workshop : From Competition to Complementarity between Air and High Speed Rail : are Models telling the Same Story ? » Brussels 27/07/97.

Michel Houée, Eric Kroes, Steven Lowe and Olivier Morellet provided useful comments on previous versions.

July 1997, Revised December 1997, January 1998

ABSTRACT

An interesting question in the analysis of travel demand models is the extent to which different modes of transport can be said to be complements, as opposed to substitutes : this question arises naturally in contexts where intermodality, or the joint use of modes, is of interest, and in particular with respect to studies of the integration between high speed rail (HSR) and air passenger transport services considered by the COST 318 Committee.

In this paper we shall recall the principal **definitions** of substitution and complementarity found in standard Economics, show the **relationship** between these notions and various decompositions in use in transport demand analysis, examine the **features** of transport demand models as they pertain to the possibility of complementarity or substitution and **classify** a number of selected studies according to these key features. We propose that results obtained from models of such different structures and properties be compared in the future using the common metric of transport diversion and induction elasticities obtainable from any transport demand model.

Key words : complementarity, substitution, diversion, induction, High Speed Rail, Air, transport demand models, elasticities, COST 318.

RÉSUMÉ

Dans l'étude de la demande de transport, il est intéressant de se demander jusqu'à quel point les modes de transport constituent des compléments, plutôt que des substituts, surtout si on se soucie de l'intermodalité, ou usage combiné de plusieurs modes, comme on le fait dans les études d'intégration entre la Grande Vitesse Ferroviaire et l'Avion rassemblées par le Comité COST 318.

Dans cette communication, nous rappelons les principales **définitions** de substitution et de complémentarité utilisées par les économistes, nous montrons les **relations** qui existent entre ces notions et diverses décompositions en usage dans l'étude des modes de transport, nous isolons les **caractéristiques structurelles** des modèles de transport qui permettent de représenter la complémentarité ou la substituabilité et nous **classifions** enfin certaines études à l'aide de ces caractéristiques. Nous proposons que les résultats obtenus de modèles si divers par leurs structures et leurs propriété soient comparés à l'avenir à l'aide de la métrique classique des élasticités de transfert et d'induction calculables pour tout modèle de demande de transport.

Mots clés : complémentarité, substituabilité, transfert, induction, Grande Vitesse Ferroviaire, Avion, modèles de demande de transport, élasticités, COST 318.

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1. Introduction: does intermodality have a meaning ?

An interesting question in the analysis of travel demand models is the extent to which different modes of transport can be said to be complements, as opposed to substitutes : this question arises naturally in contexts where intermodality, or the joint use of modes, is of interest, and in particular with respect to studies of the integration between high speed rail (HSR) and air passenger transport services.

In this paper we shall **define** substitution and complementarity in a way that is consistent with standard approaches in Economics, show the **relationship** between these notions and various decompositions in use, examine the **features** of transport demand models that make complementarity possible and **classify** a number of studies according to these key features as well as according to their results expressed using the common metric of transport diversion and induction elasticities.

The selection of key model features as they pertain to the possibility of complementarity or substitution and the emphasis on practical studies of HSR prevent any attempt at being either complete or exact in our classification and selected examples, or in giving *due credit* and references as in academic papers.

2. Three decompositions yielding gross substitutes or complements

In classical economic terminology, substitutes or complements are defined as goods the demand for which move in opposite or in the same direction when the price of one of them changes. The basic problem of explanation is therefore to provide a mechanism by which outcomes following say a drop in the price of good 1 could differ. The device used for this purpose is a conceptual decomposition of the movement of prices and quantities, one of which - the substitution effect - is always of the same sign and the other of which - the income effect - determines the net result. Here we shall follow through with this stream of thinking, using successively two established decompositions before we outline, within the same framework, the specific characteristics of the common transport decomposition - between diversion and induction effects.

This will allow us to frame the transport practices within an analytically rigorous and well known approach and to show their specificity in decomposing the same price-quantity movement. We shall also note different expressions of the classical transport decomposition which are useful for model comparison purposes, as well as other partly unresolved ambiguities associated with the classical formalism or its transport modelling uses.

A. Transport and communications in classical Economics

The classical notions can be introduced with either consumer goods or production inputs, such as capital and labour. We shall choose here transport and communication inputs and simultaneously draw the shifts in the demand for total transport T that results from changes in the prices of communications or transport.

i) Hicksian substitution

To understand how, in Figure 1, a drop in the *price of communications* leads producers and consumers to move from combination 1 to possibly different outcomes such as those exibited in *i* where less communications are bought, and in *ii* where more of both goods are bought, it is necessary to remember that the changing shape of isoquants, as one moves from lower output point 1 to higher output point 2, is decisive.

The quadrant with origin at point 1 contains the set of outcomes characterised by higher consumption of both goods following a drop in the price of either : these outcomes exhibit « gross complementarity ». The term « gross » refers to the absence of any attempt to account for the implicit income change associated with the movement. By contrast, the lower right-hand triangle contains points exhibiting « gross substitution » because more of one good, *C*, is bought but less of the other, *T*, is purchased after a fall in the price of *C*. Notwithstanding the difficulty of presenting only two goods, the upper left hand side triangle indicated in Figure 1 [*i*] contains points exhibiting the inferiority of *C* because the fall in the price of *C* results in less *C* (and more *T*) being purchased than before.

Hicksian substitution is defined by finding the tangency point between the original isoquant going through 1 and the minimum budget required to produce this output at the new relative prices of the final budget line. The idea of Hicksian decomposition is to distinguish between an hypothetical move from point 1 to point HS (keeping the output level constant) and another hypothetical move from point HS to point 2 made possible by the income « equivalence » of the new prices. Because of the structure of the isoquants, the first move - the substitution effect - is always positive following a drop in price, but the second can have any sign : the income effect can reinforce, or work against - even cancel-, the substitution effect.

In both cases shown in Figure 1 the total demand for transport *T* increases from T_1 to T_2. These « trips » can be produced by any combination of modal trips t_1 and t_2 shown on the 45° lines of the accompanying graphs.

The particular way in which the Hicksian substitution and income effects are defined opens the door to the definition of net effects. However this is a door that we do not need to open because the gross effects, defined by comparing the ORIGINAL point 1 with the FINAL point 2, allow for a definition of substitution/complementarity that is in effect independent from the type of decomposition used, as we shall presently make clear in presenting other decompositions.

ii) Slutsky substitution

Now consider a fall in the *price of transport*, but define an hypothetical price line (denoted by dots in Figure 2) that, at the new relative prices incorporated in the final budget line, makes it possible to purchase the original bundle 1 : the maximum output point SS affordable on this line defines the Slutsky substitution effect from 1 to SS and the Slutsky income effect from SS to 2. Point SS is not, when compared to point 1, an « equal output » but an « equal budget » point. The advantage of this decomposition is that it eases the presentation of the standard transport decomposition.

B. The two-mode case in transport demand analysis

To simplify, assume that a drop in the price of transport *T* is in effect the result of a drop in the price of mode 1. In Figure 3, the original and final bundles 1 and 2 correspond to points of highest achievable output (or utility). If the fall in the price of mode 1 is assumed to produce a final budget line at 45°, the parallel through point 1 can designate simultaneously an **equal total trip** and an **equal budget** (Slutsky) line. This will make it possible to compare the three decompositions on the same graph.

Figure 1. Hicksian Substitution

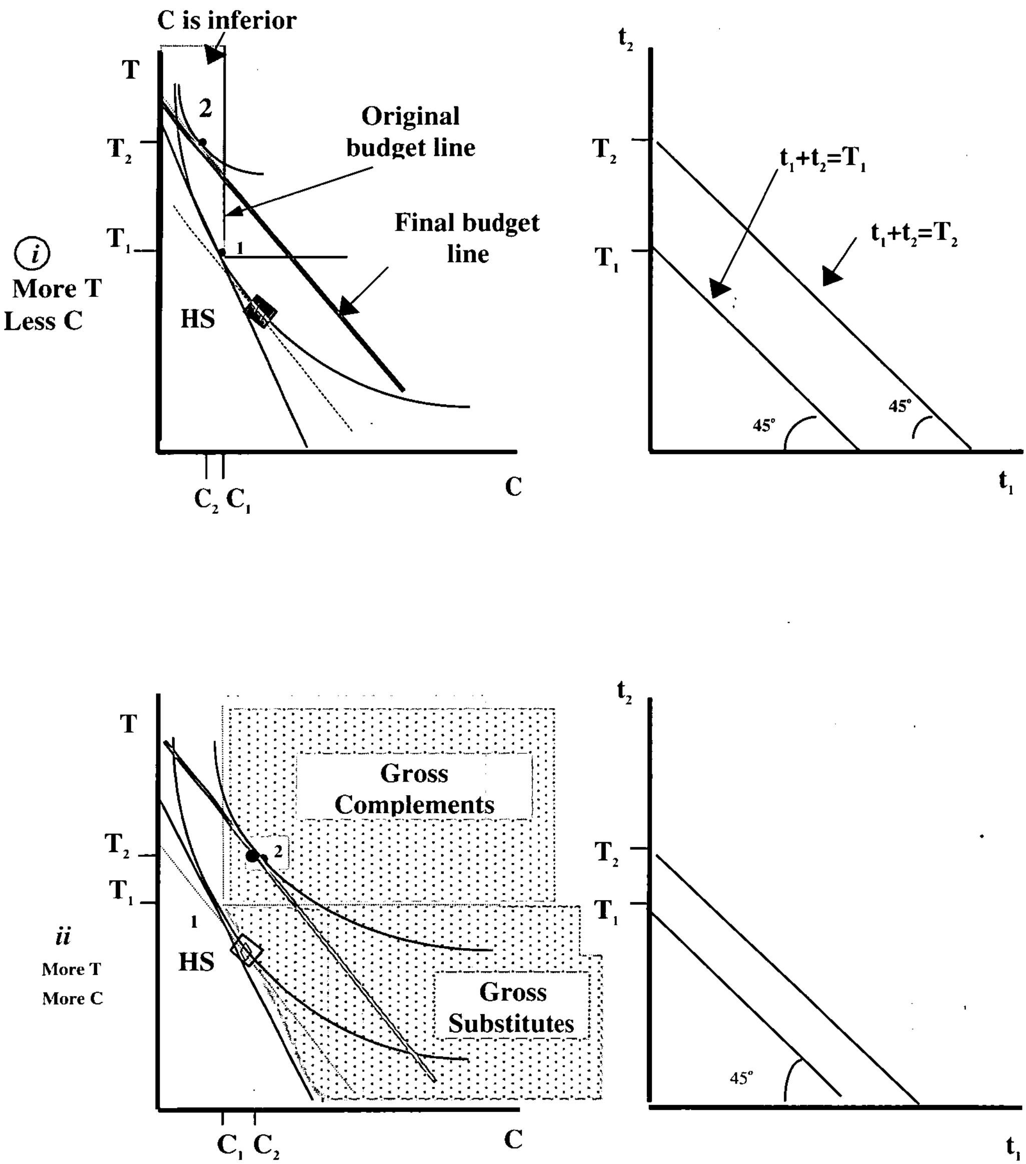
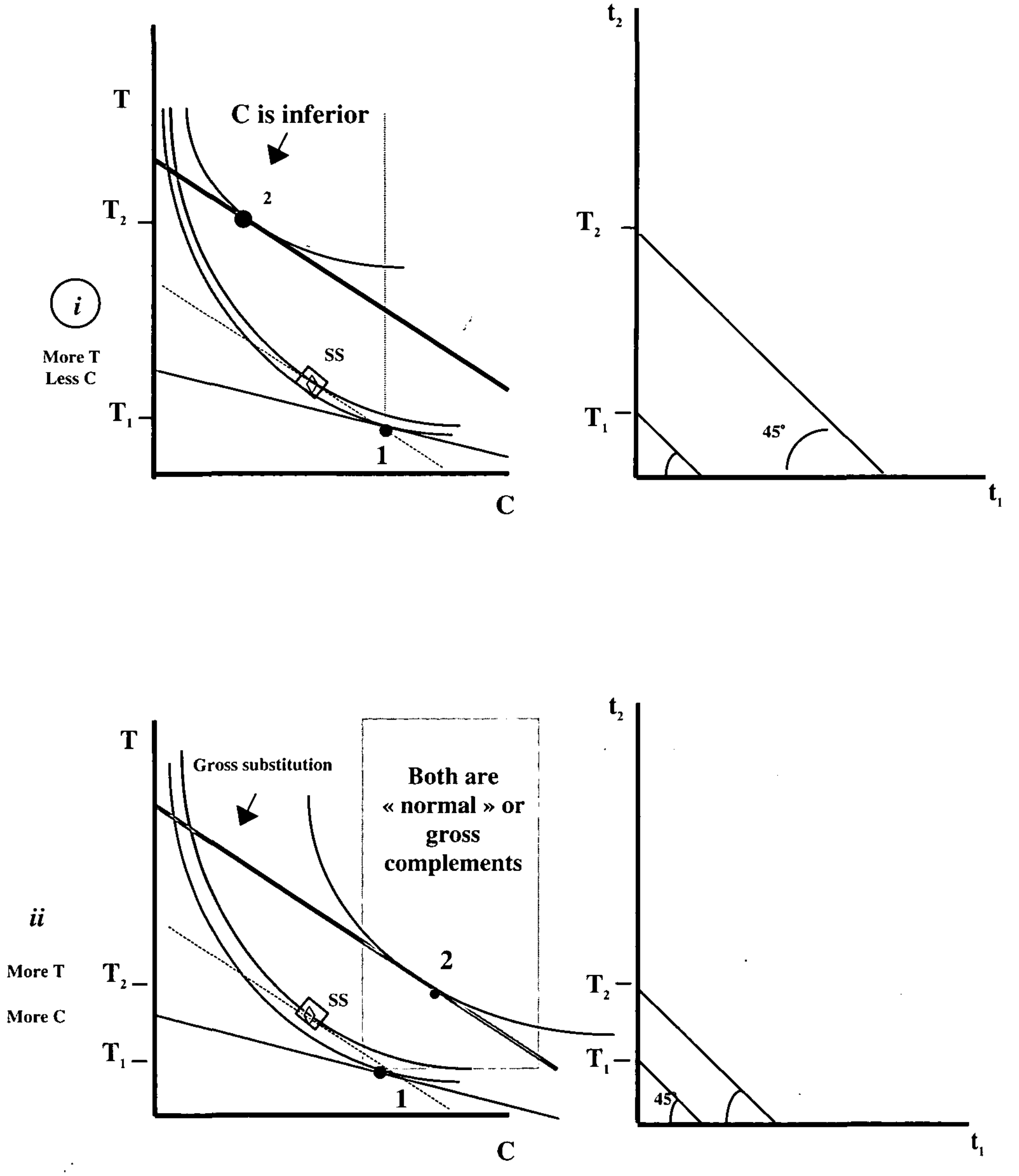


Figure 2. Slutsky Substitution



i) Modal diversion and induction

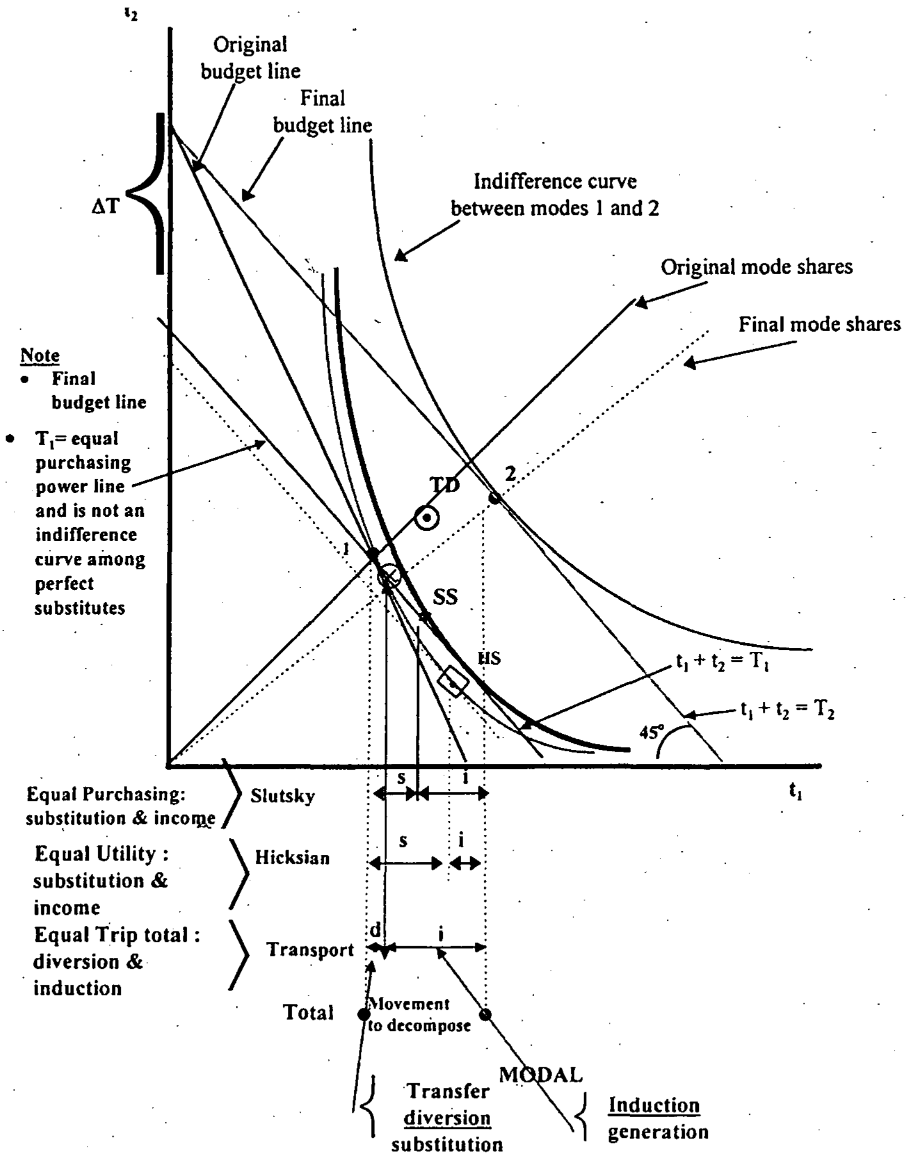
To understand the classic transport decomposition, first note that rays from the origin through points 1 and 2 denote the original and final modal splits. Along these rays, intersections with any constant total trip line will produce points, such as point TD, where the modal share has shifted from the original value at point 1, but where the total number of trips has not changed. By contrast, the movement from point TD to point 2 denotes the change in total trips holding modal shares constant. In transport analysis, the conceptual decomposition from 1 to TD is called **diversion, transfer or substitution** and the remaining component form TD to 2 is called **induction or generation**.

ii) Differences among the three decompositions

This preferred transport decomposition does not hold output or expenditure conceptually constant : rather, it holds the total number of trips constant to define the diversion effect. Although shown to be in the same direction as the Hicksian and Slutsky substitution effects in Figure 3, the diversion effect **not necessarily positive** like them because it does not rely on the map of indifference or isoquant curves : it is normally « expected » to be positive, an implicit judgement on the relative strength of the economic substitution and income effects in which it could itself be decomposed, or on the relative strength of the economic and substitution effects expected to hold as one moves from 1 to 2, a situation that is reflected in Figure 3 where these habitual expectations are fulfilled. To make stronger statements about the diversion effect, one would need special assumptions. By contrast induction, which « shifts » the modal shares and appears to work like an income effect, is only homologous—rather than analogous—to an income effect, because it is necessarily positive irrespective of the sign of the diversion effect.

The situation depicted in Figure 4 is more representative of experience than that shown in Figure 3 in the sense that the diversion effect is large and positive and the induction effect small and positive. One can fairly say that transport analysts expect diversion to be large relative to induction, or to account for most of the movement from 1 to 2, as in Figure 4. Naturally, there are many ways to compare diversion and induction effects, as one need not always use absolute values, as is done in Figure 4: it is often of interest to express the preferred transport decomposition in other ways, as we will now see.

Figure 3. Three Decompositions



Preferred Transport Decomposition

Figure 4. The Usual Transport Decomposition