

Intermodality and passenger transport

Isabelle Laplace, Nathalie Lenoir, Isabel Rebello, Francisco Pita, Antonio Valadares

▶ **To cite this version:**

Isabelle Laplace, Nathalie Lenoir, Isabel Rebello, Francisco Pita, Antonio Valadares. Intermodality and passenger transport. ETC 2005, European Transport Conference, Oct 2005, Strasbourg, France. pp xxxx. hal-01021742

HAL Id: hal-01021742
https://enac.hal.science/hal-01021742

Submitted on 15 Jul 2014

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

INTERMODALITY AND PASSENGER TRANSPORT

Isabelle LAPLACE,

M3 SYSTEMS,

Nathalie LENOIR ,

LEEA, Ecole Nationale de l'Aviation Civile, Toulouse, France

Isabel REBELLO, Francisco PITA, Antonio VALADARES

ANA Aeroportos de Portugal,SA

1. INTRODUCTION

Despite crisis and airlines demises, air traffic is still growing and projections are oriented upwards for the years and even decades to come. At the same time, major airports are already congested, and traffic flows are harder and harder to cope with. Moreover, air traffic generates pollution, and nuisances, both locally and in the atmosphere, and it is not clear today whether the forecasted increases can be sustainable in the medium to long term. The European commission, as a response to both congestion and pollution, sees intermodal travel as a valuable solution.

If there are so far few examples where intermodality at airport impacted air traffic, the number of these examples could increase with the level of airport intermodality, and the air traffic level and distribution could then be affected significantly. The European Commission assumes that a strong development of intermodal agreements could noticeably decrease air traffic on short and medium-haul. Change in traffic flows compared to the current situation, could be sizeable and involve deep changes in their traffic flow management.

This paper originates from a study performed for Eurocontrol in 2004, with a view to investigate the role of intermodality in relation to the airport of the future: "The airport of the future: Central link of intermodal transport?" [8].

In a broad sense, intermodal transport can be viewed as the transport of goods and passengers by the use of several coordinated transport modes. In the first section of this paper, we study the different forms of intermodality and define more precisely what are the forms relevant to (intermodality with) air travel. We also address the issue of financing intermodal infrastructure, and of incentives for signing agreements on the part of operators.

We turn next to the issue of the future of intermodality. The main difficulty appearing when analyzing intermodality lies in the large number of factors impacting its development and in their complex mutual influences. Determining how intermodality could develop requires to decompose the analysis in several steps. In part two, we

identify factors directly or indirectly influencing the development of airport intermodality and perform a qualitative analysis showing the factors' complex relationships. This analysis will then be used in part three for building and analyzing different scenarios of intermodality evolution at airport. Finally, in part four, those scenarios will be applied to Portugal and France, which constitute today polar cases of transport network development in Europe.

2. STATE–OF-THE-ART

Intermodality is the use of several transport modes in one trip when the transport modes are coordinated. This coordination is made thanks adequate intermodal infrastructure, and to intermodal agreements concluded by transport operators. These agreements for instance allow a common reservation for the whole trip, coordinated timetables, a common checking, the certainty to travel to the final destination despite delays faced by one or several transport modes during the trip, etc.

In the literature, the term "intermodal" transport applied to passengers using successively air and other transport modes is used equally for the airport access to the city centre or for the integration of the airport in the regional or national network of other transport modes. As the implications of both types of airport intermodality are different in terms of investment, passenger needs, operators coordination, transport policies, etc., we have chosen in this study to differentiate between them. In the case of airport access, the relevant modes to study are all public modes. In the case of integration of the airport in the regional or national network, only rail is relevant (and particularly high speed train), since bus services on long distances are quite rare in Europe, and do not seem to become more prominent in the future. Conversely, air/rail intermodality seems to offer promising opportunities for the future of the transport system by limiting the isolated use of road or air traffic (both responsible for congestion and air pollution) and providing combined trips, generally with rail. However, so far intermodal agreements are not very numerous in Europe, and it is therefore difficult to assess the real impacts of intermodality.

Despite this fact, developing air/rail intermodality remains an objective for numerous European states and for the European Commission. Intermodality and multimodality are indeed at the heart of the 2001 European Commission white paper on transport (European Transport Policy for 2010, time to decide [4]).

However, one of the major obstacles to a large development of intermodal transport is the funding problem. Indeed, building railways involves large investments in railway infrastructure (LEVINSON D., MATHIEU J.MM, GILLEN D., and KANAFARI A. [9]), which can sometimes limit the development of intermodal infrastructures. As the participation of the European Commission and of the national governments to the project financing may not be sufficient, the possibility of private funding can have a large impact on the project realization. One solution to convince airline operators to contribute with airport authorities to finance part of the project authorities could be to allow exclusive agreement between air and railway operators. When studying this aspect, GRUYER N., LENOIR N [6] conclude that without this exclusive agreement, the dominant airline could find it less interesting since other airlines could conclude

agreements with the railway operators and benefit from the intermodal link. The railway operator would also be more interested in financing with possibility of an exclusive agreement, especially if this agreement leads to the abandon of the route by the airline.

In addition, independently of funding aspects, the possibility of signing an exclusive agreement is an essential element for motivating the cooperation between railway and airline operators. Indeed airlines would be more ready to conclude an intermodal agreement with a railway company if it is certain that its rivals will not be able to negotiate other agreements. At the same time, the railway company would be all the more interested in concluding an exclusive agreement that the airline stops operating or reduces its frequencies on the considered route. This may however result in a diminution of competition detrimental to the consumer. The agreements between operators concerning specific routes, relations between operators can become complex. They indeed can be complementary in the market for connecting passengers on hub airport and at the same time rivals in the market of point-to-point travel. We can partly attribute the scarcity of intermodal agreements today to this situation where air and rail operators are competitors and have no incentives to cooperate.

3. QUALITATIVE ANALYSIS

When studying what could be the role of intermodal transport in the airport of the future in Europe, it is essential to determine what are the factors to be taken into account in our analysis. The difficulty lies in the large number of factors impacting the development of transport modes and in their complex relationships. Among these factors we differentiate the key factors from the resulting factors.

The key factors are the basic factors influencing the transport demand and supply. They may be factors external to the transport system, such as the world economy, the oil prices, the environmental policies, or the development of new technologies; or they can be internal factors such as the transport policies, the development of new transport technologies, the operators strategies.

The resulting factors are the consequences of the key factors evolution such as the level of traffic, of congestion, the transport policies. Figure 1 represents the relationships between Key and Resulting factors, which finally influence the level of airport intermodality.

In order to provide a clear representation of these relationships we have chosen to group the key and resulting factors according to their mutual influence but also according to their influence on other groups. key and resulting factors are then pooled in seven groups, each being composed of one or several factors.

Key factors composing group 1, i.e. world economy, oil prices, world geopolitical and mobility, can be considered as the basic group of factors influencing the development of air transport. Indeed these factors influence the transport demand but also the European and National policies. The propensity to use transport modes is largely influenced by the world economic and social situation.

Nevertheless changes in group 1 factors do not impact the different transport demands in the same way. For instance the development of terrorist attacks can dissuade

passenger from traveling for leisure as well as for business reasons, while it has a weaker effect on the freight transport demand. In addition, while it does not affect the passenger demand on leisure markets, the Key Factor “Development of new communication technologies” can impact on freight and business markets. That is why the Key Factor “Passenger demand on leisure markets” composes itself one group (Group 4).

Transport demand (groups 2 and 4), as well as the general economic setting (group 1) impacts on transport and environmental policies (group 3).. The Resulting Factor “Transport infrastructure development” also belongs to Group 3 since the decision building new transport infrastructures is related to the adopted transport and environmental policies.

Evolution of these three factors impacts on factors of Group 5. When elaborating their strategies, operators have to take into account policies and features of transport infrastructures. In the case of air transport, strategies of aircraft operators and aircraft builders are mutually influenced by one another. In addition the strategic decisions of operators can lead the European and national entities to adapt their policies and the need of transport infrastructure can differ according to these strategies. For instance, the arrival of low-cost airlines in secondary airports often leads to adapt the infrastructure to the additional traffic by extending the airport terminal for example.

Changes in these strategies will have a large impact on the levels of competition and cooperation (Group 6) which finally determines the level of airport intermodality.

The relationships shown between these Key and Resulting factors are used in the scenarios building.

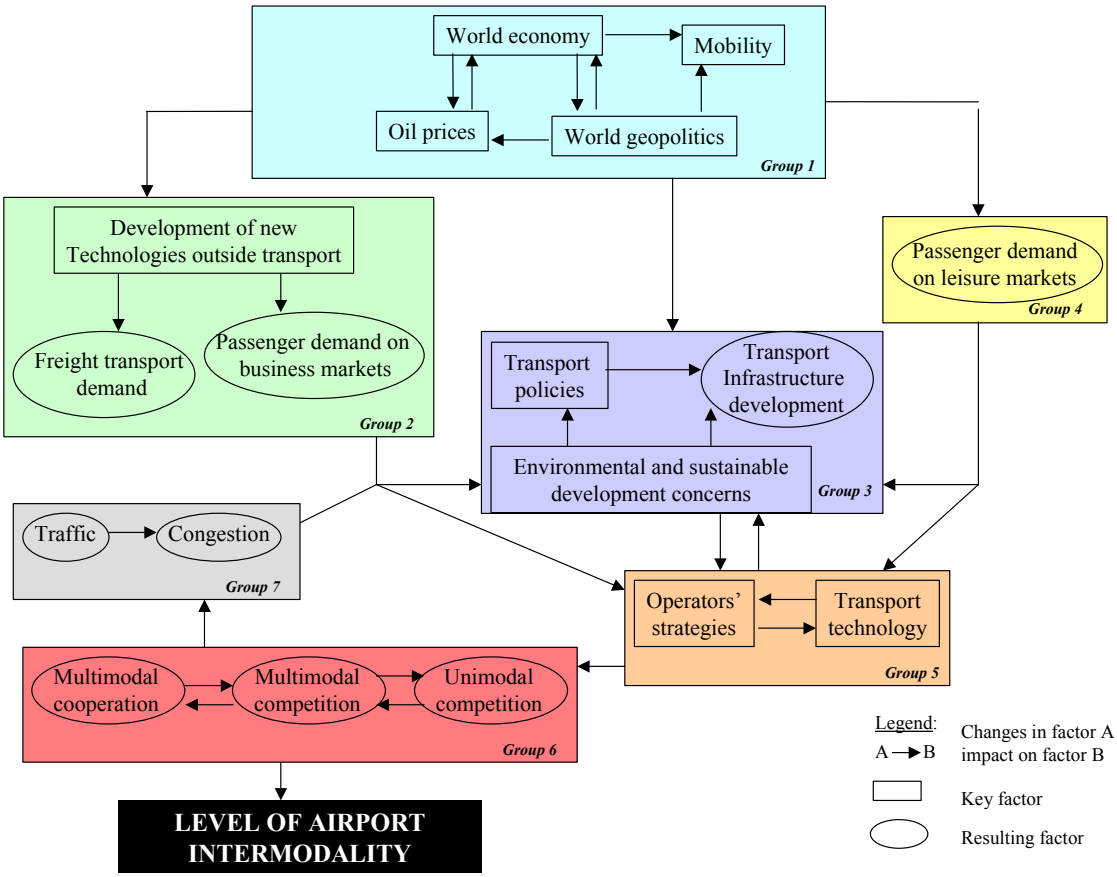


Figure 1: Relationships between Key and Resulting factors

4. SCENARIOS OF EVOLUTION OF AIRPORT INTERMODALITY

The qualitative analysis presented in the previous sections is then used for building scenarios of evolution of intermodality at airport for the next 15-20 years. Let us remark that these scenarios are not tools to be used for forecasting but tools to assess the sensitivity of intermodality development to its environment. In this context it is equally important to study a medium or "realistic" scenario as to study "extreme" cases.

As baseline of our scenarios we consider that the evolution trends of some of the key factors will be the same for all of the studied scenarios. For example, we can assume that the globalization process will go on, even if the pace can be more or less rapid. The same can be said about the price of oil, which can be expected to increase, the extent of that increase being the question mark. The details of these evolutions can be found in the study [8].

However, the extent of these trends can change between the scenarios. The association of the various nuances of these trends and of the key factors' relationships has led to consider three scenarios: a scenario A assuming a continuation in the current instability situation, a scenario B assuming an evolution toward a strong instability situation and a scenario C considering a situation of global stability. Scenario A is

furthermore split into two sub-scenarios, according to the level of environmental concerns. The main assumptions used in these scenarios are presented in Table 1.

The results of these scenarios in terms of intermodal agreements are then detailed in Table 2

Scenarios A1 and A2 both assume a high economic growth in Europe with moderate international tensions coupled with a moderate increase in oil prices. As a consequence, leisure passenger demand increases moderately due to high level of economic inequalities between world states, the geopolitical context and a moderate fear of terrorism. On the other hand, the business passengers as well as the freight demand strongly increase due to the good economic growth and the increase in world trade. The main difference between both scenarios lies in the environmental concerns in Europe which are strong in scenario A1 and only moderate in scenario A2. These difference in levels of environmental concerns will lead to different transport policies and finally to different development of intermodality at airports. In scenario A1, the transport policies are oriented towards the development of modes more environment friendly than road and air, such as rail or buses for passengers and sea or rail for freight. Conversely, in scenario A2, authorities choose to develop infrastructure so as to quickly respond to the traffic demand and the congestion problems. Investments on transport infrastructure concern all mode of transport for both scenarios but are more important on rail infrastructure in scenario A1.

Finally both scenarios will lead to different levels of intermodality development at airports. Indeed, in scenario A1, full service carriers (FSC) do need to shift part of their short and medium-haul flights on high speed train (HST) in order to free slots because airport capacity is not expanded. Hence with the strong development of HST over Europe there is a moderate use of intermodal agreements on short haul trips between majors and rail operators. These agreements are used by FSCs as a way to counter the low-cost carriers (LCC) and to free slots for long haul flights (using bigger airplanes thus increasing the number of passengers per slot). Moreover, the strong investments on rail access to main airports, especially in dedicated airport trains, favor the existence of intermodal agreements between air and rail operators allowing passengers to check-in for their flight at the rail station. Besides to these air/rail agreements, the development of secondary airports leads to the development of air/bus intermodal agreements in order to ease airport access by public transport. Rising costs of freight road transport leads to a revival of rail freight transport, on infrastructures left “vacant” (because of HST new infrastructure). This also leads to intermodal agreements with air/maritime operators and rail operators for freight transport.

In scenario A2, With an increase in airport capacity, airlines are able to cope with the demand growth without needing to cooperate with other modes. In addition, the limited development of HST infrastructure over Europe also prevents a large use of intermodal agreements on short haul trips between majors airlines and rail operators, but they still continue to conclude these agreements each time it is possible in order to counter the LCCs. At the same time, the number of air/rail intermodal agreements relative to the airport access is limited due to the moderate development of rail access. The main development of intermodal cooperation concerns the air/bus agreements concluded

both on main and secondary airports. Despite the rising costs of freight road transport, it still represents the main freight transport mode.

Scenario B assumes a low economic growth in Europe with high international tensions and high oil prices. In a context of economic crisis in Europe the environmental concerns are weak : the main aim is to find a way to quickly revitalize the economy and not to impose new environmental constraints that could impede this revitalization process. Fear of terrorism leads to a decrease in the mobility of business and leisure passengers while globalization allows a good level of freight mobility. Leisure and business passengers' transport demand is all the weaker that transport prices are high. Only freight transport demand is well oriented, although weak economic growth and high prices dampens transport growth. In this context, capacity increase is not an issue. European existing airport, rail and road capacity have to cope with the existing demand, since anyway the weak economic growth does not enable heavy investments. As a consequence, no new big projects on transport infrastructure and airport access are launched meaning that States have weak incentives to invest on rail infrastructure and on airport infrastructure.

Intermodal projects between air and HSR remain limited by the lack of infrastructure development. In general, operators do not feel the need for cooperation, as they are fighting for passengers and market shares. Air/rail intermodal agreements relative to airport access are scarce due to the small number of airport connections by rail. Only bus and air manage to moderately develop intermodal agreements. The increase in freight transport demand is translated into an increase in the freight transport by truck, and road/rail intermodal agreements are scarce due to the lack of rail infrastructure development. Nevertheless, the moderate increase in freight demand enables the development of air/road intermodal agreements, even if the number of these agreements remains small.

Scenario C assumes that while the globalization process goes on, the rise of social and humanitarian movements, as well as a revival of social policies enable a more equal increase and distribution of revenues. International instability is weak, and this allows for a moderate economic growth throughout most regions of the world (except in dynamic developing regions, like for example China or India). Weak international tensions associated to a moderate economic growth, reduce the tensions on oil prices. If oil prices increase due to the tensions in the oil production markets, they are not so volatile as in previous scenarios. As a result, there is a high general passengers' mobility level, since more people have access to decent revenue. This moderate economic growth associated to the globalization process stimulate the freight mobility. In developed countries, and specifically Europe, the environmental concerns are strong. The European transport policies are taking those concerns into account, and are therefore oriented towards the development of modes more environment friendly than road. The level of infrastructure investments in Europe is hence constrained by the moderate economic growth but at the same time stimulated by the high transport demand and environmental concerns. Investments mainly concern rail infrastructure, and favor intermodal solutions, for short to medium trips in order to reduce the strong air and road congestion due to the high transport demand.

Major FSC carriers take advantage of the HST to feed their flights in order to free slots for long haul flights. These intermodal agreements are also used by FSCs as a way to counter the Low-Cost carriers. The investments in dedicated rail link to airport also allow to decrease road congestion and favor intermodal agreements between rail and air operators for airport access. Besides these air/rail agreements, the development of secondary airports leads to the development of air/bus intermodal agreements in order to ease airport access by public transport.

Table 1: Main key and resulting factors evolutions in all scenarios

Scenario		Economic growth level	Environmental concerns	International tensions	Oil prices	Passenger demand		Freight demand
						Business	Leisure	
A	A1	High	Strong	Moderate	Moderate increase	High increase	Moderate increase	High increase
	A2		Moderate					
B		Low	Weak	High	High increase	Weak increase	Weak increase	Moderate increase
C		Moderate	Strong	Weak	Weak increase	High increase	High increase	Moderate increase

Table 2: Scenarios' results in terms of airport intermodality

Scenario		Level of use of **air/HST** intermodal agreements on passengers' markets	Level of use of **air/rail** intermodal agreements for **airport access**	Level of use of **air/bus** intermodal agreements for **airport access**	Level of use of **air/rail** intermodal agreements on **freight** markets	Level of use of **air/road** intermodal agreements on **freight** markets
A	A1	Moderate	Moderate	Moderate	High	Moderate
	A2	Weak	Weak	Moderate	Moderate	Moderate
B		Weak	Weak	Weak	Weak	Weak
C		High	High	Moderate	High	Moderate

As a consequence, scenario C would be the most favorable scenario for the development of airport intermodality, even if this scenario does not assume a good economic growth. In the framework of the considered scenarios a good economic growth would not be sufficient for strongly developing airport intermodality, while the

globalization process would lead to mixed effects on multimodal cooperation for passenger transport and to positive effects on freight transport growth and multimodal cooperation. The studied scenarios also highlight the importance of environmental concerns on the development of airport intermodality since this factor influence numerous factors such as transport policies, transport prices, etc. From these scenarios, we can identify the factors that either isolated or in combination, have a positive influence on intermodality development : pressure on (airport) infrastructures, environmental concerns, high prices of oil (by not so high as to lead to crisis, and depress transport demand)

5. FRENCH AND PORTUGUESE SCENARIOS

Concrete applications of these scenarios have been made in the case of France and Portugal, which by their difference in the current infrastructure development can be considered as representing the situation in “Core” European countries and less developed or new European countries respectively. Indeed Portugal does not have yet intermodal infrastructure but plans to integrate Porto airport in the future high-speed rail network. Hence while France can develop its intermodal infrastructures by improving the integration of airports in the TGV network, Portugal has to start building HSR infrastructure as a base of this development. This Portuguese HSR network building, which is a priority project, will start from 2006.

Table 3 and 4 present future transport infrastructure considered in each scenario for Portugal and France respectively. In both countries, the building of new airports is dependent on a good economic growth and is only considered in scenarios A1 and A2.
If only two projects are already adopted in France (TGV Est and Leslys) and appear in all scenarios, four essential projects are considered in all Portuguese scenarios (Lisbon-Porto HSR (linked to Oporto airport), Porto-Vigo HSR (linked to Oporto airport), Lisbon-Madrid HSR and Porto metro linked to Oporto airport. As well for the French as for the Portuguese cases investments on extra HST infrastructure are only considered in scenarios assuming a strong environmental concern and with a good or moderate economic growth allowing these investments(scenarios A1 and C respectively).

Another common point between both countries lies in their will to improve airport access. Indeed, Leslys project linking Lyon Saint-Exupery airport and the Porto metro linking Oporto airport, belong to the already adopted projects.If despite their difference in current level of airport intermodality similitude appear in the development of transport infrastructure, the main important similitude lies in the development of intermodal agreements . Scenarios applied to both countries lead to the same results shown in table 5 . These common impacts of scenarios on the development of intermodality despite the large differences existing in both countries, lead to the main conclusions that building new infrastructure is a condition necessary but not sufficient for developing airport intermodality.

Table 3: Portuguese transport infrastructure by scenario

		Scenario A1	Scenario A2	Scenario B	Scenario C
Transport infrastructure	***Airport***	➢ New Lisbon airport	➢ New Lisbon airport	➢ No new airport	➢ No new airport
	HST	➢ Lisbon-Porto (linked to Oporto airport) ➢ Porto-Vigo (linked to Oporto airport) ➢ Aveiro-Salamanca ➢ Lisbon-Madrid ➢ Evora-Faro-Huelva	➢ Lisbon-Porto (linked to Oporto airport) ➢ Porto-Vigo (linked to Oporto airport) ➢ Lisbon-Madrid	➢ Lisbon-Porto (linked to Oporto airport) ➢ Porto-Vigo (linked to Oporto airport) ➢ Lisbon-Madrid	➢ Lisbon-Porto (linked to Oporto airport) ➢ Porto-Vigo (linked to Oporto airport) ➢ Aveiro-Salamanca ➢ Lisbon-Madrid ➢ Evora-Faro-Huelva
	Airport access	➢ Porto metro linked to Oporto airport ➢ Dedicated rail link to new Lisbon airport	➢ Porto metro linked to Oporto airport ➢ Dedicated rail link to new Lisbon airport	➢ Porto metro linked to Oporto airport	➢ Porto metro linked to Oporto airport

Indeed, in France as well as in Portugal, the high competition level between airlines and HST on some routes, could lead airlines to conclude intermodal agreements with rail operators in order to alleviate competition. The general development of intermodal agreements between operators should also be strongly related to the level of congestion at airports. A high congestion level would be a strong incentive for airlines to feed their flights with TGV in order to free slots for other destinations.

In general, if new transport infrastructure could lead to the development of the competition between air and rail on short-haul connections, the level of this competition should play an essential role in the development of intermodal agreements. The higher the HSR market share, the stronger the airlines' incentives to cooperate with rail operators.

Table 4: French transport infrastructure by scenario

		Scenario A1	Scenario A2	Scenario B	Scenario C
Transport infrastructure	***Airport***	➢ Notre-Dame-des-Landes ➢ New Toulouse airport	➢ Notre-Dame-des-Landes ➢ New Toulouse airport	➢ No new airport	➢ No new airport
	TGV	➢ TGV Est linked to CDG airport ➢ TGV Rhin-Rhone linked to Bale-Mulhouse airport ➢ TGV Côte d'Azur linked to Nice airport ➢ TGV interconnection station at Orly airport ➢ TGV Freight Express at CDG airport ➢ TGV Toulouse-Bordeaux linked to new Toulouse airport ➢ TGV Ouest linked to Notre-Dame-des-Landes airport	➢ TGV Est	➢ TGV Est	➢ Lisbon-Porto (linked to Oporto airport) ➢ Porto-Vigo (linked to Oporto airport) ➢ Aveiro-Salamanca ➢ Lisbon-Madrid ➢ Evora-Faro-Huelva
	Airport access	➢ CDG Express ➢ Leslys	➢ CDG Express ➢ Leslys ➢ Dedicated rail link to Notre-Dame-des-Landes airport ➢ Dedicated rail link to new Toulouse airport	➢ Leslys	➢ Porto metro linked to Oporto airport ➢ Lisbon metro linked to Lisbon airport

Table 5: Development of intermodal agreements by scenario

		Scenario A1	Scenario A2	Scenario B	Scenario C
Development of intermodal agreements for passengers' transport	***Air/HST***	Moderate	Weak	Weak	High
	Air/rail for airport access	Moderate	Moderate	Weak	High
	Air/bus for airport access	Moderate	Moderate	Moderate	Moderate
Development of intermodal agreements for freight transport	***Air/rail***	Moderate	Weak	Weak	Moderate
	Air/road	Moderate	Moderate	Weak	Weak

6. CONCLUDING REMARKS

Building scenarios of transport network evolution for the next 15-20 years and applying them to the French and Portuguese cases have led us to the conclusion that building intermodal infrastructure could not prove sufficient to develop airport intermodality. Empirical evidence supports these finding, as in countries where intermodal infrastructure is developed, ,intermodal agreements remain scarce.

If as a base for intermodal development, intermodal infrastructure has to be built, the future of airport intermodality should also be largely impacted by the transport markets environment: The general economic environment, the competition levels on the transport markets, the transport and environmental policies as well as the air capacity constraints will be deciding factors in this respect. Our scenarios have shown us that the association of some conditions could promote the development of intermodal agreements between transport operators while other conditions would impede it. Favorable factors are for example : pressure on (airport) infrastructures, environmental concerns, high prices of oil (by not so high as to lead to crisis, and depress transport demand).

With a view to developing intermodality, transport policies suitable to the economic environment are decisive but they also need to be supplemented by the use of economic instruments, administrative or regulatory measures in order to promote this development by giving transport operators incentives to cooperate.

In the continuation of our work, we therefore plan to identify and study such instruments (such as for instance the introduction of a Kerosene tax or a new allocation of airport slots) as well as their effects on the development of intermodality.

We will also analyze the consequences of intermodality development on the competition levels and organization of transport markets, since intermodality, by giving incentives to transport operators to cooperate, could induce a reduction in competition detrimental to the consumer and reducing welfare.

REFERENCES

[1] ACARE, 2003, *The economic impact of air transport on the European economy*", Advisory Council for Aeronautical Research kin Europe

[2] DATAR, 2003, *France en Europe: Quelle ambition pour la politique des transports?*, Etude prospective de la DATAR

[3] EUROCONTROL, 2002, *Medium and long term sustainable growth in air transport*, EEC Note N°11/02, September 2002

[4] EUROPEAN COMMISSION, 2001, *White Paper, European transport policy for 2010: time to decide*, European Communities

[5] GROUPE DE TRAVAIL GUYARD, 2004, *Multimodalité Avion-TGV* , July 2004

[6] GRUYER N., N. LENOIR, 2004, *Air and rail: Cooperating and competing?* , Aviation Economics and Econometrics Laboratory, Ecole Nationale de l'Aviation Civile, Working Paper

[7] IATA, 2003, *Air/rail Intermodality study*, February 2003

[8] LAPLACE I., N. LENOIR, F. PITA, I. REBELLO, A. VALADARES, 2004 *CARE II: The airport of the future: Central link of intermodal transport?*, M3 SYSTEMS, ANA, ENAC-AEEL, April, Dec. 2004.

[9] LEVINSON D., J.M. MATHIEU, D. GILLEN, A. KANAFARI, 1997, *The full cost of high-speed rail: an engineering approach*, The Annals of Regional Science, N°31, pp189-215