

**Technical and Institutional Priorities for Enhancing Rail/Aviation
Cooperation for the Future Intercity Passenger Transportation**

by

Dalong Shi

Submitted to the Engineering Systems Division
in partial fulfillment of the requirements for the degree of

Master of Science in Technology and Policy

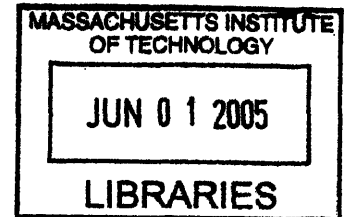
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Abstract

There are currently about 120 airport rail links existing or proposed to be constructed around the world. The growth in the number of airport rail links reflects the almost relentless growth in air travel and the associated worsening congestion and delays on both landside and airside of airports. Rail-Air Passenger Intermodal Development (RAPID) in the United States has lagged behind the world trend, especially in comparison with Europe and Japan.

This paper consists of two tasks: to examine technical priorities for the competitiveness of rail as a feeder to airports, and to identify key barriers and recommend changes for RAPID development in this nation. Having an effective intermodal connection has proved to be the prerequisite for the successfulness of RAPID. When such a connection is available, enhancing intermodal cooperation is likely to be more effective than operating high speed rail in terms of the competitiveness of rail for airport trips. The speed of trains only needs to be high enough to ensure door-to-door trip time advantages over highways and flights in short- to mid- distance corridors. All the necessary technical options for RAPID have been widely applied in the world for decades.

Even without technical challenges, RAPID development might be expensive and complicated with many stakeholders and interest groups directly and indirectly impacted. Lack of effective intermodal infrastructure has been the primary hurdle impeding RAPID development in this nation. Unbalanced development in this nation's intercity passenger transportation system has resulted in the inability of intercity railroads to promote RAPID and the unwillingness of air carriers to connect and cooperate with the rail system. These problems make RAPID unlikely to be developed by relying solely on the private sector. Mode separation in the administrative framework and modal bias in policy generate further hurdles for RAPID from the public sector in terms of public funding, information, planning and cooperation. To successfully achieve RAPID, the federal government must play a major role in terms of providing a) sufficient federal funding specifically for RAPID infrastructures and b) incentives to enhance the willingness of state and localities to support RAPID. The federal leadership and institutional support will also be necessary to increase modal integration to facilitate RAPID research, planning and decision making.

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Chapter 1: Introduction

Key Word: RAPID-Rail/Aviation Passenger Intermodal Development

Ground access to airports is an important function that must be provided at the regional level as well as in the immediate vicinity of the facility itself. Congestion problems affecting airport access are in some instances approaching unacceptable levels, including negative impacts on air quality and other environmental considerations. To meet longer term accessibility goals and to address growing congestion and air quality concerns in metropolitan areas, many airports worldwide are seriously examining rail access, especially in Europe. By 2003, there were about 120 airport rail links existing or proposed to be constructed around the world. The growth in the number of airport rail links reflects the almost relentless growth in air travel and the associated worsening congestion and delays on both landside and airside of airports. Along with increasing concerns on system mobility worldwide, more and more airports have a ready planned or are planning to be plugged into an intercity High Speed Rail (HSR) network, in which HSR services are playing two roles: 1) providing airports better access to the connected urban centers; 2) and displacing short- to mid- distance flights to free valuable airport slots for lucrative long distance flights.

The benefits and appeal of rail are well understood. Rail uses less energy, produces fewer greenhouse gases, offers travelers more comfortable and more productive services en route, and has better immunity to bad weather. Rail passenger service has the potential for competing with highway transport for shorter distances and with air transport for medium distances. For short-distance intercity passenger transportation, driving an auto might be the best option, because it is flexible, convenient and cheap. As distance increases, rail and air become more competitive. Air has significant speed advantages over other modes, but it is always less accessible to downtown residents and requires longer terminal times. A conventional intercity train operating at less than 100 mph could achieve a similar or even shorter total trip time than air for short- to mid-distance trips. Moreover, trains could provide passengers more comfortable and productive in-vehicle times. In long distance markets, speed advantages make air dominant. It will be better to think of rail as part of an intermodal network.

In comparison with European countries and Japan, intercity rail-air intermodalism has lagged in the United States. Much of this difference is due to uneven development of passenger transportation systems in the United States, modal separation within the institutional structure, inadequate information channels and inadequate intermodal planning by governments and corporations. The primary objective of this paper is to examine the technical and institutional priorities for enhancing rail/air intermodal cooperation for the future intercity passenger transportation in the United States.

This paper consists of two tasks. The first is to examine the technical priorities for the competitiveness of rail-air system under various situations. The key to the first task will be the use of a utility model that relates characteristics of the trip to the utility of passengers for a wide variety of assumptions concerning market segments. This model was applied in the author's prior

studies for passenger transportation.¹ Utility analyses will be conducted in three steps, starting from a basic scenario, in which rail and air are serious competitors and independently operated, and ending with a fully intermodal integrated system. The focus will be on three key technical options for improving the competitiveness of intercity rail for airport trips: constructing effective intermodal connections, operating high speed rail and enhancing air/rail intermodal cooperation. After the utility analyses, a number of cases from Asia, Europe and North America will be studied to generate experiences and lessons for examining the priorities of the three technical options under various situations.

The second task is to identify the key barriers impeding successful implementation of RAPID in this nation and to recommend institutional and policy changes to facilitate RAPID development in the United States. As a first step, the analyses for this task will start with an overview of the status and performance of current intercity passenger transportation in the United States. It will show that all three key components for a true rail/air intermodal system (infrastructure, information and cooperation) are missing in the United States. Meanwhile, modal bias in the United States transportation system has resulted in airlines and airports are unwilling to connect and cooperate with intercity railroad. The second step is to identify the barriers associated with public policy toward intermodal transportation in the United States, including Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The analyses will indicate that decades of modally-focused administrative structure and policy have resulted not only in the unbalanced development among the primary intercity passenger transportation modes, but also in the lack of intermodal planning, infrastructure, information, and financing. ISTEA has been a good step toward promoting intermodal transportation, but it has been insufficient to change current unbalanced development or to facilitate RAPID implementation in US. As a third step, four successful air-rail intermodal systems in European countries are studied to identify their key experiences and lessons. Finally, several institutional and policy changes are recommended to promote RAPID development in this nation.

¹ Shi, Dalong, Master of Science in Transportation Studies, *Feasibility and Effectiveness of Rail-Air Intermodalism for Intercity Passenger Transportation*, August 2003.

Chapter 2: Methodologies

This paper consists of two tasks. The first is to examine the technical priorities for the competitiveness of rail-air system under various situations. The focus is on the effectiveness of three major technical options on the competitiveness of rail for airport trips: building direct rail connection to airport, operating high speed rail and enhancing rail/air intermodal cooperation. The second task is to identify the key barriers impeding successful implementation of RAPID in the United States and to recommend institutional and policy changes to facilitate RAPID development in this nation. Utility analyses and case studies will be the key methodologies to conduct analyses in this paper. This chapter is to introduce how utility concept is applied to construct the Utility model and how cases are selected and studied to generate real experiences and lessons.

2.1 Utility Model and LOGIT Model

This thesis is a continuation of a larger project—"Identifying Critical Technologies For The International Railroad Industry"—that was conducted for the International Union of Railways (UIC) by Center of Transportation Studies, Massachusetts Institute Of Technology. Utility analysis is one of the basic methodologies used in that project to quantify the impact of technical improvements on system performance from the customer's viewpoint. A detailed utility model was constructed in author's prior thesis² to relate characteristics of the trips to the utility of passengers.

Basically, travelers' mode choice is based upon direct out-of-pocket cost, travel times and qualitative issues concerning the trip, including convenience, comfort, productivity, reliability and safety. To estimate how these factors affect travelers' mode choice in intercity passenger transportation market, Utility Model applied the utility concept in demand modeling to quantify these factors in monetary terms, producing "disutility" results for each travel option. In the utility model, disutility is calculated as a function of length of trip times, values of times, and direct out-of-pocket costs. The weights used to aggregate these parameters depend upon passenger characteristics. A LOGIT Model is then used to estimate the mode splits in certain market segments based upon "disutility" results. The following is to show how "disutility" results and modal split are calculated.

Primary Competing Modes

The utility analyses in this paper will focus on three primary intercity passenger transportation modes in the United States: private automobile, intercity trains and air flights. Each of them has their own preferred markets. Driving an auto is the best option for short-distance trips because it is flexible, convenient and cheap. As distance increase, rail and air become more and more competitive. Air has significant speed advantages over other modes, but it is less accessible to downtown residents and requires longer terminal time and fixed on-board times per trip including taxiway times, taking off and landing times. A conventional intercity train operating at less than 100 mph (top speed) could achieve a similar or even shorter total trip time than air in short-to-mid distance corridors. Moreover, rail could provide better allocation of trip time than air option in terms of better accessibility to downtown residents and providing more comfortable

² Shi, Dalong, Master of Science in Transportation Studies, *Feasibility and Effectiveness of Rail-Air Intermodalism for Intercity Passenger Transportation*, August 2003.

and productive in-vehicle times. In long distance markets, air becomes dominant because of its speed advantages.

Trip Times

Since the utility of the time spent in distinct trip segments will be varied, the utility model breaks the airport trip into three segments based upon the activity and quality of various segments: access segment, in-vehicle segment, and transfer segment.

Access segment refer to the period from the time that travelers leave home or office to the time after boarding on the vehicle. The times in this segment includes time for service reservation, access time to terminal, buffer time for access unreliability, times spent in terminal (process time, queue time and waiting time), and boarding times. Based upon the same assumptions in the utility model of the author's prior thesis [Shi, p. 29], the total access time for downtown residents is around 2.25 hour for air option, 0 for driving auto, and 1 hour for intercity trains.

In-vehicle segment refers to the period from the time that travelers board on vehicle to the time that travelers alight from vehicle. The following function was used to calculate the in-vehicle time:

$$\text{In-vehicle time} = \text{NT} + \text{TL at DT} + \text{TL at IT} + \text{TL at AT}$$

- NT: Net In-vehicle time= In-vehicle one-way distance / Operation Speed. Operation speed refers to the speed that vehicles are operated under normal condition (without any speed limit), which could be close to top speed.
- TL at DT: Time loss At Departure Terminal. It is assumed to be 0.2 hour for intercity train, which is comprised of the waiting time for departing, departing terminal under speed limit and accelerating time. For Air, it is assumed to be 0.5 in the base case, which is comprised of time loss at taxiways and time for taking off.
- TL at IT: Time loss at intermediate stops= No. Of stops * Time-loss per stop. For intercity train, Time-loss per intermediate stop is assumed to be 0.3 hour in the base case, which comprised of necessary times for passenger service, maintenance, loco changing, accelerating, decelerating, and so on.
- TL at AT: time loss at arrival terminal, which is similar to TL at DT.

Transfer segment refers to the time that passenger transfer from downtown railway stations, airport parking lots, or arriving flight to capture long-haul flight at airport. The transfer times for each option include service reservation time for long-haul flight, exiting time from vehicle, time for picking up baggage, access time to airport hub, times in hub (process time, queue time and waiting time), buffer time for transferring unreliability, and boarding time to long haul flight.

Direct Out-of-Pocket (OOP) Cost Calculation

In the Utility Model of author's prior thesis, the fare structures for the three modes were assumed as following:

- Intercity Train: It requires US \$ 25 fixed charge plus US \$ 0.3 per person mile of trip distance

- Air: It requires US\$ 100 fixed charge plus US\$ 0.5 per mile of trip distance.
- Driving Auto: the Direct Out-of-Pocket cost is assumed to be US\$ 0.3 per mile without fixed charge.
- Taxi fee: the cost is assumed to be \$1 per mile. When access to or egress from airports, there is a \$4 fixed charge for “Airport Users Charge”

Value of Time

In the utility model, the concept of values of times is applied to quantify the trip times and associated qualitative issues in each trip segment into monetary term to directly compare with direct out-of-pocket costs. When travel demand models are calibrated, they commonly show that the value of time varies for different portions of the trip, with in-vehicle time viewed as less onerous than out-of-vehicle time. The coefficients for values of times are found to be significant fractions of the average wage, which may vary for different trip purposes and different types of passengers.³ In this regard, the following sample is to demonstrate how the concept of values of times is applied in the Utility Model. If travel by air or train, business executive with an average billable rate of \$100 per hour and a salary of \$50 per hour will view the value of time for each trip segment as following:

- Value of Out-of-vehicle time: Out-of-vehicle time includes the times for taking taxi or driving an auto to or from terminals, waiting and processing at terminals, boarding / exiting from vehicles, buffer for access unreliability, etc. Compared with the time spent moving in a vehicle, these times are unproductive, uncomfortable and stressful. It should certainly have negative utility. It is hypothesized that travelers would likely be willing to pay as much as the hourly salary to reduce one hour of such time. Therefore, the value of such time is assumed to be \$50 per hour.
- Value of in-vehicle time spent on working. If it is billable time, it could be valued at the billing rate, say \$100 per hour.
- Value of in-vehicle time spent on entertainment: Travelers could spend part of in-vehicle time watching TV, reading magazines, or eating. Such time is assumed to have a neutral value (\$0/hour value of time)
- Value of in-vehicle time spent on rest or other activities. This time cannot be as comfortable as at home and may have negative utility. It is assumed the value of such time is equal to 40% of salary, i.e. \$20 per hour.
- Opportunity cost. Basically, the shorter the travel time, the better for the travelers. Early arrival may allow business travelers to catch an important meeting, may allow the students attend a commencement party, or may allow vacation travelers spend more time on the journey site. While latter departure may allow less disruption in their sleeping patterns or spend more time with their family. It is assumed that for business executive, the opportunity cost for travel time is \$150 per hour.

The value of time for each trip segment will vary with the purpose of the trip and the types of travelers. Four typical market segments are classified:

³ Carl D. Martland, Lexcie Lu, Dalong Shi, and Joseph M. Sussman, Department of Civil and Environmental Engineering, Massachusetts Institute Technology, *Performance-Based Technology Scanning for Intercity Rail Passenger Systems*, Transportation Research Board, Paper No. 03-2545, 2002

- Business Executives with the highest value of time
- General Business Travelers. The value of time is assumed to be 50% of that for business executives.
- Vacation Travelers. The value of time is Assumed to be 25% of that for business executives
- Student Travelers. The value of time is assumed to be 10% of that for business executives.

Disutility Results and Modal Splits

The disutility generated from each trip segment is comprised of disutility of the time, the opportunity cost for such time and the necessary direct OOP cost. The first two parts are directly related to the length of trip time and the assumed values of times in each segment, while the direct OOP cost is mainly refer to the fare that set by operators. The final disutility results are calculated as following:

$$\text{Disutility for each option} = \text{Length of time in each trip segment} * \text{Values of Times} + \text{Direct OOP Cost} + \text{Opportunity Cost}$$

Based on the disutility results, a LOGIT model is used to estimate the mode splits for each market segment. The function is shown as following:

$$\text{Market Share} = \frac{e^{-\text{disutility of option } i}}{\text{Scale Factor}} \bigg/ \left(\sum \frac{e^{-\text{disutility of option } j}}{\text{Scale Factor}} \right)$$

Same as in author's prior thesis [Shi, p.11], the scale factor was assumed to be 25% of the average disutility of the mode with lowest disutility for each market segment. This factor determines how strongly mode shares vary with the relative utilities. If the disutility of two modes is within 5 or 10% of, they each have a sizable market share. If the disutility of one mode is much greater, then it has a very minor share of the market.

2.2 Case Studies

As increasingly concerns on the system mobility and meeting longer term accessibility goals for airports, by 2003, more than 120 airports worldwide had constructed or were considering rail links to greater metropolitan regions. It is unfortunate that Rail-air intermodalism development in the United States has lagged behind the world trend, especially in comparison with European countries and Japan. The good news for this nation is that there are sufficient real cases to generate lessons and experiences to guide RAPID development in the future United States.

To examine the technical priorities for RAPID development, five airport-rail systems from the world will be selected and studied in Chapter 3. The focus will be on the effectiveness of the three technical options on the competitiveness of rail for airport trips: direct rail connection, high speed rail and intermodal cooperation.

- Hong Kong International Airport Express Line is the first built specially for the purpose of serving an airport with its integrated design for stations and equipment. Its story will indicate that rail's competitiveness for airport trips are mainly generated from its high quality intermodal services.
- Shanghai Maglev project provides a typical example that high speed rail is not a remedy for the competitiveness of rail for intermodal travelers.
- Frankfurt International Airport and Zurich Airport provide successful examples that when effective physical connection and high performance rail services are available, rail could be a competitive alternative for feeder flights.
- Chicago O'hare International Airport provide an example that the lack of effective physical connection make rail uncompetitive to highway modes for airport trips.

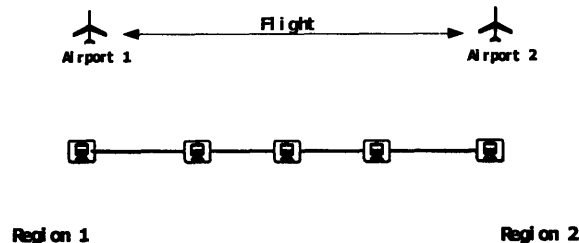
To identify the key barriers that impeding RAPID development in the United States, four European Airport-rail systems will be studied in Chapter 4, including Paris Charles De Gaulle, Lyon Airport, Frankfurt International Airport, and Dusseldorf Airport. The focus will be on how RAPID could be successfully developed by nature in European countries and what make the U.S different. The two French airport-rail links were initialized as part of the TGV network expansion project. The two German airport-rail links are demanded by airports, which are close to the existing Germany High Speed Rail network. All of them are true rail-air intermodal system with both effective physical intermodal connection and efficient intermodal cooperation.

Chapter 3: Technical Priorities

The primary objectives for enhancing the cooperation or coordination between air and intercity rail system are to provide airports more efficient and environment-friendly ground access to connected urban centers, as well as to displace short-mid distance flights to free valuable airport slots for lucrative long distance flights. To successfully achieve these goals, the aviation/rail intermodal system should be competitive with feeder flights and highway modes. The primary task of this chapter is to examine the effectiveness of various technical options on competitiveness of rail as a feeder to airports under different situations. The key to this task will be the use of a utility model that relates characteristics of the trip to the utility of passengers for a wide variety of assumptions concerning market segments, which was applied in author's prior studies for passenger transportation. Utility analyses will be conducted in three steps, starting from a basic scenario, in which rail and air are serious competitors and independently operated, and ending with a fully intermodal integrated system. The focus will be on three key technical options to improve the competitiveness of intercity rail for airport trips: constructing direct rail connection to airport, operating high speed rail and enhancing aviation/rail intermodal cooperation. As indicated in Diagram 3.2, the detailed outline of utility analyses is as following:

- Base scenario: in short-mid distance corridors, feeder flights, intercity rail and highway modes are the primary competitors for both intercity corridor travelers and hub airport transfers. As indicated in Diagram 3.1, corridor travelers refer to passengers originating and terminating in the regions inside the corridor. Airport transfers refer to passengers originating or terminating within this corridor, who transfer to or from long haul flights at the hub airport. Both of the two types of passengers are sharing the same rail service. It is assumed that railway stations are located within urban centers and airports located in suburban areas, there is no direct rail link and intermodal cooperation between railway and aviation systems. Utility analyses will indicate that railway could be easily competitive over highway modes and feeder flights for corridor travelers, but the difficulties and inconvenience associated with rail/air intermodal transferring are highly likely to make rail play as a negligible role for hub airport transfers.

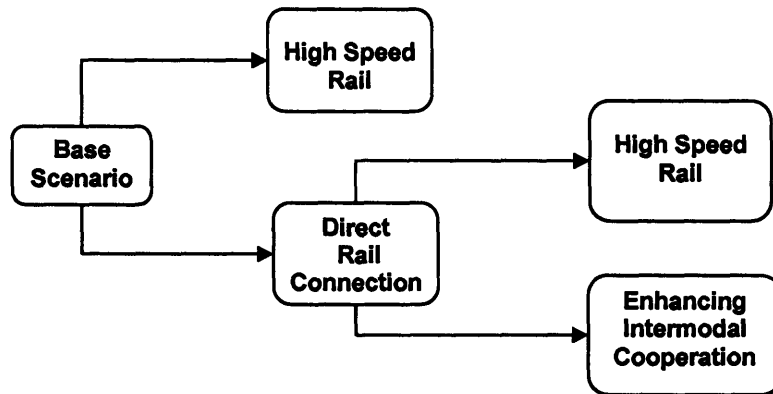
Diagram 3.1: Base Scenario Corridor



- Intermediate Scenario: the competitiveness of rail for hub transfers could be improved by either of the two technical options: 1) operating high speed rail; 2) or constructing direct rail connection to airports. Utility analyses indicate that to make rail competitive as feeder service to airport hub, direct rail connection, or at least making railway station close enough to airport, is necessary. Without direct rail link, higher speed might have significant impact on corridor travelers' mode choice, but might not be able to generate enough attractiveness to hub transfers.

- Fully intermodal integrated scenario: direct rail link to airport is available. Rail and air are fully cooperating and coordinated in terms of joint ticketing and pricing, schedule matching, and providing intermodal services such as downtown check-in and baggage handling. Utility analyses indicate that when direct rail connection is available, better intermodal cooperation could be equivalent or more effective than increasing train's speed for the improvement of system performance.

Diagram 3.2: Theoretical RAPID Development Procedure



Even though integrating aviation system into intercity railway network is still a young idea, most of technical options for RAPID have been broadly applied into many places where airports were well connected with urban rail system. After utility analyses, several cases selected from Asia, Europe and North America are discussed to examine the rationale of the results from the utility analyses. Then, based upon the potential advantages associated with RAPID, this chapter will introduce three typical situations, where RAPID is likely to be an efficient solution. Finally, this chapter will end with a summary discussion of technical priorities for RAPID.

3.1 Utility Analyses

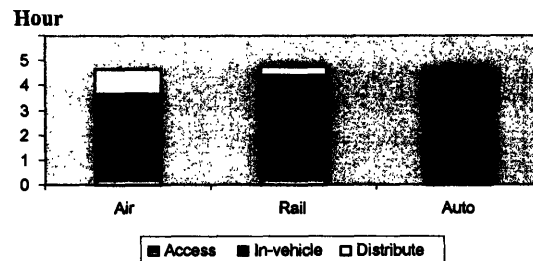
In intercity transportation market, aviation, rail and highway modes are the primary competitors. Each of them has their own preferred markets. Driving an auto is the best option for short-distance trips because it is flexible, convenient and cheap. As distance increase, rail and air become more and more competitive. Air has significant speed advantages over other modes, but it is less accessible to downtown residents and requires longer terminal time and fixed on-board times per trip including taxiway times, taking off and landing times. A conventional intercity train operating at less than 100 mph (top speed) could achieve a similar or even shorter total trip time than air in short- to mid- distance corridors. Moreover, rail could provide better allocation of trip time than air option in terms of better accessibility to downtown residents and providing more comfortable and productive in-vehicle times. In long distance markets, air becomes dominant because of its speed advantages. In this regard, the competitive range of intercity railway is defined as a distance range in which rail could achieve higher market share than autos and flights. Such range would depend on the rail's own system performance, as well as competitor's performance. Given certain transportation systems, the competitive range of rail varies for different types of travelers and different trip purposes. Utility model is used to quantify the impacts of key technical options to competitiveness of rail under various situations.

Under base Scenario, utility analyses indicated that without strong physical connection, long and onerous intermodal transfer time might make rail be unable to achieve any competitive range for hub transfers in face of strong competitions from highway modes and feeder flights

In the author's prior thesis [Shi, 2003, p.9], a 200-mile corridor was defined as the base corridor, a distance long enough for rail to be competitive with auto and short enough to be competitive over air. As indicated in diagram 3.2, it was assumed that intercity trains are operated at 100 mph of top speed with three intermediate stops and stations located within urban centers, and that hub and spoke airports locate at the suburban areas of the two metropolitan areas respectively. Based on the travel patterns and origination/destination, intercity passengers in this corridor could be classified into two groups:

- Corridor travelers refer to passengers originating and terminating in the regions inside the corridor.
- Hub transfers refer to passengers originating or terminating within this corridor, who transfer to or from long haul flights at a hub airport.

**Figure 3.1 Trip Time Allocations for Corridor Travelers
In 200 mile Corridor**



For corridor travelers, as indicated in Figure 3.1⁴, the three modes have similar total trip times in the base corridor. More than 70% of trip time for railway users is comfortable and productive (for business travelers) in-vehicle time, while more than 50% of trip time for air users is onerous and uncomfortable out-vehicle times, including accessing time to airport, processing, check-in and queue time at airport, and so on. Utility analyses indicated that better trip time allocation and utilization could allow rail to capture more than 50% of entire market share for corridor travelers. Under the same assumptions on trains' speed, values of times, and the direct Out-of-pocket costs, Utility analyses also indicates that conventional railway with 100 mph of operation speed could achieve a competitive range of "100 to 500 mile". Such range could be enlarged by operating higher speed, providing better in-vehicle services and offering lower fares.

⁴Shi, p. 9, August 2003,

Figure 3.2: Competitive Range of Rail under Base Scenarios⁵

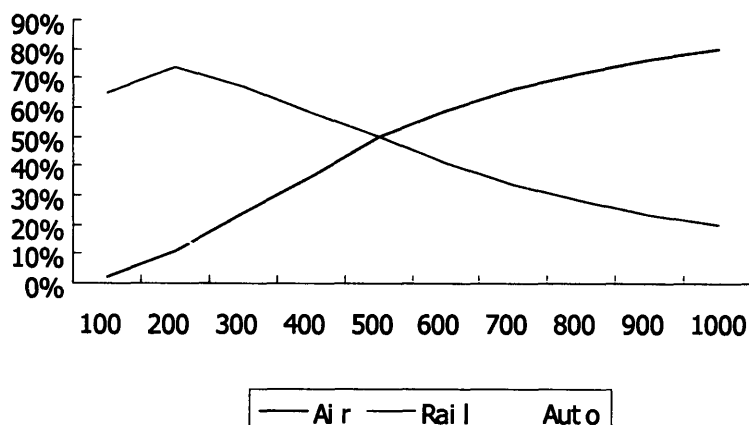
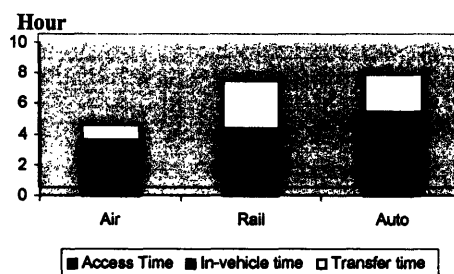


Figure 3.3: Trip Time Allocation for Hub Transfers In the 200 mile corridor



For Hub transfers, in the base corridor, Figure 3.3 indicates that air is the fastest choice and requires the shortest transfer time to or from long-haul flights. Under the condition of base corridor, rail users have to take taxi, buses or other urban transportation modes to transfer from downtown railway station to suburban airport. Considering the possibility of congestions and delays within urban areas, as well as that many passengers have big luggage, such transfer is likely to be time-consuming, onerous, unreliable and uncomfortable, which make rail lose its competitiveness to other options. Additionally, different from corridor travelers, air might be cheaper than rail option because airlines always offer high discount rate for the short-leg feeder flight. For example, the airfare for a trip from BOS via CHI to Beijing, China, is around \$800 (economic class), while the non-stop service between CHI and Beijing will cost \$750 (economic class), which means the incremental air fare is just \$ 50 for the feeder flight between BOS and CHI. Under these conditions, utility analyses indicated that rail option could achieve less than 16%⁶ of entire market in the 200-mile base corridor, which is less than feeder flight and autos.

⁵Shi, p.24, August 2003

⁶ Shi, p.34

Because of the speed advantages, the longer the trip distance, the more competitive the air would be over other modes. As distance decreases, driving an auto becomes more and more competitive because it is cheaper, more convenient and more flexible. In this regard, under the similar conditions of base scenario, rail might be unable to achieve any competitive range over highway and air options for hub transfers.

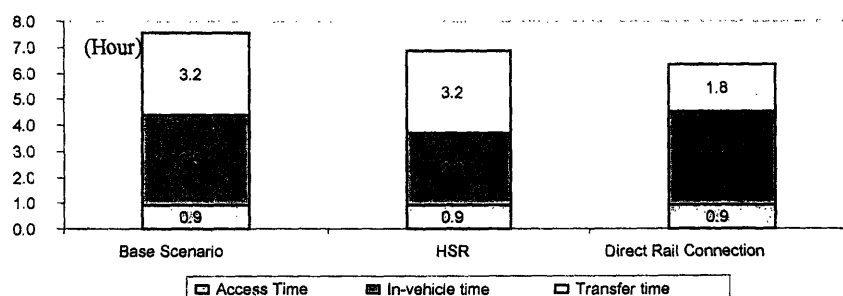
Under intermediate Scenario, utility analyses indicated that direct rail connection or at least making rail station close enough to airport, is necessary for rail to be competitive over feeder flights and highway modes for hub transfers.

Based upon base scenario, utility analyses examine two technical options to improve competitiveness of railway for hub transfers:

- Operating High Speed Rail targets on reducing in-vehicle time. In-vehicle time varies with the trip distance, operation speed and number of intermediate stops. As distances increase, the NDT from in-vehicle segment would become more and more weight to the final disutility results and therefore mode splits.
- Constructing direct rail link to airports targets on easing intermodal transferring. In the 200-mile base corridor, NDT from transfer period is the dominant part of disutility for rail users, while it has much less weight for air and auto options. Given certain physical systems in terms of location of terminals and performance of ground transportations, such time is kind of fixed time and has little space for further improvement in short term for both air and rail options. In this regard, direct rail connection, or at least making railway stations be close enough to airport, should be the ostensible way to improve intermodal transfer between rail and aviation.

As indicated in Figure 3.4, the incremental 50 mph of operation speed could reduce in-vehicle time by more than half hour for hub transfers in the 200 mile corridor. Direct Rail connection could reduce transfer time by one and half hour in the same corridor. Based upon the assumptions on the values of times associated with distinct trip segments, direct rail connection is obviously more effective to reduce passengers' disutility than increasing speed in the 200 mile corridor.

**Figure 3.4: Length and allocations of Trip Times for Rail Option⁷
Base Scenario vs. High Speed Rail vs. Direct Rail Connection**

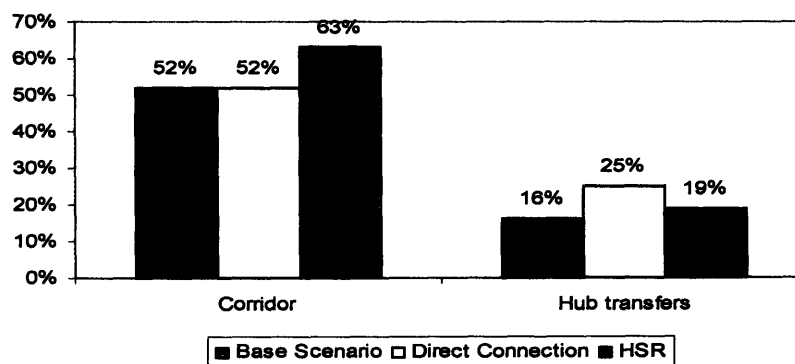


⁷ Shi, p.30

Based upon the utility analyses in prior thesis [1], Figure 3.5 indicated that:

- If operation speed of trains is increased to 150 mph, corridor travelers' mode choice is much more sensitive to the speed increasing than hub transfers. Without the significant improvement on intermodal transferring, High Speed individually can not make rail be competitive over air and highway options for hub transfers in the 200 mile corridor, a distance that is best –suited for rail option for corridor travelers.
- For hub transfers, direct rail connection could significantly improve rail/air intermodal transferring in terms of avoiding onerous and unreliable transferring by urban transportation between downtown station and suburban airports. Utility model and LOGIT model indicated that direct rail connection could increase railway's market share by around 10% for hub transfers. However, direct connection could barely benefit corridor travelers, except for the demand generating from the proximity of the connected airport.

Figure 3.5: Effectiveness of HSR vs. Direct Rail Link⁸



Even with direct rail connection, air is still the best option for hub transfers because:

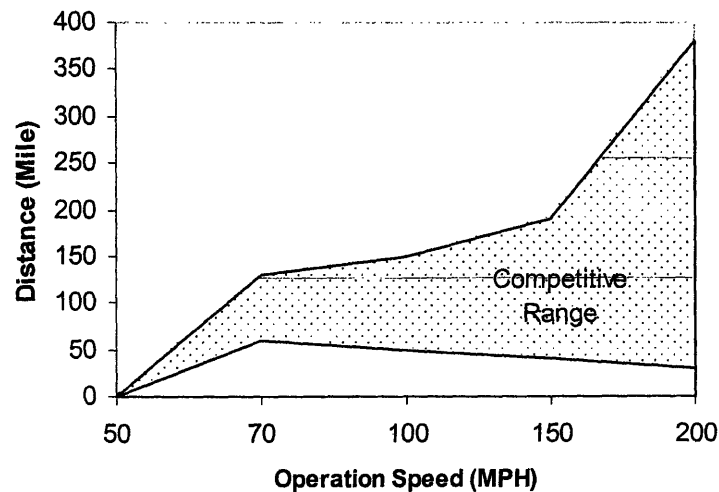
- Transferring from flight to flight is much more convenient and comfortable than intermodal transferring;
- Air users could enjoy baggage-free travel during the whole trip after first boarding;
- Air users only need book service once for the whole trip;
- Schedules are always well matched between feeder flights and long haul flights;
- Air users could enjoy discounted fare for feeder flight services;
- And so on.

All of these overshadow the in-vehicle time advantages of the rail option in short-mid distance corridors. However, when direct rail link is available, transferring between rail and air could be as or more convenient than highway modes. Under such situation, speed advantage and better in-vehicle time utilization could easily make rail be more competitive over highway options for hub transfers. It implied that for many regions without feeder flight services, rail link could be the most attractive option for hub transfers, if rail could have enough speed advantages over highway modes.

⁸ Shi, p. 21~32

In the utility model, disutility of passengers is comprised of two parts: net disutility of trip times (NDT) and direct out-of-pocket (OOP) costs. NDT depends on the length and characteristics of each trip segment as well as the associated assumptions on the values of times, while direct OOP cost is mainly determined by service providers' price strategies and trip distance. The lower the assumed values of times, the more weight of direct OOP cost to disutility results and therefore the mode splits. Given certain physical systems in terms of terminal locations, as well as the availability and performance of intermodal facilities, transfer time is kind of fixed time in short term and has little space to be improved. As distance increases, in-vehicle times have more and more weight in the disutility of passengers, and thus mode splits. To be competitive over highway modes and air, railway speed should be high enough, not necessary HIGH SPEED as TGV or Japan East, to gain enough total trip time advantages. Based upon the Utility Model in the prior thesis [Shi, 32-34], Figure 3.6 indicated that even with direct rail connection, railway with less than 50 mph of operation speed might have no competitive range over both highway and air options, while higher speed could enlarge the range steadily.

Figure 3.6: Competitive Range of Rail for Hub Transfers Under Various Operation Speed⁹

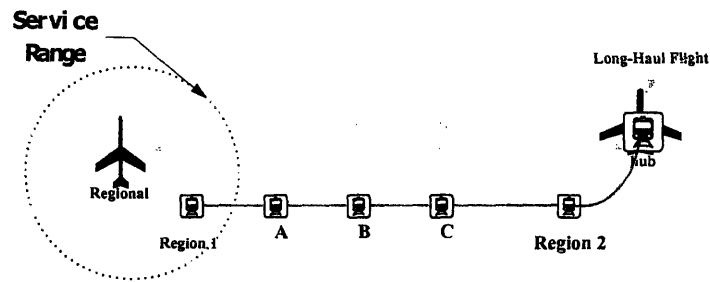


Under fully integrated scenario, utility analyses indicated that when direct rail connection is available, enhancing intermodal cooperation, such as joint ticketing, matching schedule, providing intermodal service, might be as or even more effective than increasing speed to gain passenger utility and thus affect passengers' mode choice.

As indicated in Diagram 3.3, when direct rail connection has been available, two major technical options are examined to further improve the competitiveness of rail system for hub transfers by either operating high speed rail or by enhancing intermodal cooperation.

⁹ Shi, p.32-34

**Diagram 3.3: Rail/Air Intermodal System
With Direct Rail Connection**



- Option 1: operation speed of rail is increased to 150 mph, which is assumed to reduce in-vehicle time of rail option by around half hour.
- Option 2: enhancing intermodal cooperation between rail and air to achieve a fully intermodal integrated system (FII). Under the condition of FII, it was assumed that 1) railway terminals could function as airport branches, where hub transfers could check-in and deliver baggage at the remote railway station; 2) joint ticket is available, which allow passenger book services once for the whole trip as air-hub-air option; 3) rail-to-air transferring at hub airport could be as convenient as flight-to-flight transferring; 4) because downtown rail stations are likely to be less crowded than busy airport hub, rail users might need shorter queue time at railway stations for processing and check-in than at airport; 5) the schedules of feeder trains and long haul flights are well matched, which reduce the waiting time at terminals for hub transfers. Under these assumptions, Figure 3.7 indicated that through full intermodal cooperation, rail option could achieve similar total trip time to air options with better time allocation.

Based upon above assumptions, utility analyses in the prior thesis [1] indicated that, as shown in Figure 3.8.

- Direct connection or making railway station be close enough to airports is the critical threshold for rail to be competitive over air and highway options for hub transfers. However, it would be not likely to have significant impact on corridor travelers' mode choice.
- Without direct connection, operating higher speed would not likely generate significant attractiveness for rail to hub transfers. But corridor travelers are much more sensitive to speed increasing.
- When direct rail connection is available, enhancing intermodal cooperation to achieve a fully air/rail intermodal integrated system is likely to be more effective than operating higher speed for reducing hub transfers' disutility in the 200 mile corridor. However, intermodal cooperation would be not likely to generate positive impact on corridor travelers' mode choice.

**Figure 3.7: Length and allocations of Trip Times¹⁰
(Air vs. Rail vs. Highway)**

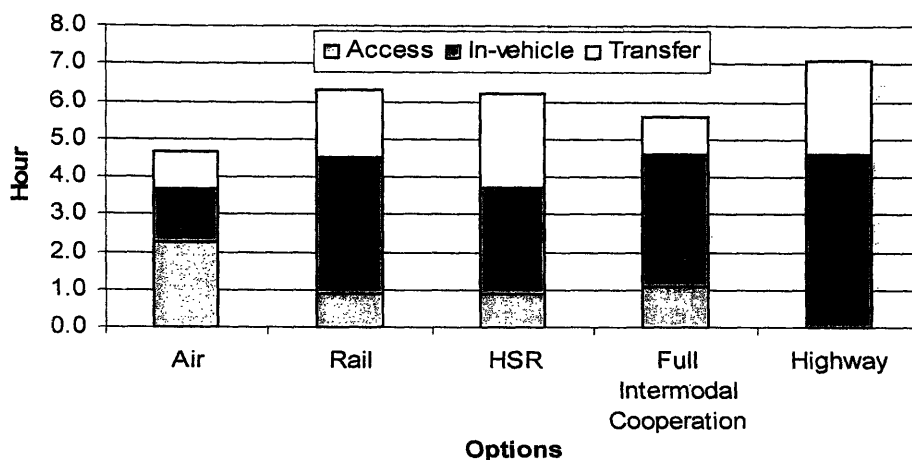
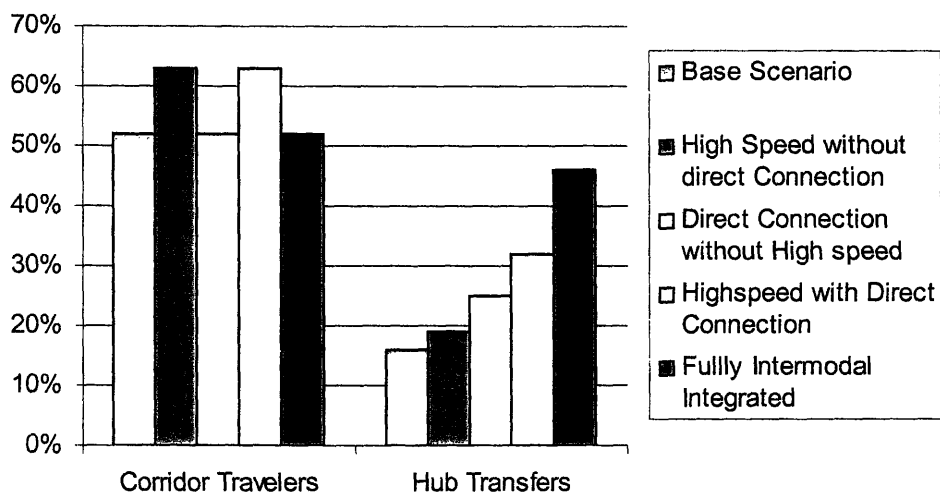


Figure 3.8: Mode Share of Rail Under Various Situations in the 200-mile Corridor¹¹



3.2 Real World Experiences and Lessons

The idea of enhancing the intermodal cooperation and collaboration between intercity rail and aviation is still young. The first HSR connection to an airport in Europe was at Lyon in July 1994, with the opening of the so-called “TGV-satolas” station. As increasing concerns on the system mobility and meeting longer term accessibility goals for airports, by 2003, more than 120 airports worldwide had constructed or were considering rail links to greater metropolitan regions. Even though most of these rail links refer to urban railway systems, all of the necessary technical options for RAPID have been widely applied, such as high quality intermodal services in Hong

¹⁰ Shi, p.34- 37

¹¹ Shi, p. 21, 32,, 34 ,36, 37

Kong International Airport Express Line, Zurich International Airport, Frankfurt International Airport, and even Maglev technology in Shanghai Putong International Airport. To examine the technical priorities for RAPID, five airport-rail systems from the world were selected and studied. The focus will on the effectiveness and priorities of the three key technical options (direct rail connection, high speed rail and enhancing intermodal cooperation) for the competitiveness of rail as a ground access mode to major airports, which have been discussed in the utility analyses.

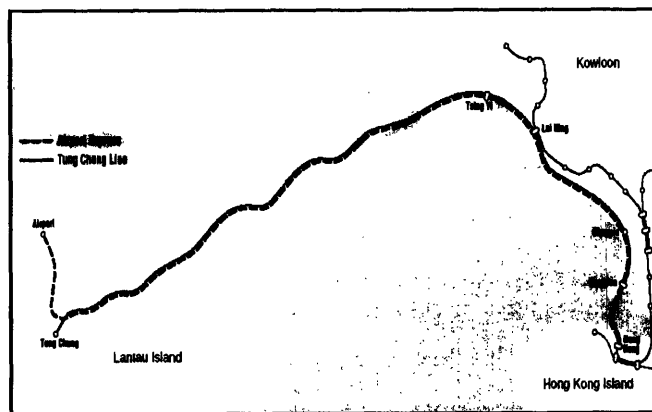
This section will start with a detailed case study on Hong Kong International Airport Express Line, which was the first railway built specially for the purpose of serving an airport with its integrated design for stations and equipment, and is providing a world-class service for airport trips. And then, four other airport-rail cases are selected to compare with HKIA, each of which is major international or national hub with distinct characteristics of rail/air intermodal connection. Shanghai Maglev project provides a typical example that High Speed Rail is not a remedy for the competitiveness of air/rail intermodal system. The two European cases provide successful examples that strong intermodal connection and cooperation could make intercity rail be competitive over other modes for airport trips. Rail transit in Chicago O'hare International Airport is playing a minimal role for airport trips, which largely owes to the lack of intermodal cooperation, as well as its auto-favored transportation environment.

3.2.1 Hong Kong International Airport Case Study

HKIA is located at Chek Lap Kok, an underdevelopment island that is 40 kilometers (25 miles) away from Hong Kong City. As the gateway to China and most of Asia, HKIA is one of the busiest airports in the world. In year 2003/2004, over 34 million passengers passed through the airport. More than 70 airlines operate around 4,000 flights a week from HKIA to more than 130 destinations worldwide.¹²

HKIA was linked to the heart of Hong Kong by almost 40 kilometers (25miles) new roads, a dedicated high-speed railway and landmark bridges and a new town. The airport railway was the first railway built specially for the purpose of serving an airport with its integrated design for stations and equipment,¹³ and is providing two types of services: Airport Express (AEL) and Local service (TCL) with trains operating at maximum speeds of 135 kilometers (84 miles) per hour on the same track.

- Airport Express Line (AEL) was designed as all-seated, business-class type service carrying passengers between airport and the Hong Kong Central business district with two scheduled intermediate stops at kowloon and Tsing Yi. AEL is providing a world-



¹² Hong Kong International Airport, Annual Report 2003/04, <http://www.hongkongairport.com/eng/aboutus/report.html>, August, 2004

¹³ Hong Kong International Airport Home Page: <http://www.hongkongairport.com/eng/aboutus/index.html>, 2004

class service for airport trips. In the past few years, AEL has proven to be one of the most reliable public service in the world. The average on-time rate is as high as 99.9%. During the design and planning period of HKIA, a high priority was placed on providing a convenient and efficient rail service to the airports. Off-airport check-in facilities for passenger are provided at the two stations, and baggage could be delivered at the Kowloon and Hong Kong station.

- Tung Chung Line (TCL) is a local mass transit commuter service operating between Hong Kong and new town Tung Chung. It uses the same tracks as AEL, but separate platforms. This service initially began operating with 7 cars, which are capable of carrying 312 passengers, thus bring much needed relief to the busy Nathan Road section of the Mass Transit Railway.

Current Performance and Competitors

Bus services, private autos and TCL are the major competitors for AEL services. As indicated in Figure 3.8¹⁴, in FY2001, bus service is capturing around 45% of the total annual airport trips. The market share of AEL is around 23% in FY2003, and Figure 3.9 indicates that this number is decreasing in the past five years, which mainly owe to the significant improvement on road network and bus services in the past few years.¹⁵

Different from local travelers, transporting to and from airports always is an ideal role for mass transit. Airports are a significant destination in most cities, making it plausible to justify rail connections to them. This is clearly the case of Hong Kong International Airport, which is located at an underdevelopment land. Local trips to and from this region is relatively minimal compared with airport trips. Compared with mass transit services, the characteristics of airport trips by private auto are much different from public service users, and difficult to estimate and analyze. Airport users will much less likely drive a private auto by themselves to access airport than local travelers when high quality public services are available, because 1) for air travelers, their days spent in destination is uncertain. It could be extremely expensive to park their autos in airport for a long time. 2) For travelers arriving from flights, they would not likely have their private auto available in a airport parking lots, except their friends come and picking them up. Even if driving by others, the mode split of air trips by private auto is highly sensitive to auto ownership, highway condition, tolls and many other factors, all of which are beyond the scope of this paper to discuss. In this regard, the following analyses in the HKIA case will concentrate on public services. The overall market share of airport trips by bus, AEL and TCL is 76%,

¹⁴ Hani S. Mahmassani, Texas Department of Transportation, Domestic and International Best Practice Case Studies, February 2001.

¹⁵ Hong Kong International Airport, Annual Report 2003/04, <http://www.hongkongairport.com/eng/aboutus/report.html>, August, 2004

Figure 3.9:
Overall Mode Splits of Airport
Trips in FY 2001 [Hani, p.20]

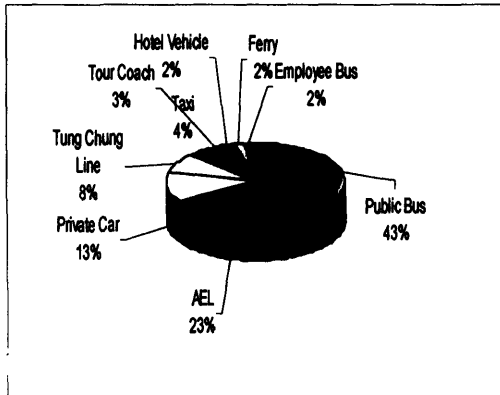
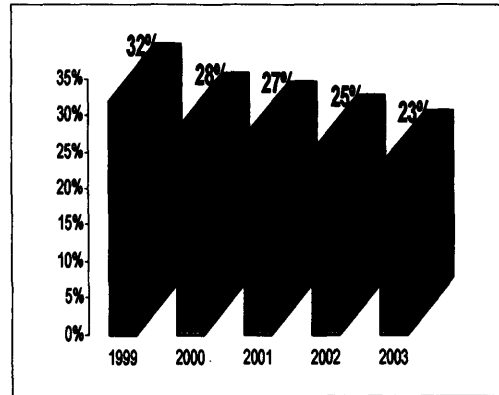


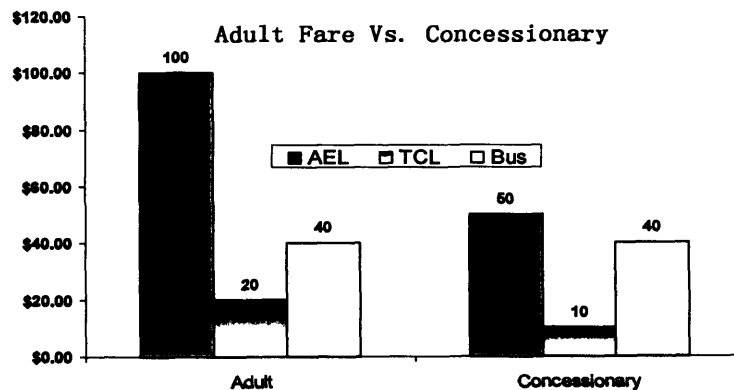
Figure 3.10:
Market Share Change of AEL
From FY1999 to FY2003 [HKIA
Annual Report, p.50]



○ *AEL is the Most Expensive Public Services for Airport Trips*

As indicated in Figure 3.12, AEL is the much more expensive than TCL and Bus. For adult (normal) travelers, the single journey fare of AEL is HK\$ 100 (12 US\$), which is much higher than Bus (HK\$40) and TCL (HK\$20). Airport railway (both AEL and TCL) provide 50% discount for student and old person. While, there is no concessionary for bus service.

Figure 3.12: Fares of Public Services to HKIA in FY 2004



Compared with TCL, which operated on the same track and with similar speed, the higher fare for AEL service is mainly from:

- AEL provide one-seat rail service directly connecting downtown with airport, while, TCL users need ride a bus, take a taxi, or walk to transfer between Tung Chung Station and airport (around 2 mile long).
- Downtown check-in and baggage delivery service provide great convenience for flight catchers in terms of baggage-free during transfer, shorter queue time at downtown terminals, and so on. Such off-airport service requires additional labors, facilities and equipments, which result in higher unit operational cost of AEL per passenger than local

service.

- *Bus is more flexible , more accessible and cheaper*

Compared with AEL, bus need longer in-vehicle trip time between downtown and airport (60 vs.23 minutes), but it has much broader network with higher frequency and lower fare than AEL and TCL. Easy access, high frequency and lower fare have gained bus service great competitiveness over AEL services.

Downtown intermodal service of AEL is critical, but not beneficial to everybody

Downtown check-in and baggage delivery is aimed at maximizing passenger convenience and encouraging passengers with heavy baggage away from the private car or taxi. Passengers take their bags at Hong Kong or Kowloon stations for Airport Express. Airline staffs take them, tag them, ask the standard security questions and give passengers their boarding card. Bags are transported to the airport in sealed containers in secure accommodation on board the train. On arrival at the airport, the bags are conveyed to the airport sorting system where they are screened in the same way as transfer bags.

Downtown check-in and baggage delivery may be the most contributive measure for AEL to achieve a higher market share and compete with other modes. Hong Kong and Kowloon Stations provide check-in counters for all airlines; passengers can check-in and collect their boarding passes from one day in advance to 100 minutes before take-off. These off-airport services provide great convenience for many travelers, in that:

- Check-in and baggage delivery is generally one of the most time-consuming and stressful activities during air trips. Early Check-in at downtown station could allow travelers better utilize their time, and feel less stressful during the regional trip.
- Downtown stations are likely to be less crowded than the busy airport, travelers would need shorter queue time for process and check-in process time at downtown station than in airport.
- Baggage-free during most of the trip has great attractiveness to travelers with big bags.

However, such service is one-way, and not beneficial to every body:

- These off-airport services are not useful for arrivers.
- Downtown service is less attractive for travelers without check-in bags.

Lower Market Share of TCL Implied the Importance of Intermodal Connection

TCL has a better integration with the broader local metro rail network, and provides the least expensive service—HK\$20, which is half of the bus fare and four times lower than AEL service. Additionally, compared with AEL, TCL has more intermediate stops en route and provides higher frequency service with similar in-vehicle time (26 minutes) and reliability to AEL. The 3 minutes in-vehicle time difference could generally be ignored in real life.

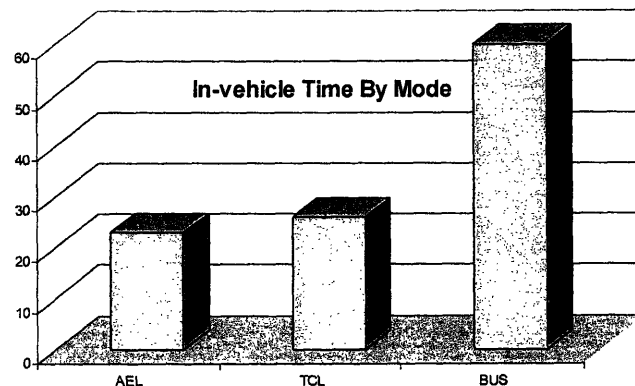
Even though TCL has these advantages over other modes, the difficulty of transferring between Tung chung station and airport (around 2 miles walk distance) make it much less competitive than the other two public services. Its 8% market share implied that:

- Even though AEL is less accessible and much more expensive than TCL, the high quality off-airport services and direct rail connection to airport make AEL be much more competitive than TCL for airport trips.
- 8% market share is not very bad performance compared with similar systems worldwide, which implied that there is still large potential market from low-income travelers with or without big bags, who prefer to enjoy the cheapest service.

High Market share of Bus services Implied the Less Importance of Train Speed

Different from local travelers, transporting to and from airports always is an ideal role for mass transit. Airports are a significant destination in most cities, making it plausible to justify rail connections to them. This is clearly the case of Hong Kong International Airport, which is located at an underdevelopment land. Local trips to and from this region is relatively minimal compared with airport trips. The long distance between airport and central business district provide an opportunity for railway to fully utilize its speed advantages. As indicated in the Figure 3.13, the in-vehicle trip time from Hong Kong downtown station to airport is 23 minutes by AEL, 26 mins by TCL and 60 minutes by bus.

Figure 3.13: In-vehicle Trip Time of three major HKIA Access Modes



However, High-speed is not enough for rail to achieve a high market share. Higher speed could only reduce the in-vehicle time. As mentioned in the utility analyses part, in-vehicle time is the least onerous time among all the trip activities. In the HKIA case, even though TCL is faster and cheaper than buses, it captures much less market share than buses largely owing to the fact that bus-air transferring is much easier than TCL-airport transferring.

In Sum, through the comparison of system performance of buses, Tung Chung Line and Airport Express Line, HKIA case implied that:

- It is impractical to expect that railway could achieve better or equivalent accessibility than highway modes. Downtown check-in and baggage delivery could efficiently attract

travelers with big-bags from private auto and buses. However, the expensive fare hurts AEL's attractiveness to airport users without check-bags, as well as those passengers with low value of times.

- Low market share of TCL service for airport trips implied that intermodal connection play as a critical role for the competitiveness of rail.
- Train speed is playing a less important role than direct connection and high quality intermodal services for the competitiveness of AEL.

3.2.2 Experiences and Lessons from Other Cases

As indicated in the following table, Five airport-rail-link cases are selected to compare with HKIA (the first two from the Europe and the last two from the United States), each of which is either major international or national hub, and enjoy large proportion of ending trips. Meanwhile, compared with AEL in HKIA, each of them has special characteristics of the airport rail system.

Table 3.1: Characteristics and Performance of Airport Rail Links (FY2001)¹⁶

	Time to CBD (min)	Service Headway (min)	Mode Share	Transfer Convenience	Downtown Service	Fare level relative to buses	In-vehicle Service
Zurich IA	10	10	42.2%	Direct Connection	Y	Similar	Normal
Frankfurt IA	11	15	31.0%	Direct Connection	Y	Similar	Normal
Hong Kong IA	23	10	23.0%	Direct Connection	Y	Expensive	Business Class
Shanghai Maglev (2004)	8	20	Low	Direct Connection	N/A	Much more expensive	Business Class
Chicago O'hare	44	7	4.0%	1-mile moving walkway	N/A	Similar	Normal

- Shanghai Maglev project provides a typical example that High Speed Rail is not a remedy for the competitiveness of air/rail intermodal system.

Shanghai Maglev Demonstration Line is the world's first high-speed maglev train put into commercial use. It is also China's first maglev line that integrates urban traffic, sightseeing and tourism. The line starts at the south of the Longyang Station of Shanghai Subway Line 2 and runs eastward to the Pudong International Airport, covering a length of 30 kilometers. The train, which consists of 9 compartments, is capable of carrying 959 passengers. The designed speed and actual speed of the train are 505 and 430 kilometers per hour respectively and the in-vehicle time is only 8 minutes to reach the Pudong International Airport from the downtown station.¹⁷



¹⁶ Hani S Mahmassani, Texas Department of Transportation, *Domestic and International Best Practice Case Studies*, 2001.

¹⁷ Shanghai Maglev Train Open to Public , <http://www.china.org.cn/english/Life/52740.htm>, refer at December 2004

One of the primary objectives of Shanghai Maglev is to provide a competitive connection between Pudong International Airport and urban centers. In this regard, it did not achieve this goal. From the author's point of view, Shanghai Maglev is a beautiful show-case, but not an efficient transportation solution. Even though there have been no official statistics on its ridership since its operation in 2003, a group from Shanghai Tongji University conducted a study in the February 2004, who observed that the load factor of the Shanghai Maglev is below 20% even during peak hours. Compared with more than 10 million passengers annually served by Pudong airport, the mode share of the Maglev link would likely be no more than 2%. Even though the Maglev link has much shorter journey time (8 minutes) between downtown station and airport than other modes (taxi 40 minutes, bus 60 minutes), it is not attractive enough to airport users, which owes to the following facts:

- There is no off-airport service as HKIA did in downtown station. Passengers still need to take their luggage when transferring from place to place.
- Only a single station is located at border of the Shanghai central business district, which limit its accessibility to most downtown passengers.
- Its fare is much higher (75 RMB) than shuttle buses (20 RMB), and close to taxi fare (90 to 100 RMB). Both buses and taxi are much more accessible and flexible than the Maglev services.

Compared with HKIA express line, Shanghai Maglev is much faster and has similar accessibility to downtown residents. Meanwhile, they both offer much higher price than other public services. However, high quality intermodal services make HKIA AEL much more successful than Shanghai Maglev.

- The two European cases provide successful examples that strong intermodal connection and cooperation could make rail be competitive over other modes for airport trips.

Frankfurt International Airport

Frankfurt International Airport is Germany's busiest airport with over 45 million passengers annually served. With the emergence of the trans-European High-Speed rail network, the strategic vision for FIA is to become a key hub for high speed trains traveling from as far west as Britain via the Channel Tunnel, as far south as Italy via the Alps, as far north as Scandinavia and perhaps as far east as Warsaw and Moscow.¹⁸ FRA is directly served by High-speed trains. Beginning May 30, 1999, HSR services to major cities throughout Germany have been offered from the new Alrail Terminal, which is served by a total four national lines: two regular-speed Intercity Lines and two High-speed Intercity Express lines. Passengers arriving at FIA's Long-distance train station (ALRAIL terminal) by intercity express lines have the option of check-in for their flights at the new "Check-in T" area located in the connector building. At the "Check-in T" passengers are able to check in their baggage and receive a boarding card up to 45 minutes before their flight departure. In addition, intelligent concepts that provide high quality services for intermodal travel are key issue in the development of the new ALRAIL terminal at FIA. For example, Lufthansa passengers may check baggage through to their final destination and pick up

¹⁸ Frankfurt/Main International Airport Press Center, Press Archive, <http://www.frankfurt-airport.de/>, refer at December 2004.

boarding passes on the evening before their departure at the main stations in Dusseldorf, Cologne, Bonn, Wuzburg and Nuremberg. All of these provide significant convenience to rail-air transfers generating from the proximity of these regions. As a result, the market share of rail in some corridor, such as Lufthansa-Frankfurt, is as high as 60% for airport trips.

Similar to FIA, Zurich International Airport is advertised as the central traffic junction in Switzerland¹⁹. It has its own railway station, operated by the Zurich Transport Federation and is integrated into the regional bus, train and streetcar network with combined tickets available for the modes of transportation. Passengers have the option of checking in at any of 23 rail stations in Switzerland. One of the main reasons for including ZIA in this case study is that it provides a successful example of remote check-in and providing relief for the luggage to airport users. Most airlines allow passengers to make reservations for their preferred seat on plane, check in baggage, and pick up boarding cards at the remote baggage counters. Efficient intermodal services allow the rail to attract a high level of demand. In 1994, the passenger modal split was 34% for the public transport for all the airport trips, and the number is increased to 42% in 1999. [Mahmassani, p.26]

Different from HKIA AEL, the two European Cases provide successful practices of aviation/intercity rail systems, where high level intermodal connection and coordination make RAPID be the dominant access mode to airport hub.

- Rail transit in Chicago O'hare International Airport is playing a minimal role for airport trips, which largely owes to the lack of strong intermodal connection and cooperation, as well as its auto-favored transportation environment.

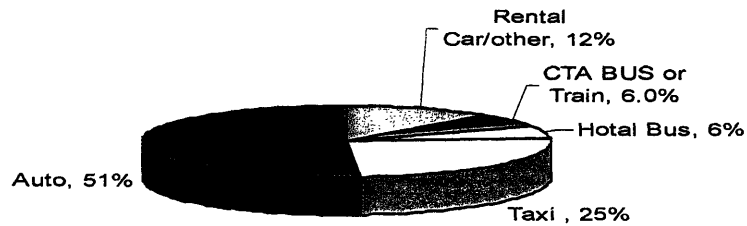
Chicago O'hare International Airport (ORD) is considered one of the commercial aviation capitals of the world. It is the hub of national air-transportation in the United States and the region's number one economic engine²⁰. Chicago Transit Authority (CTA) Blue Line Train provides 24-hour service between downtown Chicago and ORD. Lower-level pedestrian passageway inside the airport terminals lead directly to CTA station. The Station is equipped with an elevator to take passengers with mobility impairments to and from the platform.

The Blue Line Train connects the downtown area from the Dearborn Street Subway to ORD, which is located 15 miles to the northwest of the city. Trips take about 35-45 minutes from downtown to airport. As indicated in Figure 3.14, in 1994, the overall market share of CTA buses and train for airport trips was only 6%, while driving auto is the dominant access mode, which took around 51% of market share.

¹⁹ Zurich International Airport, http://www.uniqueairport.com/e_default.htm/, refer in December, 2004

²⁰ Foote, P, Labelle and Stuart, "Increasing Rail Transit Access to Airports In Chicago", in Transportation Research Board 1600. p. 1-9, Washington DC: National Research Council, 1997.

Figure 3.14 Modal Splits for O'Hare International Airport²¹



Compared with HKIA AEL and the two European Cases, the low market share of rail for airport trips in ORD might owe to the following facts:

- Different from HKIA AEL, CTA Blue Train takes much longer trip times and is much less accessible and flexible than driving auto.
- There is no intermodal service available as in HK and European Cases.
- CTA station is connected with ORD by a half-mile pedestrian mover. For passengers with big bags, such transferring is more onerous than park-and-ride and kiss-and-ride.
- ORD has a more auto-favored environment than in HKIA and the two European Cases, which owe to the high auto-ownership, lower usage fee and well-developed freeway networks in US.

3.3 Favorable Situations for RAPID Application

Utility analyses and case studies have indicated that through effective connection and enhancing intermodal cooperation, conventional railway could be competitive over highway modes and flights for airport trips in short- to mid- distance corridors. When effective intermodal connection and coordination is available, higher speed could further enlarge rail's competitive range. Meanwhile, rail uses less energy, produce fewer greenhouse gases, offers travelers more comfortable and more productive services on trains, and has better immunity to bad weather. All of these fuel the interests for greater use of rail for intercity passenger transportation.

The analyses in above sections implied that intermodal connectivity is the dominant factor that affects the competitiveness of RAPID for airport trips, while, effective physical connection, or at least making train stops be close enough to airport, should be the prerequisite. However, constructing new rail connection might be extremely expensive and hard to estimate how it will exactly cost. It depends on what kinds of system needed, where, when and how long to be built, etc. A single-track freight line with few locomotives and simple signaling, running across a flat, sparsely populated landscape in a developing country may cost as little as or even less than \$ 10

²¹ Mandle, P, 1994, "Rail Service to Airports" , In aviation Crossroads: *Challenges in a Changing world*, proceedings of the 23rd Air Transport Conference, p. 224, Arlington, Virginia, June 22, 1994

million per kilometer including electrical and mechanical equipment. A double-track underground metro line in a densely populated metro-area with difficult geological conditions and requiring high technology specifications and high capacity trains could cost as much as or even more than \$ 200 million per kilometer²². Meanwhile, as discussed in the Utility Analyses section, intermodal connection and coordination might be not likely to have significant impacts on corridor travelers' mode choice.

On the other side, railway service always enjoys huge economies of scale and economies of scope. When a well-connected physical system is available, enhancing intermodal cooperation to capture higher market share is more likely to be a profitable strategy. Therefore, to determine where is best-suited for RAPID and where is not, the decision making should be based upon the evaluation of a variety of measures, including market share, transport system efficiency (e.g. reduced congestion at airports), regional economic benefits (air quality, transportation system capacity), system redundancy, etc. The weight of these measures for the final decision making would greatly vary from case to case and from region to region. As a result, it is impractical to set a unique model to justify the necessity and effectiveness of RAPID in all the cases. Based upon the key advantages of RAPID, this section will introduce three typical situations, where RAPID is likely to be an efficient solutions.

Displacement of Feeder flights to release airport capacity

Congestion and delays have been one of the major constraints that hamper the sustainable development of aviation system around the world. Insufficient airport runway capacity is responsible for much of the congestion. Currently, global concerns on noise and pollution and their effects on health and quality of human life have led to increasingly severe environmentally related restrictions on aviation. In the case of airports, these restrictions have greatly affected operating and capital cost, as well as the ability of airport operators to increase capacity in order to meet growing demand. Even with the apparent need for additional runway capacity, it is usually extremely difficult and time-consuming to increase substantially the capacity of the runway system of a major airport. New runways, along with associated protection zones, noise buffer space, etc, typically require acquisition of a large amount of additional land. Equally important, they have significant environmental and other external impacts that necessitate long and complicated review-and-approval processes with uncertain outcomes. In the U.S, the current runway planning and approval process routinely takes ten years and has often taken much longer. At some airports, a new runway is infeasible due to physical constraints or strong political opposition. For example:

“At Boston/LOGAN, a heated controversy has been going on since the 1970s, concerning the construction of the proposed 5000ft Runway 14/32. Only smaller Non-jets and some regional jets would use this short runway. Communities around the airport have strenuously opposed it because of its feared environmental impacts. Its proponents have claimed that it will provide environmental benefits by distributing noise more equitably among the affected communities and by facilitating more over-water approaches to the airport. Practically every Local politician and civic organization has taken part in the passionate debate over the years. As of 2002, the issue

²² Railway finance, <http://www.trainweb.org> Feb 1, 2001,

had yet to be resolved, some 30 years after Massport, the airport's operator, first proposed the new runway"²³

Utility analyses and case studies have indicated that through efficient intermodal connection and cooperation, rail could be a competitive and environment-friendly alternative for feeder flights. In this regard, when expanding capacity is extremely difficult and expensive for a seriously congested airport, RAPID could be an efficient, attractive and economically feasible solution for the capacity problem. Through the displacements of short-mid distance flights, airport capacity could be freed for more cost-efficient and lucrative long distance flights. Meanwhile, a double track conventional rail could provide twice as much as capacity or even more than a four-lane highway. As shown in the utility analysis model, improved rail service could largely reduce the highway demand, which could not only release the pressure on highway congestion, but also could reduce the air pollution from autos.

Meeting Longer Term Access goals

Because of more and more concerns about environmental and security issues, airports are moving further away from central regions and air users require longer time in airports. As a result, in short- to mid- distance market, travel by air would require more time on ground than in-vehicle, which means commercial flights would not be significantly faster than other modes, especially rail.

Therefore, rail could achieve a similar or even shorter trip time than flights in short-to-mid distance corridor with better allocation of trip time.

Short-leg feeder flights are usually provided by small or mid size airplanes. Their little personal space always makes travelers feel uncomfortable, while by providing more personable space, intercity train could offer more comfortable and productive in-vehicle service to travelers.

Additionally, since rail has better immunity to bad weather than air, intercity train is more reliable than feeder flight.

Feed Demand to Secondary or New Airports

Many major metropolitan areas worldwide have one than more one airport. Such multi-airport systems are always comprised of a primary airport that has the most traffic, and one or more secondary airports with between 10 and 50 percent of the traffic. The significantly different levels of traffic always make the primary airports heavily congested, while much of the excess capacity in the secondary airports is wasted. Table 3.2 lists 21 major metropolitan areas in the world with multi-airport systems, which indicates that compared with the primary airport, most secondary airports are has much lower demand level than the primary airports. Even though primary airports are serving the most traffic, they are not necessary the largest. For example, Montreal/Mirabel has much more capacity than the downtown primary airport.

²³ Richard De Neufville/Amedeo Odoni, Pp168, Airport System Planning, Design, and Management, 2002

**Table 3.2: Traffic Of Secondary Airports In Several Major²⁴
Multi-Airport System In The World**

Metropolitan Region	Traffic At Secondary Airports (% Of Primary Airport)				
	Second	Third	Fourth	Fifth	Sixth
London	49.5	14.7	6.3	2.2	
New York	95.9	74.3	2.9	1.5	
Los Angles	11.4	9.9	6.9	1.9	0.9
Chicago	22.1	0.1			
Tokyo	45.6				
Paris	52.8	0.8			
Dallas/Fort Worth	11.7				
San Francisco	31.8	26.7			
Miami	47.3	17.3			
Washington	98	78.5			
Houston	25.9				
Hong Kong	15.9	8			
Osaka	80.4				
Boston	23.7	4			
Orlando	3.9				
Brussels	27.5	1			
Montreal	16.5				
Milan	38.8	6.5			

When heavy congestion happens in primary airports and a new reliever airport is necessary to be built up further away from the metro areas, one of the major difficulties for such development is that there is not enough traffic to support the new airport. Such embarrassing failure of new airport construction is extensive in the nations and regions all over the world, such as Kuala Lumpur, London, New York, Saint Louis and Washington. When new major airports have been built, operators found that it is extremely difficult to attract customers. Many airport operators have tried to force passengers and traffic to move from the busy airports to secondary airports with excess capacity based upon any or all of the following concerns:

- Reduce congestion and delays in the crowded airports.
- Make better use of the existing facilities.
- Avoid further investment on the congested airports.

Even though there are such straightforward benefits associated with the traffic allocation, there have been few successful cases around the world. For example, it might be more reasonable to relocate traffic from congested San Francisco/ International to San Francisco/Oakland, which has excess capacity to serve more transcontinental traffic, rather than build more capacity at the busy San Francisco/international. However, the City of Oakland has wanted to build up its traffic for

²⁴ Richard de Neufville, "Airport Systems Planning, Design, And Management", P137, Table 5.4, 2001

over 30 years and still can not achieve their goals. Similar embarrassing failures have extensively happened in the world, such as, Los Angeles, London, Milan, Washington and so on. In fact, operators in above systems have taken lots of efforts to achieve their purpose. For example, the British Airports Authority has continuously tried to attract move traffic out of London/Heathrow to London/Gatwick by providing \$ 20 to \$ 30 discounts to passengers to persuade them shift their patterns²⁵. But such efforts have proved to have no significant effect. Additionally, they have pressured foreign flights to use their secondary airports, but not many countries have accepted the assignment to the less popular airports. The above samples give out a fact that under the current multi-airport system, successful traffic allocation is extremely difficult to achieve by only market measures. Although there are still some successful cases happened in the world, most of them are achieved by severe and compelling government pressures. Such as, Japanese government closed Tokyo/Haneda to international traffic forcing all service beyond Japan to go to Tokyo/Narita. Similar cases happen at Osaka and Paris/De Gaulle. However, severe regulation and government pressure are always less economically efficient for airlines and airports operators than market measures²⁶.

Through strong intermodal connection and coordination, rail access could make secondary airports be more accessible to many regions than primary airports, and thus attract more passengers to use them by market measure.

3.4 Summary of Chapter 3

The primary objectives for enhancing the cooperation or coordination between aviation and intercity rail system are to provide airports more efficient and environment-friendly ground access to connected urban centers, as well as to displace short-mid distance flights to free valuable airport slots for lucrative long distance flights. To successfully achieve these goals, the aviation/rail intermodal system should be competitive over feeder flights and highway modes. Through utility analyses and case studies, this chapter has examined the effectiveness of three key technical options to the competitiveness of rail for airport trips, which implied that:

- Intermodal connectivity is the dominant factor that affects the competitiveness of RAPID for airport trips. Strong physical connection, or making train stops be close enough to the airport terminal, should be the prerequisite to achieve seamless intermodal connectivity. In this regard, under the base scenario, constructing a direct rail connection should have priority over operating high speed rail to improve the competitiveness of rail for air trips. However, intermodal connection might have no significant effects on corridor travelers' mode choice.
- When an effective physical connection is available, enhancing intermodal cooperation in terms of joint ticketing, remote check-in and baggage delivery, schedule matching, etc, could be more efficient to gaining passenger utility than high speed rail for airport trips. Considering the potential high costs associated with increasing train speed, enhancing intermodal cooperation, when direct rail connection available, should be more cost-

²⁵ Agam N. Sinba, Federal Aviation Administration, *Aviation Gridlock Phase II: Airport Capacity And Infrastructure*, April 11, 2001.

²⁶ Richard de Neufville, "Airport Systems Planning, Design, And Management", 2001

effective to improve RAPID competitiveness for airport trips. Again, intermodal cooperation would not likely provide significant benefits to corridor travelers.

- Train speed needs to be high enough, but not necessary as high as TGV and Maglev, to ensure its time-competitiveness over highway modes and shuttle flights in short-mid distance corridors.

In sum, under the similar situation to base scenario, building direct rail connection to airport hub should be set higher priority over operating high speed rail for the competitiveness of rail to airport trips. When effective intermodal connection available, enhancing intermodal cooperation should be more effective than operating high speed for airport transfers.

Chapter 4: Institutional Analysis

The analyses in the technical priorities chapter supported four conclusions: First, intermodal connectivity is the dominant factor that affects the performance of RAPID. A good connection might be the prerequisite for achieving efficient and seamless intermodal transfer. Second, when a good connection is available, enhancing intermodal cooperation in terms of joint ticketing and reservations, offering intermodal services, and matching schedules are likely to significantly improve the competitiveness of rail for airport trips. Third, the speed of train does not need to be as high as TGV and Maglev, but should be high enough to ensure door-to-door trip time advantage over highways and air planes in short-to-mid distance corridors. Fourth, there is almost no need for any new technologies along with the implementation, operation and management of RAPID. All the technical options have been well applied in many places worldwide for decades, especially in numerous European airports.

In short there are no technical challenges and many studies have demonstrated the benefits associated with enhancing the intermodal cooperation between rail and aviation, the development of RAPID in the United States has lagged behind the world trend, especially in comparison with European countries and Japan. The primary tasks of this chapter are to identify the key barriers impeding the RAPID development in the U.S and to provide institutional and policy recommendations to facilitate RAPID implementation for the future U.S intercity passenger transportation.

Based upon Muller²⁷, true intermodal transportation should be defined as that “transporting passengers and freight on two or more different modes in such a way that all parts of the transportation process, including the exchange of information, are efficiently connected and coordinated”. In this regard, successful RAPID system requires three key components:

- Effective infrastructures to provide seamless intermodal transfer.
- Two types of information: 1) information for market research and decision making; 2) and information for enhancing intermodal cooperation and offering intermodal services.
- Efficient intermodal cooperation for operation and management of integrated systems.

RAPID is a complicated and expensive (in many places) system with many individuals and groups directly or indirectly impacted by its development. The implementation, management and operation of RAPID would involve number of key stakeholders, including railway, airlines, airports, governmental agencies, local governments, central governments, public and other interesting groups. All of these stakeholders have various interests, competition priorities, institutional culture and structures, etc. The implementation of RAPID might benefit some, while hurting others in some ways. Therefore, successful implementation of RAPID requires a consensus among key stakeholders to be built up in the decision making period and continue along the entire implementation process. Achieving this consensus is largely determined by the willingness and capability of key stakeholders toward RAPID implementation.

²⁷ Muller, Gerhardt, 1999, *Intermodal Freight Transportation*, 4th Edition, Washington DC, p.1

Stakeholders' willingness refers to their opinions or responses toward the implementation of RAPID, ranging from enthusiastic to strong disagreement. In reality, for stakeholders in private sector, such as airlines, railway companies and airports, their willingness are mainly derived from the potential economical benefits, as well as the potential risks they might face. For stakeholders in public sector, such as government agencies and authorities, their willingness is not only from economical benefits, but also from social and environmental benefits, as well as their political interests. Stakeholders' capability refers to their potential contribution and influence toward RAPID development, which is comprised of both political/social influence for decision making and planning, and financial influence in terms of how much funding they might contribute. Successful implementation of RAPID requires those stakeholders with strong willingness have the capability to proceed with such intermodal systems.

As the first step of the institutional analyses, this chapter will go through the status and performance of current intercity passenger transportation in the United States. It will show that that unbalanced development among the major intercity transportation modes has resulted in airlines and airports being unwilling to connect and cooperate with intercity rail in most places of the U.S. Meanwhile, intercity rail is incapable to provide effective intermodal infrastructure individually. The focus is on the barriers associated with private or market sector. The conclusion is that that successful RAPID implementation in the United States is unlikely to be achieved by relying solely on the private sector or market forces in the near future.

The second step is to identify the barriers derived from public sector with the focus on modal separation structure of current US transportation system and the primary intermodal transportation policy in U.S (Intermodal Surface Transportation Efficiency Act of 1991). The analyses will indicate that the decades of modally focused administration structure and policy have resulted not only in the unbalance development among the primary intercity passenger transportation modes, but also in the lack of intermodal planning, infrastructure, information, and financing. ISTEA has been a good step for this nation to promote intermodal transportation, but it has been insufficient to change current modal bias situation and facilitate RAPID implementation in US.

As a third step, four successful air-rail intermodal systems in European countries are studied to identify their key experiences and lessons. This is followed by a discussion of the applicability of European experiences and lessons for future RAPID development in the United States. Finally, this Chapter will end with a series of institutional and policy recommendations to facilitate RAPID implementation in the United States.

4.1 Intercity Passenger Transportation in the United States

In today's United States, intercity passenger transportation services are mainly provided by private autos and three major for-hire modes including intercity rail (Amtrak), airlines and intercity buses. Most of the for-hire modes are operated by private companies. The primary of task of this section is to identify the key barriers purely from the market and demand point of view that impede RAPID implementation by the private sector. The analyses are comprised of two parts, starting with a brief background for the primary intercity passenger transportation

modes and followed by a discussion of the key hurdles from private sector that impede RAPID implementation.

Unbalanced Development among Intercity Passenger Modes

U.S domestic intercity passenger transportation is dominated by private autos, and aviation is the second biggest mode. In contrast, intercity rail played a minimal role in the intercity passenger transportation market. The relative weight of each mode to the entire market had no significant change in the past decade. The unbalanced development of intercity passenger transportation is tied to the technological breakthroughs and the evolution of U.S transportation development policies in the past century.

Table 4.1: Percentage of U.S Domestic Intercity Passenger-Miles For All modes from 1996 to 2002²⁸

	1996	1997	1998	1999	2000	2001	2002
Air	15.3%	15.4%	15.4%	15.9%	16.4%	15.6%	14.8%
Private Auto	79.8%	79.6%	79.6%	78.8%	78.5%	79.5%	80.5%
Intercity Bus	4.8%	4.8%	4.8%	5.1%	5.0%	4.7%	4.5%
Intercity Rail (Amtrak)	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%

Private Automobile

Along with the innovation of motor vehicle and sequent technological breakthrough, automobiles have revolutionized the nation’s transportation system. Besides its inherent advantages of speed, convenience and reliability for short-to-mid distance trips, the dominance of auto traveling for intercity trips is tied to the nation’s well-developed public roads and highway systems, as well as the relative lower usage fees in comparison with other developed countries as Western Europe and Japan. In the early 1920s to 1930s, highway construction made motor vehicles as serious competitors to railroads. The massive road construction and highway programs in the post-World War II period , especially along with the inauguration of the Interstate Highway program in 1956, created a highly auto-favored transportation system and propelled auto traveling to a position of overwhelming dominance in U.S passenger transportation at both intercity and intra-city scales. Such position was continued to be strengthened till the late 1990s. By 2002, as indicated in table 4.1, over 80% of U.S domestic intercity passenger-miles are taken by private automobiles.

Airlines

Along with the invention of the airplane and subsequent technological developments in Aviation, air transportation became a major transportation mode since 1950s, and in the following 40 decades, its growth rate had exceeded all other modes. By 2002, it accounted around 15% of U.S domestic intercity passenger miles.

²⁸ Bureau of Transportation Statistics, U.S Department of Transportation, *National Transportation Statistics*, 2004. http://www.bts.gov/publications/national_transportation_statistics/2004/html/table_01_37.html

The development of U.S airline industry experienced two different regulatory phases.²⁹ From 1938 to 1978, the Civil Aeronautics Board regulated the industry with respect to market entry and exit, pricing, mergers and acquisitions, and subsidies. Airlines were required to receive CAB approval for any changes they wished to make in route, fares, or company structure. In 1978, deregulation of airline industry phased out CAB and heralded the second phase of airline industry evolution. Airlines were allowed to serve any route at any fare, while they were also allowed to merge with acquire other airlines.

Intercity Bus

Along with the rapid growth of auto and air industries, intercity bus industry has seen its share of intercity passenger-miles decreasing steadily since 1940s. In 1997, it still accounted for 359 million intercity passengers, second to air among the for-hire transportation modes. According to the American Bus Association, bus services are serving 4274 towns in US, considerably more than air and rail. There are approximately 3,600 bus companies operating in the U.S today. Greyhound Lines is the largest, accounting for around 20% of Revenue Passenger Miles in 2000, and is the only nationwide provider of scheduled intercity bus transportation services in the US, serving more than 2500 destinations.³⁰ Most other bus companies operate contract chapter and special services, offering non-scheduled specialized service to and from specific points for groups of passengers.

Intercity Rail

The U.S once had the most developed nation-wide railway system in the world. From the mid-1800s to the 1920s, intercity passenger transportation in the US was dominated by the private railroads. From 1945 to 1970, the private rail passenger industry experienced a period of dramatic decline largely owe to the serious competition from autos and airlines. By 1970, intercity rail travel shrunk to 10% of levels attained during the early 1940s and all the private railroads were losing money on their passenger services.³¹ Such situation led directly to government intervention to try to salvage passenger railroad service through the creation of the national railroad passenger cooperation, a quasi-governmental corporation, known as Amtrak. Amtrak relieved private railroads of their passenger obligations through establishment of a basic nationwide network of rail passenger service initially using private railroad rolling stock and rights of way. Since 1970, Amtrak has tried to stabilize and reinvigorate the passenger rail in the US. Although revenue passenger miles have increased somewhat since 1970, intercity rail continues to fall farther behind private auto and airlines. [Nice, p.90]

Amtrak suffered financial difficulties since its beginning of operation, and never turned a profit. The percentage of costs covered by revenues has ranged from 37% to 80%³². The most successful part of Amtrak's operation has been the Northeast Corridor Service between Boston, New York and Washington. In this congested high-density corridor, frequent and relatively high-speed trains have been effective competitors to the highways and airlines. "Today, Amtrak is the most highly subsidized form of intercity transportation per passenger. Based on the FRA report,

²⁹ Goetz, Andrew R. and Christopher J, 1997, *The Geography of Deregulation in the U.S Airline Industry*. *Annals of the Association of American Geographers* 87, p-238-263.

³⁰ Greyhound Webpage, <http://www.greyhound.ca/en/>

³¹ Sampson, Roy, 1990, *Domestic Transportation: Practice, Theory and Policy*, 6th Edition, p. 143

³² Nice, David C: *Amtrak: The History and Politics of a National Railroad*, p.90.

the average taxpayer subsidy per Amtrak rider is \$100, or 40% of the total per-passenger cost. On some long-distance routes, such as New York to Chicago, the taxpayer subsidy per rider exceeds \$1000. After 25 years of federal ownership and \$13 billion of federal subsidies, Amtrak appears no closer to financial independence than the day taxpayer assistance began. It makes a negligible contribution to the nation's transportation system and has virtually no impact on reducing traffic congestion, pollution, or energy use³³.

In sum, intercity passenger transportation in the US is dominated by the private automobile/highway system and the air transportation system. Intercity railroad is playing a minimal role for the entire intercity passenger market, and has no capability for initializing system update by itself.

Hurdles for RAPID Implementation from Private Sector

In comparison with European countries, the process toward rail-air intermodalism in U.S has lagged. As the primary nationwide intercity passenger rail service provider, Amtrak, by 2000, has alliances with only two air carriers in United States, Alaska Air and United. Neither of the two alliances are true intermodal agreement. The Alliance with Alaska Air allows Alaska Airlines Mileage Plan members to earn miles when they travel on Amtrak's Coast Starlight, Cascades, Capitols, San Joaquin's or San Diegans rail service. The Alliance does not include any service agreements between them. The alliance with United, known as Air Rail Program, allows a passenger to fly one direction on United and Amtrak provide transportation in the other direction. Air Rail allows the passenger to make up to three stopovers along the Amtrak portion of the journey and is priced cheaper than if each service is purchased separately.³⁴

As mentioned, the successful implementation of RAPID relies on three critical factors: infrastructure, information and cooperation. Among these, utility analyses and case studies in Chapter 3 have indicated that effective intermodal infrastructures are the prerequisite for the successfulness of RAPID. However, a rail connection might be expensive in many places. Meanwhile when physical connection is available, efficient intermodal services are also critical for the competitiveness of RAPID, which require effective intermodal cooperation among rail, airlines and airports. Unfortunately, in the existing U. S intercity passenger transportation systems, all three factors are missing.

The following discussion is to indicate that the three critical components are not likely to be achieved in the near future by purely relying on the efforts of private sector and market forces. The main problems are due to the lack of effective intermodal infrastructure, as well as the lack of incentives for airlines and airports to promote RAPID development.

³³ Detroit News, *Time to End Amtrak's Subsidies*, October 2002, <http://www.detnews.com/2002/editorial/0210/02/a08-601861.htm>

³⁴ Andrew, R Geotz, Department of Geography and Intermodal Transportation Institute, University of Denver, *Process in Intermodal Passenger Transportation: Private Sector Initiatives*, 2000, p.14

Lack of Intermodal Infrastructure for RAPID

In 2000, Chief Executive Officer of Greyhound, Craig Lentzsch, pointed out two different reasons why intermodal services are facing difficulties in the United States.³⁵ The Lack of intermodal facilities is the first hurdle faced by companies that want to provide intermodal services. While bus and rail services are linked at a number of terminals across the nation, the linkages at airports are fewer and farther between. Without dedicated terminals, intermodal services will continue to be difficult to achieve in the US.

More and more transportation experts in United States have recognized the necessity and efficiency to enhance the use of rail for intercity passenger transportation through better connection with airports [street, p.2]. Linking Amtrak stations to airports has been appeared since the 1980s. However the progress is slow and there is still not any rail-connection available as effective as those in European Airports. The Amtrak station at Baltimore-Washington International Airport is located several miles away from the airport terminal, and passengers must take bus or other modes for transferring between the two locations. Connections between Amtrak and airports in Newark, New Jersey and Providence, Rhode Island are currently being or have been developed; however, in neither case will the rail line connect directly into the terminal. There is no existing or planned intercity rail stations in the US located directly underneath an airport terminal building, as found in European systems.

Amtrak Might Welcome RAPID, but Has No Capability to Proceed

Railways will be the core operators within a RAPID system and might be the biggest advocate for RAPID. The expected benefits for railways might include:

- Aviation system in this nation is the dominant mode for mid-long distance intercity passenger transportation market. Strong intermodal connection could allow rail access to larger demand resource.
- RAPID might allow Amtrak to improve their network and update current system through increasing federal funding support and by utilizing funding from other modes, especially from airlines and airports

Unfortunately, Amtrak has no capability to precede RAPID:

- Amtrak itself is a highly subsidized-operator, which largely limited its financial capability to invest on intermodal infrastructures and facilities.
- As of 2004, no legislation comparable to the interstate Highway Act has cleared the way for massive investment in railway. Most state DOTs and local governments have either highway-oriented or transit-oriented policies when planning transportation projects. Few of them provide financial support to intercity rail system.
- In most corridors, intercity passenger trains shared rights-of-ways with freight trains. Limited capacity limits the ability of rail to extend service in many places.

³⁵ Statements of Craig Lentzsch, Chief Executive Officer, Greyhound Bus lines, July 27, 2000.

Lack of Incentives from Aviation Side toward RAPID in US

A survey of the websites and schedules for the largest US airlines shows that only two, United and Frontier, promote their passenger intermodal service domestically.³⁶ United's intermodal service, known as GROUNDLINK, is bus or van service from selected United Airline destinations to other metropolitan cities that are more efficiently served by ground transportation than by air. Frontier Airlines based at Denver International Airport, offer a similar product to United' GROUNDLINK called the Freeway Flyer. The Freeway Flyer is motor Coach service from Boulder to Denver six times a day. What make this product unique is that the service is free. By 2000, none of domestic airlines in U.S is taking active efforts to promote intermodal connection and cooperation with the intercity rail system, which does not mean air carriers against RAPID, but largely due to the lack of high performance of intercity rail services and the lack of effective intermodal connection.

The Vice President of Southwest Airlines, Pete McGlade, pointed out that airlines may not be the best entity to provide seamless travel. McGlade believes that his company is so successful because they focus on one thing, carrying air passengers and a foray into other modes would deviate resources away from this success. This does not mean that the carrier is against intermodal services. The carrier believes in intermodal linkages if another transportation company can tap into the strength of the carrier and provide a service that benefits both of them. McGlade pointed to the success of the Betty Bus, a bus that carries Memphis travelers to Little Rock where they can fly on Southwest to their destination for less than they could from Memphis, as an example of the type of indirect relationship in which the carrier participates.³⁷

In comparison with the highly-developed highway systems and the dominance of auto traveling for intercity passenger transportation, intercity rail has limited network coverage and low market share in most corridors. Along with deregulation of aviation industry in US, airfare was significantly reduced. Meanwhile, services were largely improved. Passengers have been used to using airplane for their mid- to long-distance intercity trips. Even if RAPID would be finally developed, it might be much more difficult and take longer time to encourage passengers to change their travel pattern than in EU countries, where HSR services has been prevailing in intercity passenger transportation market for half a century. It is not realistic to expect airlines to fund an expensive intermodal linkage to a mode with low market share and limited service coverage that might not provide them significant economic benefits in near term.

Compared with the domestic market, internationally, many United States airlines have had intermodal service agreements with European train companies. For example, United Airline and American Airlines have code-share agreements with the French Railway Company (SNCF) to provide intermodal service between Charles de Gaulle airport in Paris and selected destinations in France and Belgium. Also, both of the two carriers have agreements with SNCF on its high speed rail service for a number of destinations in France. In addition, American Airline had an intermodal agreement with Thalys, a joint train venture between Belgian, France, British and German Railways, for service between Paris Charles De Gaulle International Airport and Brussels. These intermodal agreements allow passengers check in and deliver their baggage at

³⁶ Andrew R. Goetz, *Progress in Intermodal Transportation: Private Sector Initiatives*, Department of Geography and Intermodal Transportation Institute, University of Denver, p. 21, 2000

³⁷ Street, Jim, 2000. *Intermodal Travel: Getting there*, Airport Magazine.

selected stations. The successful intermodal cooperation between United States Airlines with European intercity rail systems further implied that if effective intermodal infrastructure is available, airlines would be likely to cooperate and promote intermodal services with high performance railroads, otherwise they would wait instead of actively promoting such intermodalism.

Similarly, airports in the U.S, as the core of the RAPID, would be likely to welcome RAPID, but still be unwilling to actively promote it, even though they might be suffering serious congestions and delays problems in both airside and landside. Since there are currently no policies or common guidelines to accommodate ground transportation at airports, each airport has its own decisional authority regarding the extent to which it will accommodate ground transportation service providers. When considering the accessibility, airport design and planning in U.S always set priorities to well connect with public roads and highways, instead of intercity rail.

In summary, current intercity passenger transportation system are suffering unbalanced development. Mass highway construction and deregulation of airline industry have made the nation's intercity passenger transport dominated by autos and airlines. Intercity rail's contribution is minimal. Such unbalanced status put the RAPID development in U.S into a vicious-circle in private sector. In one side, lack of strong intermodal infrastructure is the primary hurdle that impeding RAPID implementation. Intercity rail, Amtrak, might welcome RAPID to improve its performance, but has little capacity to promote it. In the other side, low market share and limited performance of rail service resulted in the lack of willingness or incentives from airlines and airports to actively promote intermodal connection with rail. In the near future, without strong government involvement and policy support, RAPID is extremely hard to be achieved purely through the efforts of private sector and market force.

4.2 Failures of Institutional Structure and Insufficiencies of ISETA

As discussed in above section, RAPID implementation is not likely to be achieved by relying solely on the private sector. It is the time for strong governmental involvement and policy support. However, current modal focus administration structure for U.S transportation limited the capability of government to promote RAPID in terms of the lack of intermodal funding, planning, intermodal information, etc. Intermodal Surface Transportation Efficiency Act of 1991 was an important step for this nation to promote intermodal solutions to address the challenges in U.S transportation system. Nevertheless, ISTEA is insufficient for the successful implementation of RAPID in U.S. The primary task of this chapter is to identify key barriers impeding RAPID implementation from the public sector. The focus is on the failures of current U.S modal separation structure and the insufficiencies of ISTEA.

Modally-Focused Structure Generates Hurdles for RAPID Implementation

In the past decades, the Federal Transportation Act had a strong modal focus, which results in the different transportation agencies (Federal Railroad Administration, Federal Aviation Administration, and Federal Highway Administration) focused on the specific modes when financing, planning and conducting research on transportation projects. The existing funding programs and policies did not encourage and require system integration among different modes, and have generated significant barriers for RAPID development, as following discussion.

Modal Focus Has Resulted in the Unbalanced Development of Transportation Modes

From 1958 to 1975, the interstate Highway Act had made significant modifications to the nations' transportation infrastructures. Tens thousands of new roadway miles have been constructed under the Act, which accompanied by the closure of thousands of mile of rail lines to passenger and freight traffic. Such massive investment in one mode of transport resulted in a transportation Network that is heavily weighted in favor of the automobile and trucks. Due to federal, state and local governments' modal bias towards highways, many modes have not been equally represented in the national transportation network. Currently, auto traveling is taking more than 80% of the total intercity passenger-miles. While, intercity passenger rail is taking only 0.6% of the total passenger miles.

During the similar period, along with the deregulation of aviation industry since 1978, the entire aviation industry enjoys a rapid growth in terms of both significant traffic growth and wide-spread aviation network. The United States has over 500 commercial airports in operation. All of the top 30 airports are facing serious congestion and delays problem in both landside and airside. As indicated in table 4.1, by 2002, air travel took around 15% of intercity passenger-miles, second only to private auto.

Along with the rapid growth of auto and air traveling, railroads in the U.S experienced dramatic decline since the early 1950s and many private railroads declared bankruptcy in the 1950s ~ 1970s. Under the Rail Passenger Service Act entitled in 1970, Amtrak was created to take over the provision of nation-wide intercity passenger transportation. After thirty years of operation, Amtrak was highly subsidized by federal funding and never turned a profit. It makes a negligible contribution to the nation's intercity passenger transportation.

Modal bias further fuels the bias of resource allocation

Modal Biased policy has resulted in unbalanced development among the three major intercity passenger modes. The dominance of auto and air traveling generates more and more safety and efficiency problems from highway and air systems, which, under the modal focus framework, directly lead to more and more funding flow into these dominant modes, instead of improving the performance of alternative modes such as railroad.

For 2005, Department of Transportation of the United States is proposing \$58.7 billion in budgetary resources for transportation programs, among which, as indicated in table 4.2, around 24% is for aviation, around 60% for highway programs, and only 1.7% for railroad (both freight and passenger).

**Table 4.2: Federal Transportation Budget Allocation
Among Highway, Aviation and Rail Road³⁸**

	2003 Actual	2004 Enacted	2005 Request
Aviation	13,510	13,873	13,966
Highway	31,805	34,764	34,478
Railroad (sum)	1,261	1,443	1,088
<i>Amtrak</i>	<i>1043</i>	<i>1218</i>	<i>900</i>
<i>Safety & Operation</i>	<i>116</i>	<i>130</i>	<i>142</i>
<i>Research & Development</i>	<i>29</i>	<i>34</i>	<i>36</i>
<i>Next Generation of High Speed Rail</i>	<i>30</i>	<i>37</i>	<i>10</i>
<i>Pennsylvania Station</i>	<i>20</i>	<i>--</i>	<i>--</i>
<i>Other</i>	<i>23</i>	<i>25</i>	<i>--</i>

Table 4.2 also indicated that a round 80% of the federal budget for railroads is used to cover deficit of Amtrak operation, and there are no funds provided for the update of intercity passenger rail system. As mentioned, strong physical intermodal connection is the necessity for the successfulness of RAPID and might be expensive in many places. Around 85% of federal funding is allocated to highway and air, but they would not likely utilize their resource to update railroad system under the modal focus structure, even though RAPID might bring them a more efficient and long-term solution to their difficulties such as airport congestion and safety problems.

Beside the shortage of federal financial support, RAPID implementation is also facing difficulties to receive support from state and local level. RAPID deals with the connection between air and intercity rail, which might involve more than one states and metropolitan areas. Even though the physical construction likely happens in a single region, the whole system intends to benefit all the connected regions. For example, Boston-New York corridor, which is believed to be one of the few corridors suitable for RAPID, passes through four states, Massachusetts, New Hampshire, New Jersey, and New York. The intermodal connection could be built within any of the four states, while the whole system is serving the entire region. Different local, state and regional officials have their own Transportation Management Area, agendas, studies and processes, and their decision often reflects political concerns as well as transportation needs. Because of the political concerns, state and local government are more likely to utilize their resources in projects that could generate short-term benefits for local residents, instead of those projects without near-term local benefits.

In sum, RAPID implementation in U.S is impeded by the lack of sufficient financial support from the public sector.

³⁸ U.S Department of Transportation 2005 Budget in Brief, <http://www.dot.gov/bib2005/FOC.html>, January 2005.

Modal focus resulted in the lack of Intermodal Planning

Even though many researches have indicated that system integration between aviation and railroads could provide efficient and effective solutions for their challenges and improve their performance, until 2000, both rail and airports' planning and policies are separately constructed and evaluated. For example, to achieve financial independence, Amtrak's primary long-term strategies are to get more funding from federal government to improve its competitiveness over other modes in certain rail-oriented corridors by providing high speed rail³⁹. Meanwhile, most congested airports are trying to either build new runways or new airports. Neither of the two modes have long-term plan and policies to promote system integration to achieve more flexible and efficient system.

Modal separation also resulted in that various modes have various standards and views on the evaluation of transportation projects with the concentration on their individual interests, which significantly impede building up consensuses and successful financing for intermodal system.⁴⁰ In the Northeast Corridor, for example, intercity rail service provides good service and is competitive with short-distance flights and highway modes. This suggests a potential for enhancing air-rail cooperation. However, Air and rail are competing for not only demand, but also federal subsidy under current modal focus framework. RAPID is a rail-oriented intermodal system, aiming at enhancing the use of rail for intercity transportation, which might reduce the profitability of airlines and airports, as well as more federal budget flow into their competitor. As a result, airlines might be reluctant to form partnerships with rail to conduct intermodal planning.

Modal Focus Result in the Lack of Intermodal Information

Until now, DOTs still have no specific program to collect and analyze data for planning of RAPID. The shortcomings of the current research program result from a number of problems.

- First, many agencies do not have adequate funding to address emerging research needs. MPOs, for example, are now primarily responsible to decisions that affect air quality, land use planning, and other policy issues, yet few are large enough to support substantial research programs.
- Second, most transportation research institutions are devoted to short-term goals, and do not focus on long-term or system-wide issues. For example, the US Department of Transportation's modal agencies conduct research to maximize performance of single modes, making it difficult to set aside funding for intermodal research. Thirdly, most research funding is tied to specific activities by Congress before it reaches agency budgets, limiting the extent to which agencies can explore new research topics.

ISTEA is a Good Step toward Intermodalism, but Insufficient for RAPID

As the primary legislation to promote intermodal transportation in U.S, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) was enacted in December 1991 and reauthorized in 1998, known as TEA-21. The stated goal of the Act is to "encourage and promote development of a national intermodal manner, provide the foundation for improved productivity

³⁹ Statement of Phyllis F. Scheinberg, Director, Physical Infrastructure Issues. *Intercity Passenger Rail: Assessing the Benefits of Increased Federal Funding for Amtrak and High-Speed Passenger Rail System*, 2000, p.2.

⁴⁰ TCRP Report 14, Institutional barriers to Intermodal Transportation Policies and Planning In Metropolitan Area, 2001, p. 6

growth, strengthen the nation's ability to compete in the global economy, and obtain the optimize yield from the nation's transportation resources." ⁴¹ In line with this goal, the ISTEA explicitly emphasizes the development of the national intermodal transportation system (NITS). The ISTEA envisions the NITS as a unified, combined transport network consisting of air, road, railroad, and sea links connected by efficient intermodal terminals. The legislation implicitly assumes that the optimization of transportation system performance inherent in the development of such a system would significantly reduce resource consumption, increase network connectivity, and reduce transportation costs. ⁴²

According to Russel Leibson, ⁴³ ISTEA is "not an evolution, but a revolution" and "the most complex piece of legislation in the history of the United States". The very core of ISTEA and TEA-21 is the concept of flexible funding for transportation projects, which is aiming at maximizing the latitude of transportation planners in using funds for transportation projects involving multiple modes. The so called "revolution" beneath the concept of flexible funding is twofold: 1) ISTEA promoted intermodal transportation solutions by emphasizing funding flexibility across modes and facilities; 2) and ISTEA delegated transportation planning and programming responsibilities to state and local government, which allows state and local governments to develop appropriate solutions. ISTEA is a revolutionary step to break the modal and governmental barriers when funding multimodal projects. However, it is still a highway-oriented legislation, can not mitigate current modal bias situation in the United States, and is insufficient to promote RAPID development in the United States.

ISTEA is Highway-Oriented Legislation and Insufficient for RAPID

On December 18, 1991, President Bush signed ISTEA providing authorizations for highways, highway safety, and mass transportation for the next 6 years. The total funding was enacted as \$155 billion in fiscal year 1992 to 1997. ISTEA's comprehensive coverage is reflected in its eight titles, among which Title I, II, III, IV and VI were to authorize funding programs relevant to highway-related and metro transit-related projects and intermodalism-oriented research programs; Title V "Intermodal transportation" was a legislation to establish intermodal office; Title VII "Air transportation" was amendments to Metropolitan Washington Airport Act of 1986; and Title VIII was legislation for extension of highway related taxes and highway trust funds.

⁴¹ 49 U.S.C. § 302 (c)

⁴² Samuel K. Skinner, Transportation Secretary, *Intermodal Surface Transportation Efficiency Act of 1991-Summary*, 1991, <http://ntl.bts.gov/DOCS/ste.html>, p.1

⁴³ Russell Leibson, William Penner, *Legal issues Associated with Intermodalism*, 2000, p.1

Table 4.3: Funding Allocations Authorized by ISTEA⁴⁴

	Title I	Title II	Title III	Title IV	Title V	Title VI	Title VII	Title VIII	Total (billion)
ISTEA Funding Allocation By Title and Year (Billion US \$)									
1992	18.70	0.28	3.60	0.12		0.12		Extension of Highway Related Taxes and Highway Trust Funds	\$22.82
1993	20.50	0.29	5.20	0.08		0.14	Amendments to Metropolitan Washington Airports Act of 1986		\$26.21
1994	20.50	0.30	5.10	0.08	Establish Intermodal Office	0.14			\$26.12
1995	20.40	0.30	5.10	0.08		0.14			\$26.02
1996	20.40	0.21	5.10	0.09		0.15			\$25.95
1997	20.40	0.22	7.30	0.09		0.15			\$28.16
Total	121.00	1.60	31.50	0.53		0.83			\$155.00
ISTEA Funding Allocation By Modes Highway vs. Rail									
% of ISTEA Funding Potentially Used For Highway-Related Projects	100%	100%	100%	100%					
% of ISTEA Funding Potentially Used For Intercity Passenger Rail-Related Projects	30%	0%	0%	0%					
% of ISTEA Funding Potentially Used For Air-Rail Intermodal Infrastructure	0%	0%	0%	0%					

⁴⁴ Samuel K Skinner, Secretary of Transportation of the United States, Intermodal Surface Transportation Efficiency Act of 1991-Summary, 1991, p.38 -42

According to the ISTEA funding programs list [Samuel, p.31-41], 100% of the ISTEA funding could be potentially utilized in highway related projects including road building and maintenance, highway safety improvement, intermodal connection between road and other modes and so on. In contrast, there were few funding programs specifically aiming at the improvement of intercity passenger transportation systems. Under ISTEA, the potential funding opportunities for intercity passenger rail-related projects were mainly concentrated on four funding programs under Title I (Surface Transportation), including Surface Transportation Program (STP): transportation enhancements program (TEP), congestion mitigation and air quality improvement program (CMAQ), and National High-Speed Ground Transportation Programs (NHSGTP)

Surface Transportation Program (STP)

“STP provides funding for highway projects on all but local streets. Projects eligible for STP funding include construction and rehabilitation of highways and bridges, transit and capital projects eligible under the Federal Transit Act Amendments of 1991, and carpool, fringe and corridor parking, bicycle transportation and pedestrian walkway programs.” [23 U.S.C § 133 (b)] The legislation language in STP explicitly emphasize that the funding from STP (\$23 /year billion for the 6 year period) should be used by states and localities for any roads that are not classified as local or rural minor collectors. In this regard, rail-related projects are eligible for STP funding only when such projects are critical parts of any eligible highway projects, such as the improvement of grade crossing and road access to rail terminal. Actually, as a primary source for road construction and maintenance funds, hundreds of highway projects competed for this funding in each state each year during the 6 year ISTEA life period. There were not any rail-related projects funded by STP. ⁴⁵

Transportation Enhancements Program

ISTEA required that “Once funds are distributed to the states, 10% of all STP funds, or roughly \$3 billion dollars over six years life period of ISTEA, be set aside to fund non-traditional highway projects that enhance the existing transportation infrastructure. Each state has been apportioned a percentage of this \$3 billion in accordance with a population-based formula.” [Samuel, p. 9] The Enhancements Program funding was eligible for the following ten activities:

1. Bicycle and pedestrian facilities;
2. Acquisition of scenic easements and scenic or historic sites;
3. Scenic or historic highway programs;
4. Landscaping and scenic beautification;
5. Historic preservation;
6. Rehabilitation and operation of historic transportation buildings, structures or facilities (including historic railroad facilities and canals);
7. Preservation of abandoned railway corridors (including the conversion and use thereof for pedestrian and bicycle trails);
8. Control and removal of outdoor advertising;
9. Archaeological planning and research; and
10. Mitigation of water pollution due to highway runoff.

⁴⁵ Jeff Allen, Trail-to-Rail Conservancy, *Acquiring Rail Corridors: A How to Manual*, Chapter 7, 2000.

Railway-related projects might be eligible for TEP funding under categories 1 and 7. Under category 1, TEP funding might be used to improve railway terminal pedestrian and bicycle environment. Under category 7, TEP funding could be used to preserve abandoned railway corridor. Neither of them is applicable for RAPID development.

Congestion, Mitigation and Air Quality Improvement Program (CMAQ)

CMAQ tied funding of transportation projects to air quality improvement. “In states with areas in nonattainment with Air quality levels set in Clean Air Act, CMAQ funds may be used on projects likely to contribute the attainment of a national ambient air quality standard.” [23 U.S.C 149 (b)] Under this program, ISTEA authorized \$ 6 billion nationally over six years, which were distributed based on state’s share of the population of air quality non-attainment areas weighted by degree of air pollution. Under CMAQ, states and metropolitan planning organizations are required to use a variety of transportation control measures to reduce air pollution. [Samuel, p. 9] Obviously, enhancing the use of rail could be an eligible measure. Since CMAQ did not address specifically to railway, rail-related projects faced serious competition for CMAQ funding from many other types of projects, such as bicycle and pedestrian facilities.

National High-Speed Ground Transportation Programs

ISTEA authorized a Magnetic Levitation (Maglev) prototype development program at a sum of \$ 725 million for the 6 year period. These funds were directed toward the development of one prototype project, selected from applicants across the nation. [Samuel, p.11] Clearly, the funding program targeted on research and experiment on new high speed ground transportation technology, instead of funding any rail systems for commercial operation.

In sum, ISTEA is still a highway-oriented legislation. Most of the funding was allocated to highway-related projects. It provided some funding opportunities for enhancing the use of rail in this nation. However, since there are few programs specifically designed for railroad, it was difficult for rail-related projects to compete with the limited funding resource with other types of projects. Several intercity passenger rail systems have successfully received funding under ISTEA, but there were not any projects relevant to the intermodal connection between intercity passenger rail and airports (RAPID).

TEA-21 Enhanced the opportunities of Rail projects, but failed to address RAPID

As discussed above, ISTEA made a number of revolutionary changes in the way that the U.S. supports its transportation system, with greater federal program funding flexibility to choose between highway and transit projects. However, intercity passenger rail were not given major attention in ISTEA. Built up the initiatives of ISTEA, Transportation Equity Act for the 21st Century (TEA-21) was enacted on June 9, 1998 and expired in 2003. Still TEA-21 provided federal funding for transportation planning at the state and local levels through a statutory formula.⁴⁶ TEA-21 refined ISTEA with key rail provisions, including: enhancement of the Operation Lifesaver, High Speed Rail corridors, and Highway Rail Grade Crossing Programs; and establishment of the Transportation Infrastructure Finance and Innovation (TIFIA) program, a Federal credit program for transportation projects of national significance, providing secured loans, loan guarantees, and lines of credit for eligible projects including intercity passenger rail

⁴⁶ TEA-21 - Transportation Equity Act for the 21st Century, Summary Information, 1998, <http://www.fhwa.dot.gov/tea21/index.htm>

facilities and vehicles and components of magnetic levitation rail systems.⁴⁷ Under TEA-21, Section 1103 (c) authorized six high speed rail corridor designations including "a Gulf Coast high-speed railway corridor; a Keystone high-speed railway corridor from Philadelphia to Harrisburg, Pennsylvania; and an Empire State railway corridor from New York City to Albany to Buffalo, New York". It also authorized \$250,000 per year for eligible improvements on the Minneapolis/St. Paul-Chicago segment of the Midwest High-Speed Rail Corridor.⁴⁸ Neither of these have addressed intermodal connection between rail and airports.

Under TEA-21, Federal Highway Administration and Federal Transit Administration are authorized to manage program funding. Therefore, applications for rail projects are made through the appropriate FHWA or FTA field office.⁴⁹ Since formal project requests must be made through FHWA and FTA regional office, it is not surprising that to be successfully approved, rail-related projects have to be tied to the interests of regional highway and transit system. Since there are no programs and statutory languages under TEA-21 that specifically emphasize on promoting rail/air intermodalism, RAPID projects, which have no direct relation to highway and transit interests, are hard fund from TEA-21.

In summary, Intermodal Surface Transportation Efficiency Act (1991) and its reauthorization in 1998 (TEA-21) are the primary legislation to promote intermodal systems in this nation's transportation system for both freight and passenger. However, the core of the two acts is flexibility of using federal funding and is still putting emphases on highway related projects, which is not able to mitigate the modal bias situation and promote RAPID development in this nation. By 2003, there were five high-speed rail corridors authorized under ISTEA and six under TEA-21 for a total of eleven corridors. To date the Department of Transportation has designated ten corridors that are listed below in chronological order⁵⁰.

- October 15, 1992. Secretary of Transportation Andrew H. Card, Jr. announced designation of the Midwest high-speed rail corridor linking Detroit, MI with Chicago, IL, St. Louis MO and Milwaukee WI.
- October 16, 1992. Secretary of Transportation Andrew H. Card, Jr. announced designation of the Florida high-speed rail corridor linking Miami with Orlando and Tampa.
- October 19, 1992. Secretary of Transportation Andrew H. Card Jr. announced designation of the California high-speed rail corridor linking San Diego and Los Angeles with the Bay Area and Sacramento via the San Joaquin Valley.

⁴⁷ Federal Railroad Administration, *Intercity Freight and Passenger Rail: State and Local Project Reference Guide, Section 1*, Introduction, 2002, <http://www.fra.dot.gov/us/content/188>

⁴⁸ Federal Railroad Administration, *CHRONOLOGY OF HIGH-SPEED RAIL CORRIDORS, 2004*.
<http://www.fra.dot.gov/us/content/618>

⁴⁹ Ibid, section 4.

⁵⁰ Federal Railroad Administration, *CHRONOLOGY OF HIGH-SPEED RAIL CORRIDORS, 2004*.
<http://www.fra.dot.gov/us/content/618>

- October 20, 1992. Secretary of Transportation Andrew H. Card Jr. announced designation of the Southeast high-speed rail corridor connecting Charlotte, NC, Richmond, VA, and Washington, DC.
- October 20, 1992. FRA Administrator Gil Carmichael announced designation of the Pacific Northwest high-speed rail corridor linking Eugene and Portland, OR with Seattle, WA and Vancouver, BC, Canada.
- November 18, 1998. In New Orleans, LA Secretary Slater announced designation of the TEA-21 authorized Gulf Coast high-speed rail corridor.
- December 10, 1998. Secretary Slater announced designation of the TEA-21 authorized Keystone and Empire State corridors.
- October 11, 2000. Secretary Slater designated two new high-speed rail corridors: Northern New England corridor with a hub in Boston that will serve destinations in Maine, New Hampshire, Vermont and Montreal and South Central corridor with Dallas/Ft. Worth as its hub that will serve Oklahoma, Arkansas and Texas.

Neither of these designated high speed rail corridor is relevant to RAPID.

4.3 European Experiences and Lessons

With concerns on system mobility within European countries, an increasing number of major European airports have already plugged into or are planning to plug into the expanding high speed rail network, including Paris Charles De Gaulle, Frankfurt, Dusseldorf, Cologne-Bonn (in the near future), Amsterdam, Copenhagen, London Gatwick and Zurich. Four of them will be examined in this part to provide some institutional implications on the future RAPID development in US. The two French airport-rail links were initialized as part of the TGV network expansion project. The two German airport-rail links were demanded by airports, which are close to the existing Germany High Speed Rail network. All of them are true rail-air intermodal system as defined by Muller [Muller, p.2] with both effective physical intermodal connection and efficient intermodal cooperation.

Background of the Four European Airports

Roissy-Charles De Gaulle Airport

Paris Roissy Charles de Gaulle Airport, 23 kilometres (14 miles) north-east of Paris, is the city's largest airport and was one of the first airports in Europe to have an integrated train system serving it. CDG connected with regional rail within Paris Basin, and with HS TGV network to Brussels, Lille, Dijon, and many other destinations within France. The RER rapid TGV train service reaches central Paris in approximately 45 minutes, Disney World in ten minutes, and Lille and Brussels in an hour. The airport has three terminals serving 200,000 passengers and more than 6000 tons of baggage and freight daily⁵¹.

⁵¹ Charles De Gaulle International Airport webpage : <http://www.airwise.com/airports/europe/CDG/>

Lyon Airport (Satolas)

Lyon is considered to be the food capital of France. Its airport, Lyon-Satolas Airport is about 16 miles from the city center and is serviced by bus, taxi and rail service. Supported by the country's most powerful economic engine after the Paris region, the airport handled 5.7 million passengers in 2002, up from 5.2 million in 1998 and 4.4 million in 1995. Although it is operating close to capacity, LSA is believed to have the potential to double in size to more than 10 million by 2010.⁵²

Frankfurt Airport

Frankfurt Airport is located in Frankfurt am Main, Germany Frankfurt. It is the largest airport in Germany and the second or third-largest in Europe (depending which data are used), serving as an important hub for international flights from around the world.

When Frankfurt Airport was opened in 1971, it was served by urban rail transit network with a travel time of 12 min between urban center and airport. Subsequently, long-distance intercity services were integrated in the early 1980s. The new station situated some 200 m from the existing one and on the other side of motorway, became a true rail-air modal interchange center form by the end of 2002, with the railway replacing some of the air services currently operating.⁵³

Dusseldorf International Airport

Düsseldorf Airport is the third biggest airport in Germany, and the fourteenth biggest in Europe, handling about 15 million travellers each year. It was severely damaged in a fire in 1996, which provided the impetus for the expansion project. Dusseldorf Airport's ownership is shared between city of Dusseldorf, Hochtief AG, and Aer Riantia International. Aer Riantia International is part of Ireland's state-owned airport authority, and take the share of Dusseldorf Airport as a result of a US\$ 57 million investment in 1997. Aer Riamta provides the airport management expertise and Hochtief provides the building and finance management skills. Within the expansion projects, Dusseldorf Airport purchased the neighboring land and constructed a HSR station, which was opened in 2000.⁵⁴

Rail-Oriented Policy Created High Perportation Intercity Railway Network

According to Vinois, France and Germand, as well as many other European countries have had a public transportation oriented development policies for decades and set high priorities to High Speed Rail service when developing their intercity transportation system⁵⁵. During the past 20 years, the European High-Speed Rail network has developed to nearly 3,700 km of new lines, and such number will double by the end of 2010. Since 1950s, rail has been the prevailing method for intercity passenger transportation in Europe. By now, EU has the best High Speed Railway network in the world with advanced technique and great demand resource. In many intercity corridors, HSR has been the dominant intercity passenger transportation modes. Figure

⁵² Lyon Airport Webpage : <http://www.openjet.com/public/airport/Lyon.html>

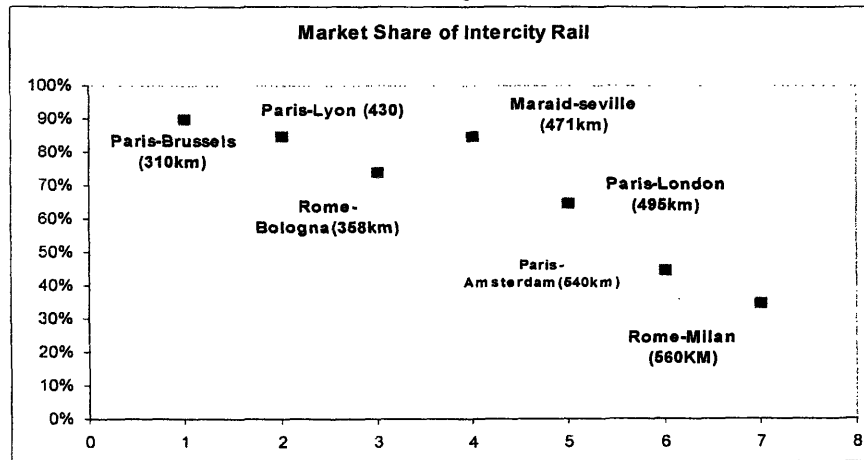
⁵³ Frankfurt International Airport Webpage: <http://www.airwise.com/airports/europe/FRA/>

⁵⁴Dusseldorf International Airport Webpage: <http://www.duesseldorf-international.de/>

⁵⁵ Jean Arnold Vinois, Head of Unit Interoperability and Rail Transport, *High Speed Rail In Europe*, 2003, p.2

4.1 indicates that all seven key intercity rail corridors involved in the four EU airport-rail systems are taking the entire intercity market from 35% to as high as 90%.

**Figure 4.1: Market Share of High Speed Rail
In the Seven Key Corridors⁵⁶**



As highway in the United States, high performance of intercity rail service is dominating intercity passengers market in many short-to-mid distance corridors, which directly lead to that numerous European Airports put emphases on rail connection to improve their accessibility. As indicated in Table 4.4, RAPID appeared in various types of airports from international hub with around 50 million passengers of annual air traffic, as CDG and Frankfurt, to regional or secondary airport with relatively low level of air traffic, as Lyon airport.

**Table 4.4 Airport Characteristics and
Type of Rail Connection (Data 2001)**

Airport	Annual Air Traffic (Million Passenger)	No. of Trans/Day Stopping	Type of rail Connection		Reference Speed (KM/H)
			Main Line	Branch Line	
Paris-CDG	48.3	55	X		230
Frankfurt	48.4	84	X		160/200
Dusseldorf	14.7	40	X		160/200
Lyon	5.7	14	X		300

The Four European air-rail systems were developed by Nature

Instead of being promoted by intermodal policy or legislation, as ISTEAs in United States, the four European airport-rail systems were implemented by market force, which were initialized by the needs of individual modes.

In 1987, French government planned to extend the TGV network by building the High Speed TGV-North Line and the TGV interconnection that would join the TGV-North with the TGV-

⁵⁶ Hani S. Mahmassani, Texas Department of Transportation, Domestic and International Best Practice Case Studies, February 2001

Atlantic and the TGV-Southeast, via a line that passed through eastern Paris. As part of this project, it was considered that positioning the TGV station at Roissy Airport in a North-South Direction was the most suitable aspect, which could allow the airport users using the interconnection lines to access HSR network. Similarly, Lyon Airport Rail systems were also part of the TGV network expansion project, in which in which French Railways planned to extend the HSR line from Lyon to Valence where the route involved passing through the eastern suburbs of Lyon near Satolas Airport was considered as the best alternative. In both of these two systems, Airlines played as “follow-up” actors, which means that they were not actively involved in the decision-making and planning period, instead, after the physical connection finished, increasing number of airlines began to cooperate with railroads in terms of joint marketing and providing off-airport intermodal services. Such “follow-up” procedures took many years. For example, the rail extension projects in CDG were started in 1987, while the code sharing agreements between French Railways and Air France started in 1995, and some other airlines began to join in this game after 2000.

Different from CDG and Lyon Airport, Frankfurt and Düsseldorf Airports mobilized and demanded the HSR connection with the existing HSR network that is close to airports. During the implementation period, airports, as well as the local governments, were co-investors with German rail companies and central governments, and also actively involved in the decision-making and system design and planning.

U.S Facing More Difficulties for RAPID Development than EU

Compared with European countries, RAPID implementation in US is facing much more difficulties, including:

- 1) The U.S today is short of high performance rail services. EU has a well developed HSR network with 200-250 km/h operation speed, which allows rail to have time-advantage over other modes for 100-600 km distance intercity trips. The average speed of most US rail corridors is less than 100 km/h, which make it have much smaller competitive range over highway and air.
- 2) As discussed in section 4.2, Amtrak, the primary national provider of intercity passenger rail service, is facing financial difficulties. Without additional governmental support, it has no capability of promoting RAPID;
- 3) Compared with EU cases, US airlines might be reluctant to cooperate with rail services, due to the facts that: a) domestic flights are major revenue sources of US airlines, while international and transcontinental markets are the dominant revenue sources for EU airlines. b) EU countries have had public-transportation-oriented development policies for many decades, which make rail the prevailing service for intercity transportation. In US, auto dominates the short- to mid-distance market, rail plays a minimal role for the entire market, which hurts its attractiveness to airports and airlines. While the US has the most developed highway networks in the world. Airlines would be more likely to welcome the cooperation with highway modes than rail.

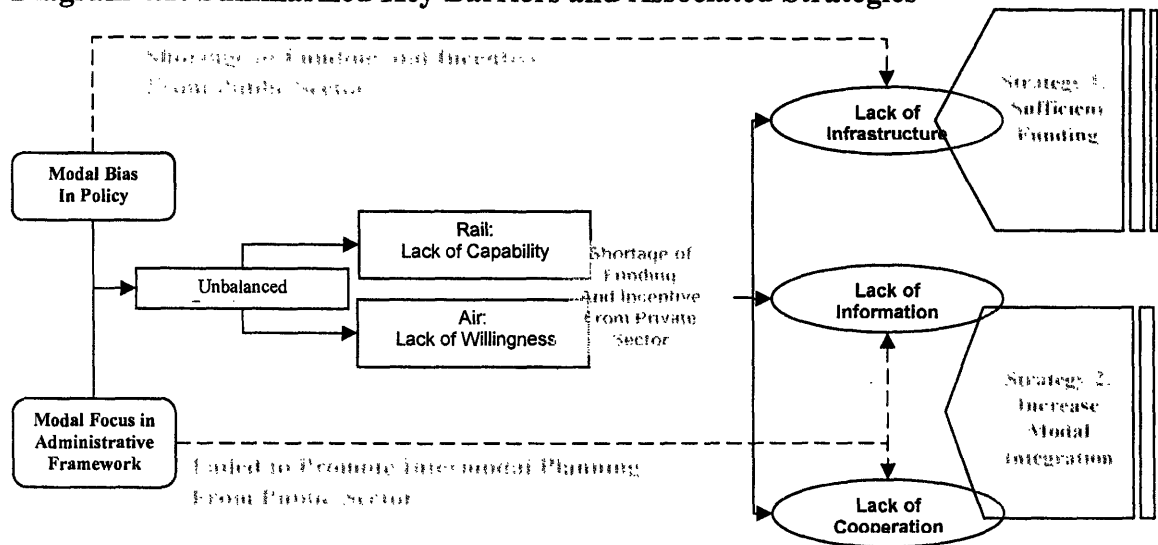
4.4 Barriers Summary and Recommendations

According to Muller's definition on intermodalism, a true air-rail intermodal system requires three key components: effective intermodal infrastructure, necessary information for both service providers and customers, and efficient intermodal cooperation. Of these, the analyses in Chapter 3 concluded that effective intermodal infrastructure might be the prerequisite for the successfulness of RAPID. European experiences further implied that when both effective intermodal infrastructure and high performance of rail systems are available, RAPID could be achieved by nature. Both airlines and airports would welcome effective intermodal cooperation with intercity rail to meet their goals, including meeting longer term accessibility problems, releasing high value airport slots for lucrative long distance flights, and so on. Unfortunately, all of these key components for RAPID are missing in today's intercity passenger transportation systems in the United States.

Lack of rail-air intermodal infrastructure as effective as in European countries is the primary hurdle that impedes RAPID development in U.S. However, decades of modally-biased policy have resulted in the nation's intercity passenger transportation being dominated by auto and air travel with little contributed by intercity rail services. Not surprising, highway and air have received the most public funding in the recent decade, which further worsens the modal bias. In contrast, intercity rail service is playing a minimal role in the entire intercity passenger transportation market. Amtrak, as the primary nationwide intercity passenger rail service provider, has faced financial difficulties since its beginning of operation in the 1970s. It is now the highest subsidized passenger transportation form in terms of subsidy per passenger, which results in its inability to advance RAPID on its own. Meanwhile, air and highways, which are receiving most federal funding, have no incentives or obligations to promote RAPID by funding rail connections with airports, even though RAPID might provide them effective solutions for their current difficulties. All of these factors lead to a conclusion that RAPID in U.S will not be achieved in the near future by relying solely on private sector and market forces.

Since RAPID can not be achieved by the private sector, it is the time for strong financial and policy support from the public sector, especially the federal government. Nevertheless, the administration system of transportation in U.S is modally-separated. Instead of facilitating, this framework hurts RAPID solutions in terms of a lack of intermodal funding, a lack of intermodal planning and a lack of intermodal information. Intermodal Surface Transportation Efficiency Act (1991) and its reauthorization in 1998 (TEA-21) are the primary legislation to promote intermodal systems in this nation's transportation system for both freight and passenger. However, the core of the two acts is flexibility of using federal funding and they still emphasize on highway-related projects. These facts did not mitigate the modal bias or otherwise promote RAPID development.

Diagram 4.1: Summarized Key Barriers and Associated Strategies



In short, as indicated Diagram 4.1, the primary hurdles for RAPID development in the United States are generated from the modally-focused administrative framework and modally-biased transportation policy, which directly and indirectly result in the absence of three key components for RAPID (infrastructure, information and cooperation) in the United States.

- For the private sector, because of the unbalanced development, intercity rail is incapable of providing necessary intermodal infrastructure, while air is unwilling to connect and cooperate with railroad.
- For the public sector, modal bias has resulted in the shortage of funding for building effective rail-air intermodal infrastructures. While modal separation framework provides hurdles for efficient intermodal planning.

Thus, for successful implementation of RAPID in the United States, the following recommendations target two strategies: providing sufficient funding for effective rail-air intermodal infrastructures and increasing modal integration to facilitate intermodal planning and decision making.

Recommendation 1: The federal Government should play as the major role to provide effective rail-air intermodal infrastructures by authorizing sufficient funding resources specifically to promote rail-air intermodalism.

As discussed in this chapter, lack of intermodal infrastructure is the critical barrier that impeding the successful implementation of RAPID in the United States. However, such infrastructures might be expensive and unlikely to be achieved by private sector. Meanwhile, because of the political concerns, state and local governments are unwilling to promote expensive intercity rail-airport projects that are unlikely to achieve significant near-term benefits for local residents

under current modal bias situation in the United States. In this regard, federal funding has to be the major resource for building RAPID infrastructures. ISTEA and TEA-21 have been good steps to promote intermodal solutions to the nation's transportation system. Under TEA-21, funding opportunities for intercity passenger railroad-related projects have been enhanced through several specific funding programs. Nevertheless, Federal Highway Administration and Federal Transit Administration are authorized to manage funding programs under TEA-21, which largely limited the opportunities of rail-airport intermodalism related projects to access funding from these programs. TEA-21 will be renewed in May, 2005. This paper recommends that the renewed act should enhance the funding opportunities for RAPID by including funding programs specifically addressing rail-air intermodalism. These programs should be jointly managed by Federal Railroad Administration and Federal Aviation Administration, instead of FHA and FTA.

Additionally, Federal government could add additional funding to the existed and ongoing High-Speed-Rail corridor extension projects to promote rail-airport connection. As did in many European Air-rail intermodal systems, when intermodal connection is economically feasible, setting stations at major airports could be a part of these High Speed Rail projects. Based upon European experiences, both passengers and carriers could benefit from the creation of an integrated intermodal transportation system between intercity rail and air. DOT and FRA have had plans to upgrade current intercity rail network in some corridors by providing high speed service in the next decade. Serious high-speed rail have begun in Northeastern United States with the introduction of Amtrak's new Acela Express high speed trains, which are operated at maximum speed of up to 150 mph. The trip time between New York and Boston was reduced to around 3 hours from 4.5 hours. Currently, Acela service has been a competitive mode with highway and flights. Meanwhile, it is linking directly or indirectly to airports, including stations at T.F Green in providence, Rhode Island, Baltimore Washington International in Maryland, Newark Airport in New Jersey. All of these are providing a potential for the implementation of RAPID by improving current intermodal connection and enhancing intermodal cooperation.

Recommendation 2: The federal government should provide funding and other incentives to enhance the willingness of state, regional and local governments and agencies to support RAPID

The purpose of this recommendation is to allow rail-air intermodal planning and the resulting projects to receive special promotion and attention from state and localities. The incentives could be provided by either offering direct funding support or amending project selection criteria in a RAPID-favored way.

In 1995, Interstate Transfer Program provided an opportunity to transfer interstate highway funds to transit users, and an 85% percent federal match provided an incentive over the standard 80% federal transit match. Several metropolitan areas took advantages of the program to update their metropolitan transit system by highway funding.⁵⁷ Similar program could be designed and applied for RAPID development in the future, such as authorizing programs to allow airport

⁵⁷ Transit Cooperative Research Program, *TCRP report 14: Institutional Barriers To Intermodal Transportation Policies and Planning in Metropolitan Areas*, 1996, p.17

funds for capacity extension or accessibility improvement to be specifically transferred to rail projects.

Another incentive could be to amend project selection criteria in a RAPID-favored way. For example, since rail is more environment-friendly and energy-efficient than highway and air, CMAQ program under ISTEA and Clean Air Act have enhanced the opportunities for intercity rail projects to be funded in state and local level through setting environmental restrictions on project selection. Similarly, air quality or other environmental concerns could be given more weight to select projects relevant to airport ground access, which could allow rail connections to be more attractive to state and local decision makers.

Recommendation 3: The federal government should provide leadership and institutional support to increase modal integration to facilitate information collection and analyses, market research, system planning and design, decision making and project evaluation.

To fully embrace the benefits associated with true intermodal systems as explicitly emphasized in ISTEA and TEA-21, transportation plans must “consider a range of transportation options designed to meet the transportation needs of the nation including all modes and their connections.” [Samuel, p.3]

Ideally, to achieve this goal, transportation agencies at both the federal and state level need to select projects aiming at maximizing the long-term benefits for the nation’s entire transportation system, instead of individual near-term benefits. However, under the current modally-focused framework, transportation planning and decision making is split among numerous jurisdictions (federal, state and local) and among the different transportation modes (highway, rail and air). Each of them is served by different carriers and has distinct interests. As a result, distinct criteria are used to conduct research, plan, and evaluate transportation projects among different modes with focus on their own interests. All of these are impeding the achievement of true intermodalism.

Successful RAPID development requires efficient cooperation between rail, airline and airports along the entire implementation process. Such cooperation is missing in the United States. For the private sector, even in some corridors such as Northeast Corridor, where intercity rail service is competitive and has a potential for RAPID, air carriers and airports are reluctant to form partnership with rail because they are competing for not only demand but also federal subsidy. For the public sector, political concerns make state and local decision makers overemphasize transportation projects that could provide significant near-term benefits to local residents. In this regard, federal government should provide leadership and institutional support to increase modal separation to promote RAPID development.

In 1995, the U.S Department of Transportation proposed to merge the highway, transit, and railroad agencies into an Intermodal Transportation Administration⁵⁸. Although the proposal was not realized, this effort indicated that DOT has recognized the necessity to alter current modally-focused structure to an organization focusing on the nation’s transportation and interaction

⁵⁸ Transit Cooperative Research Program, *TCRP report 14: Institutional Barriers To Intermodal Transportation Policies and Planning in Metropolitan Areas*, 1996, p.14

among various components. The entire restructuring of the administrative framework was proved to be extremely difficult and may not be desirable to federal government as well as state and local stakeholders. Nevertheless, functional integration of major transportation responsibilities has been successfully achieved in many cases. For example, in the federal level, under ISTEA 1991, a new office of intermodalism was established within the office of the Secretary of transportation. The responsibilities of this office were to maintain and disseminate intermodal transportation data, and coordinate federal research on intermodal transportation [Samuel, p.29]. At the state level, Florida increased functional integration through establishing teams at the district level to encourage intermodal cooperation between highway and transit. Each team consists of a highway engineer, a transit official and the District Secretary. [TCRP 14, p.15]

To facilitate RAPID development, similar functional integration between intercity rail and air could be established at both federal and state level. The primary responsibilities of such integrated organization should include:

- Provide institutional support to encourage communication between rail and air;
- Conduct data collection and analyses for market research, system planning, and service operation and management;
- Define clear principles and standards for system evaluation and feasibility studies;
- Establish research programs on not only physical connection, but also security, intermodal baggage transfer and joint ticketing and pricing;
- Select suitable places to implement RAPID;

In summary, by now, all the three key components for Rail-Air Intermodalism Development (RAPID) are missing in the United States. Under current situation, RAPID is not likely achieved in the near future by solely relying on private sector and market forces. Meanwhile, modal bias policy and modally focused administration framework generate numerous hurdles that impeding RAPID implementation from public sector. To successfully implement RAPID in U.S, it requires strong governmental involvement and policy support, in terms of providing sufficient funding from public sector and increasing modal integration to facilitate RAPID implementation.

Chapter 5: Conclusion

Ground access to airports is an important function that must be provided at the regional level as well as in the immediate vicinity of the facility itself. Congestion problems affecting airport access are in some instances approaching unacceptable levels, including negative impacts on air quality and other environmental considerations. There are currently about 120 airport rail links existing or proposed to be constructed around the world. The growth in the number of airport rail links reflects the almost relentless growth in air travel and the associated worsening congestion and delays on both landside and airside of airports. Along with increasing concerns on system mobility worldwide, more and more airports have already plugged into or are planning to plug into intercity high speed rail network. In these rail-air intermodal systems, intercity passenger trains are playing two roles: 1) providing airports better access to the connected urban centers and 2) displacing short- to mid-distance flights to free valuable airport slots for lucrative long distance flights. The benefits and appeal of rail are well understood. Rail uses less energy, produce fewer greenhouse gases, offers travelers more comfortable and more productive services en route, and has better immunity to bad weather.

Rail-air intermodalism development in the United States has lagged behind the worldwide trends, especially in comparison with European Countries and Japan. Through utility analyses and case studies, this paper has examined technical priorities for competitiveness of rail-air intermodal system, identified the key barriers that impeding RAPID development in the United States, and recommended institutional and policy changes in this nation to promote RAPID development.

5.1 Summary of Technical Priorities

The primary objectives for enhancing the cooperation or coordination between the aviation and intercity rail systems are to provide airports more efficient and environment-friendly ground access to connected urban centers, as well as to displace short- to mid-distance flights to free valuable airport slots for lucrative long distance flights. To successfully achieve these goals, the aviation/rail intermodal system should be competitive with feeder flights and highway modes. Through utility analyses and case studies, three key technical options are examined to identify their priorities for the competitiveness of rail as a feeder service to airports: improving physical connection between rail and airport, operating high speed rail, and enhancing rail-air intermodal cooperation.

Utility Analyses

In intercity transportation market, aviation, rail and highway modes are the primary competitors. Each of them has their own preferred markets. Driving an auto is the best option for short-distance trips because it is flexible, convenient and cheap. As distance increases, rail and air become more and more competitive. Air has significant speed advantages over other modes, but it is less accessible to downtown residents and requires longer terminal time and fixed on-board times per trip including taxiway times, taking off and landing times. A conventional intercity train operating at less than 100 mph (top speed) could achieve a similar or even shorter total trip time than air in short-to-mid distance corridors. Moreover, rail could provide better allocation of trip time than a air option in terms of better accessibility to downtown residents and providing more comfortable and productive in-vehicle times. In long distance markets, air becomes

dominant because of its speed advantages. In this regard, the competitive range of intercity railway is defined as a distance range in which rail could achieve higher market share than autos and flights. The nature of this range would depend on the rail system's performance, as well as competitors' performance. For a given transportation system, the competitive range of rail varies for different types of travelers and different trip purposes. A utility model was used to quantify the impacts of key technical options to competitiveness of rail under various situations.

Utility analyses were conducted in three steps, starting from a basic scenario, in which rail and air are serious competitors and independently operated, and ending with a fully intermodal integrated system. The focus is on the effectiveness of the three technical options to the competitiveness of rail as a feeder service to airports: direct rail connection to airport, operating high speed rail and enhancing aviation/rail intermodal cooperation.

Utility Analyses under Base Scenario

A 200-mile corridor was defined as the base scenario corridor, a distance long enough for rail to be competitive with auto and short enough to be competitive over air. Under the base scenario, it was assumed that railway stations are located within urban centers and airports located in suburban areas. There is no direct rail link and intermodal cooperation between railway and aviation systems. Based on the travel patterns and origination/destination, intercity passengers in this corridor could be classified into two groups:

- Corridor travelers refer to passengers originating and terminating in the regions inside the corridor.
- Hub transfers refer to passengers originating or terminating within this corridor, who transfer to or from long haul flights at a hub airport.

For corridor travelers, the three modes have similar total trip times for the 200 mile intercity trip. Utility analyses indicate that better trip time allocation and utilization could allow rail to capture more than 50% of entire market share for corridor travelers. Under the same assumptions on trains' speed, values of times, and direct costs, utility analyses also indicated that conventional railway with operating at 100 mph could achieve a competitive range of "100 to 500 miles" over highways and flights. Such a range could be enlarged by operating higher speed, providing better in-vehicle services or offering lower fares.

For Hub transfers, in the same corridor, air is the fastest choice and requires the shortest transfer time to or from long-haul flights. Rail users have to take taxi, buses or other urban transportation modes to transfer from downtown railway station to suburban airport. Considering the possibility of congestions and delays within urban areas, as well as that many passengers have luggage, such transfers are likely to be time-consuming, onerous, unreliable and uncomfortable, which may make rail lose its competitiveness. Utility analyses indicated that feeder flights are the best choice for hub transfers, and rail is the worst. Because of the speed advantages, the longer the trip distance, the more competitive the air would be over other modes. As distance decreases, driving an auto becomes more and more competitive because it is cheaper, more convenient and more flexible. In this regard, under similar conditions to base scenario, rail might be unable to achieve any competitive range over highway and air options for hub transfers.

Utility Analyses under Intermediate Scenario

Relative to the base scenario, rail performance for hub transfers could be improved by either of the two technical options:

- Operating High Speed Rail targets reducing in-vehicle time. If operation speed of trains is increased to 150 mph, in the same 200-mile corridor, the total in-vehicle time for hub transfers could be reduced by around a half hour.
- Constructing direct rail link to airports targets easing intermodal transferring. If a direct rail connection is available, the total transfer time between rail and air could be reduced by one and a half hours.

Utility analyses indicated that corridor travelers' mode choice is much more sensitive to the speed increases than hub transfers. Without a significant improvement in intermodal transferring, High Speed Rail can not make rail be competitive over air and highway options for hub transfers in the 200 mile corridor.

For hub transfers, a direct rail connection could significantly improve rail/air intermodal performance by avoiding onerous and unreliable trips between downtown rail stations and suburban airports. A direct rail connection could increase railway's market share by around 10% for hub transfers. However, even with direct rail connection, air is still the best option for hub transfers because:

- Transferring from flight to flight is much more convenient and comfortable than intermodal transferring;
- Air users could enjoy baggage-free travel during the whole trip after first boarding;
- Air users only need to book service once for the whole trip;
- Schedules are usually well matched between feeder flights and long haul flights;
- Air users often enjoy discounted fare for feeder flight services;

Nevertheless, direct rail connections could allow transferring between rail and air to be as or more convenient than highway modes. Under such a situation, the speed advantage and better in-vehicle time utilization could easily make rail be more competitive over highway options for hub transfers. This implies that for many regions without feeder flight services, rail link could be the most attractive option for hub transfers, if rail has enough speed advantage over highway modes.

In sum, under the intermediate scenario, utility analyses conclude that to make rail competitive as a feeder service to airport hub, direct rail connection, or at least making the railway station very close to airport, is necessary. Without a direct rail link, higher speed might have significant impact on corridor travelers' mode choice, but still be unable attract to people transferring at the hub. Given certain physical systems in terms of terminal locations, as well as the availability and performance of intermodal facilities, transfer time is a kind of fixed time in the short term and has little space to be improved. As distance increases, in-vehicle times have more and more weight in the disutility of passengers, and thus mode splits. To be competitive over highway modes and air, railway speed need only to be high enough to gain total trip time advantages. High Speed Rail, such as TGV and Shinkansen, is not necessary.

Utility Analyses under Fully Integrated Scenario

If a direct rail connection is available, two technical options can further improve the competitiveness of rail for airport trips:

- Option 1: operation speed of rail is increased to 150 mph, which is assumed to reduce in-vehicle time of rail option by around half hour.
- Option 2: enhancing intermodal cooperation between rail and air to achieve a fully intermodal integrated system (FII). Under the condition of FII, it was assumed that 1) railway terminals could function as airport branches, where hub transfers could check-in and deliver baggage at the remote railway station; 2) a joint ticket is available, which allows passengers to book services once for the whole trip, as with air-hub-air option; 3) rail-to-air transferring at the hub airport is as convenient as flight-to-flight transferring; 4) because downtown rail stations are likely to be less crowded than busy airport hub, rail users might need shorter queue time at railway stations for processing and check-in than at the airport; 5) the schedules of feeder trains and long haul flights are well matched, which reduces the waiting time at terminals for hub transfers. Under these assumptions, the rail option could achieve total trip time similar to air option with better time allocation.

Utility analyses indicated that when a direct rail connection is available, enhancing intermodal cooperation to achieve a fully air/rail intermodal integrated system is likely to be more effective than operating higher speed for reducing hub transfers' disutility in the 200 mile corridor.

Real World Experiences and Lessons

The idea of enhancing the intermodal cooperation and collaboration between intercity rail and aviation is still young. The first HSR connection to an airport in Europe was at Lyon in July 1994, with the opening of the so-called "TGV-Satolas" station. As increasing concerns on the system mobility and meeting longer term accessibility goals for airports, by 2003, more than 120 airports worldwide had constructed or were considering rail links to greater metropolitan regions. Even though most of these rail links refer to urban railway systems, all of the necessary technical options for RAPID have been widely applied, such as high quality intermodal services in Hong Kong International Airport Express Line, Zurich International Airport, Frankfurt International Airport, and even Maglev technology in Shanghai Putong International Airport. To examine the technical priorities for RAPID, five airport-rail systems from the world were selected and studied.

Hong Kong International Airport

HKIA was linked to the heart of Hong Kong by almost 40 kilometers (25miles) new roads, a dedicated high-speed railway and landmark bridges. The airport railway was the first railway built specially for the purpose of serving an airport with its integrated design for stations and equipment,⁵⁹ and is providing two types of services: Airport Express (AEL) and Local service (TCL) with trains operating at maximum speeds of 135 kilometers (84 miles) per hour on the same track.

⁵⁹ Hong Kong International Airport Home Page: <http://www.hongkongairport.com/eng/aboutus/index.html>, 2004

Through the comparison of system performance and characteristics of buses, Tung Chung Line and Airport Express Line, the HKIA case implied that:

- Downtown check-in and baggage delivery could efficiently attract travelers with luggage from private auto and buses. However, the expensive fare hurts AEL's attractiveness to airport users without bags to check, as well as those passengers with low values of times.
- Low market share of TCL service for airport trips implied that intermodal connection plays a critical role for the competitiveness of rail.
- Train speed is playing a less important role than direct connection and high quality intermodal services for the competitiveness of AEL.

Shanghai Maglev, China

Shanghai Maglev Demonstration Line is the world's first high-speed maglev train put into commercial use, which links Pudong International Airport with Shanghai downtown areas, covering a length of 30 kilometers. Even though the Maglev link has much shorter journey time (8 minutes) between downtown station and airport than other modes (taxi 40 minutes, bus 60 minutes), it is not attractive enough to airport users, owing to the lack of high quality intermodal services, limited accessibility to downtown residents and expensive fares. Based upon data collected in February 2004 by Shanghai Tongji University, the market share of Maglev for airport trips appears to be lower than 2%.

Compared with HKIA express line, Shanghai maglev is much faster and has similar accessibility to downtown residents. However, high quality intermodal services make HKIA Express Line much more successful than Shanghai Maglev. Shanghai Maglev project provides an excellent example that High Speed Rail is not a remedy for the competitiveness of air/rail intermodal systems.

Two European Airport-rail Systems

Frankfurt International Airport is Germany's busiest airport with over 45 million passengers annually served. FIA is directly served by high-speed trains. Beginning May 30, 1999, HSR services to major cities throughout Germany have been offered from the new Alrail Terminal, which is served by a total four national lines: two regular-speed Intercity Lines and two High-speed Intercity Express lines. Similar to FIA, Zurich International Airport is advertised as the central traffic junction in Switzerland⁶⁰. It has its own railway station, operated by the Zurich Transport Federation and is integrated into the regional bus, train and streetcar network with combined tickets available for the modes of transportation.

In both of the two European airports, high quality intermodal services are provided. Passengers have the option to check-in and deliver baggage at remote railway stations. By 2001, the modal split of HSR for airport trips was 60% for Frankfurt Airport and 42% for Zurich International Airport.

The two European Cases are providing successful practices of aviation/intercity rail systems, where high level intermodal connection and coordination make RAPID the dominant access mode to airport hub.

⁶⁰ Zurich International Airport, http://www.uniqueairport.com/e_default.htm/, refer in December, 2004

Chicago O'Hare International Airport (ORD)

Chicago O'Hare International Airport (ORD) is considered one of the commercial aviation capitals of the world. Chicago Transit Authority (CTA) Blue Line Train provides 24-hour service between downtown Chicago and ORD. In 1994, the overall market share of CTA buses and train for airport trips was only 6%, while driving auto was the dominant access mode, which took around 51% of market share. Compared with HKIA and the two European systems, the minimal market share of rail transit for airport trips was largely owed to its lack of effective intermodal connection and more auto-favored transportation environment.

In summary, utility analyses and cases studies have proved that rail can be competitive with highway and flights as a short- to mid-distance feeder service to airports. When effective connections and high quality intermodal services are available, RAPID could capture a very high market share for airport trips. For the technical priorities, utility analyses and case studies supported four conclusions. First, intermodal connectivity is the dominant factor that affects the performance of RAPID. A good connection might be the prerequisite for achieving efficient and seamless intermodal transfer. Second, when a good connection is available, enhancing intermodal cooperation in terms of joint ticketing and reservations, offering intermodal services, and matching schedules are likely to significantly improve the competitiveness of rail for airport trips. Third, train speed does not need to be as high as TGV or Maglev, but should be high enough to ensure door-to-door trip time advantage over highways and air planes in short-to-mid distance corridors. Fourth, there is almost no need for any new technologies along with the implementation, operation and management of RAPID. All the technical options have been well applied in many places worldwide for decades, especially in numerous European airports.

5.2 Summary of Institutional Analyses

Even though there are no technical challenges and many studies have demonstrated the benefits associated with enhancing the intermodal cooperation between rail and aviation, the development of RAPID in the United States has lagged behind the world trend, especially in comparison with European countries and Japan. Based upon Muller⁶¹, true intermodal transportation should be defined as "transporting passengers and freight on two or more different modes in such a way that all parts of the transportation process, including the exchange of information, are efficiently connected and coordinated". In this regard, successful RAPID system requires three key components:

- Effective infrastructures to provide seamless intermodal transfer.
- Two types of information: 1) information for market research and decision making and 2) information for enhancing intermodal cooperation and offering intermodal services.
- Efficient intermodal cooperation for operation and management of integrated systems.

It is unfortunate that all the three key components are missing in the United States. This paper has identified the key barriers impeding RAPID development in the United States, and recommended institutional and policy change to facilitate RAPID implementation.

⁶¹ Muller, Gerhardt, 1999, *Intermodal Freight Transportation*, 4th Edition, Washington DC, p.1

Hurdles That Impede RAPID Development in the United States

Among the three key components (infrastructure, information and cooperation), utility analyses and case studies concluded that effective intermodal infrastructure might be the prerequisite for the successfulness of RAPID. In 2000, Chief Executive Officer of Greyhound, Craig Lentzsch, pointed out two different reasons why intermodal services are facing difficulties in the United States.⁶² The lack of intermodal facilities is the first hurdle faced by companies that want to provide intermodal services. While bus and rail services are linked at a number of terminals across the nation, the linkages at airports are fewer and farther between. Without dedicated terminals, intermodal services will continue to be difficult to achieve in the US.

Linking Amtrak stations to airports has been underway since the 1980s. However the progress is slow and there is still not any rail-connection available as effective as those in European Airports. The Amtrak station at Baltimore-Washington International Airport is located several miles away from the airport terminal, and passengers must take bus or other modes for transferring between the two locations. Connections between Amtrak and airports in Newark, New Jersey and Providence, Rhode Island are currently being or have been developed; however, in neither case will the rail line connect directly into the terminal. There is no existing or planned intercity rail stations in the US located directly underneath an airport terminal building, as found in European systems. Lack of rail-air intermodal infrastructure as effective as in European countries has become the primary hurdle that impeding RAPID development in U.S.

Decades of modally-biased transportation policy have resulted in the nation's intercity passenger transportation being dominated by auto and air with little contributed by intercity rail services. Not surprisingly, highway and air received the most public funding in the past decades, which further worsened the modal bias. In contrast, intercity rail service is playing a minimal role in the entire intercity passenger transportation market. Amtrak, as the primary nationwide intercity passenger rail service provider, has faced financial difficulties since beginning operation in the 1970s; it is now the highest subsidized passenger transportation form in terms of subsidy per passenger, which is why it is unable to proceed toward RAPID on its own. Meanwhile air and highway carriers, which are receiving most federal funding, have no incentives or obligations to promote RAPID by funding rail connection with airports, even though RAPID might provide them effective solutions for their current difficulties. All of these factors indicate that RAPID in U.S will not be achieved in the near future by solely relying on private sector and market forces.

Since RAPID cannot be achieved by the private sector, it is the time for strong financial and policy support from public sector, especially the federal government. Nevertheless, the administrative system of transportation in U.S is modally-separated, which instead of facilitating, impedes RAPID solutions. Problems include a lack of intermodal funding, a lack of intermodal planning and a lack of intermodal information. ISTEA and TEA-21 have been good steps to promote intermodal solutions to the nation's transportation system. However, the core of the two acts is flexibility of using federal funding, and the emphasis is still on highway-related projects, which is not able to mitigate the modal bias situation and promote RAPID development in this nation. Under TEA-21, funding opportunities for intercity passenger railroad-related projects have been enhanced through several specific funding programs. Nevertheless, Federal Highway Administration and Federal Transit Administration are authorized to manage funding programs

⁶² Statements of Craig Lentzsch, Chief Executive Officer, Greyhound Bus lines, July 27, 2000.

under TEA-21, which largely limited the opportunities of rail-airport intermodalism related projects to access funding from these programs.

In short, the primary hurdles that impede RAPID development in the United States are generated from the modally-focused administrative framework and modally-biased transportation policy. These biases directly and indirectly result in the absence of the three key components for RAPID in the United States: infrastructure, information and cooperation

- For the private sector, because of the unbalanced development, intercity rail is unable to provide the necessary intermodal infrastructure, while air is unwilling to connect and cooperate with the rail system.
- For the public sector, modal bias has resulted in a shortage of funding for building effective rail-air intermodal infrastructure. Meanwhile modal separation in the administrative framework provides hurdles for efficient intermodal planning.

Recommendations

Based upon analyses of the key barriers impeding RAPID development in this nation, the following recommendations target two strategies: providing sufficient funding for effective rail-air intermodal infrastructures and increasing modal integration to facilitate intermodal planning and decision making.

- Recommendation 1: the federal Government should play the major role in providing funds for effective rail-air intermodal infrastructures
- Recommendation 2: the federal government should provide funding and other incentives to enhance the willingness of state, regional and local governments and agencies to use existing resources, such as funds for airports and highways, to promote RAPID
- Recommendation 3: the federal government should provide leadership and institutional support to increase modal integration to facilitate information collection and analyses, market research, system planning and design, decision making and project evaluation.

In summary, all three key components for Rail-Air Intermodal Development (RAPID) are missing in the United States. Unbalanced development in this nation's intercity passenger transportation system has resulted in the inability of intercity railroads to promote RAPID and the unwillingness of air carriers to connect and cooperate with the rail system. These problems make RAPID unlikely to be developed by relying solely on the private sector. Mode separation in the administrative framework and modal bias in policy generate further hurdles for RAPID from the public sector in terms of public funding, information, planning and cooperation. To successfully achieve RAPID, federal government must provide a major role in terms of providing sufficient federal funding specifically for RAPID infrastructures, along with incentives to enhance the willingness of state and localities to support RAPID. The federal leadership and institutional support will also be necessary to increase modal integration to facilitate RAPID research, planning and decision making.

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