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Cooperation between High-Speed Rail and Air Travel in the United States

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Cooperation between High-Speed Rail and Air Travel in the United States

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Dedication

This report is dedicated to my parents, who have given my decision to pursue a graduate degree their full support. I could not have done it without them.

Abstract

Cooperation between High-Speed Rail and Air Travel in the United States

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The United States as a whole is embarking on the historic task of implementing high-speed rail (HSR) throughout the country in an attempt to improve regional mobility, including congestion at some of the nation's busiest airports. However, despite the wide overlapping of service that both air and HSR provide and the goal of reducing airport congestion, little discourse has occurred on the topic of how these two modes might interact in an intermodal context.

This report explores how air travel and HSR might cooperate in the US, which is defined as an explicit attempt by the two modes to utilize each other in order to transport a passenger to their final destination. It will document potential benefits of cooperation, survey how cooperation works elsewhere in the world, and investigate the current climate within the US for cooperation, including a review of current HSR plans and analysis of

air travel data. This information will form the basis for suggested airports for the integration of HSR and air travel, and for how US airlines might utilize HSR. Lastly, lessons learned will form a list of best practices to follow in order to better insure a cooperative and successful relationship between HSR and air travel.

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INTRODUCTION

In 1993, Texas was attempting to be at the forefront of high-speed rail (HSR) development in the United States. But the endeavor ultimately failed, primarily due to opposition from Southwest Airlines (The Houston Chronicle, 2009). Eighteen years later, the United States as a whole is embarking on the historic task of implementing HSR throughout the country in an attempt to improve regional mobility, including congestion at some of the nation's busiest airports. However, despite the wide overlapping of service that each mode provides and the goal of reducing airport congestion, little discourse has occurred on the topic of how these two modes might interact in an intermodal context. Are there opportunities for cooperation? Which airports would be the best candidates for cooperation? What are some of the best practices for such a relationship? These are important questions given the rocky history between the two modes in the US.

Any investment in a transportation system has the base goal of improving the travel experience for its users. And when private firms are providing services in that system, competition is often seen as a healthy element to hold those firms accountable to their customers and promote innovation, all while keeping costs low. However, in an intermodal system both competition and cooperation exist and are considered healthy (cars and air travel for example), yet HSR in the US has primarily been viewed strictly as a competitive mode to air travel. Although the two modes may compete in most markets, there are opportunities for them to form an intermodal link that is seamless and beneficial to users. This report will discuss this potential by exploring how similar relationships already exist elsewhere, and by dissecting current data and future predictions in the US to determine where cooperation might work best and be beneficial.

Chapter 1: Definition & Methodology

This report aims to utilize past research to obtain lessons learned for best practices and as a starting point for where cooperation exists, while analyzing current aviation data to suggest where cooperation could be beneficial in the US. The result is the most current and comprehensive documentation of cooperation between HSR and air travel to date, and the first national look at the potential for cooperation in a US context. In order to achieve these goals, cooperation must first be defined, along with the following scope and approaches that were used to guide the research.

DEFINITION

Cooperation is made up of both physical and logistical elements that allow for seamless transfer of modes for the passenger. The base element to cooperation is a physical integration between airports and HSR stations. There is an array of ways the two can be connected, from HSR stations situated below a terminal to a nearby offsite HSR station that is connected via a dedicated people-mover. But cooperation goes beyond physical integration. It involves a relationship between HSR operators and airlines that creates a logistical integration. This is typified by code-sharing, where the airline utilizes a scheduled train within its itinerary system just like a connecting flight. But it could also involve an airline operating train cars or whole trains, making the train segment of the journey almost identical to a connecting flight within the airline's network. However, the most basic logistical integration is the ability for a passenger to purchase a HSR trip as their connecting service within the same process of purchasing their flight, but without it being a coded "flight". Typically this allows the passenger to choose their train rather than being reserved on a particular departure. *Table 1.1* outlines the strength of individual cooperative elements, while also illustrating the ideal scenario including or improving on

each previous level from the top. Thus the ideal scenario, which will be explained later in the report, is seamless passenger connectivity with automated baggage transfer, code-sharing, and having the purchase take place in one transaction. The idea of an airline operating a train or car is not noted as being required for the ideal scenario, but would represent an additional level of cooperation.

Strength	Cooperative Element	Example Airport(s)
Peak	Train/Car operated by airline	Frankfurt
Peak	Seamless passenger connection[1]	--
Strong	Automated baggage transfer	Zurich
Strong	Code-sharing of trains as flights	Frankfurt, Paris
Moderate	Physical integration[2]	Frankfurt, Paris, Amsterdam
Moderate	Combined purchasing[3]	Frankfurt, Paris, Amsterdam, Madrid
Weak	Separate facilities, but linked[4]	Madrid

Table 1.1: Measuring Cooperation between HSR and Air Travel

In essence, cooperation is an explicit attempt by the two modes to utilize each other in transporting passengers to their final destination. It allows passengers to make their trip without individually orchestrating such an intermodal transfer, instead having it offered via a prearranged agreement. The two modes don't just happen to be linked together, they are planned to be together, and each makes a conscious effort to use the other in order to transport passengers.

SCOPE

The objective of this report is to provide a glimpse as to what cooperation between HSR and air travel could look like in the US, and what best practices should be

[1] Defined as being equal to making a connecting flight.
[2] On airport grounds is the most basic of physical integration, followed by adjacent to the airport. As this report will note, ideal integration involves positioning the HSR station below an airport terminal.
[3] Can buy air and rail services together.
[4] Separate HSR station from the airport, but linked via some form of people-mover or transit.

adhered. It is meant to look at how cooperation is organized and where in the US such a relationship might work best based on current air service data and anticipated future conditions of airport congestion. Competition between the two modes will not be explored or debated, but may be referenced to provide context. Furthermore, the economic suitability of any recommendations will not be investigated, but stated benefits of cooperative relations will be provided. This report should be seen as a first-step guidance into the potential for such relationships based on characteristics identified as ideal for successful cooperation. It is encouraged that this report be used as a starting point for continued research into exactly how cooperation can occur at specific locations and whether it would be fiscally advantageous for all parties involved while providing a better option for users.

CASE STUDIES AND FINDINGS

In order to explore what cooperation between HSR and air travel might look like in the US, other markets that have implemented HSR were studied. Airlines, airports, and HSR systems in Europe and Asia were analyzed in order to paint a picture as to how cooperation currently operates and what are some lessons learned for future application. Because rail linkages have been present at European airports for some time, a host of papers have been produced on how HSR has been incorporated. These reports were analyzed in order to obtain a perspective of how well cooperation is working in Europe and what lessons have been learned and suggested by the researchers.

COOPERATIVE RELATIONSHIPS IN THE US

In order to determine which airports may be the best location for integration between HSR and air travel, and to which markets they should be connected to, a variety of air travel data was analyzed. Based on current passenger and flight operations data,

several airports were selected as prime initial candidates and were investigated further. A list of recommended airports for integration was developed using this data, along with anticipated capacity concerns developed by the FAA, future flight volume predictions, and orientation-destination flight volumes between the selected airports and their short-haul airport markets. The list is split into two, with the first being the best options, and the second being a list of potentially good targets in the future or having qualities that may be advantageous for integration, but still lack some other factors. Once these airports were identified, a comprehensive look at how airline networks align with those airports was conducted to see how airlines might utilize connected airports for cooperative services.

Lastly, the information and findings from the case studies were then used to produce a list of best practices that can be utilized in developing the HSR system in the US for cooperation and integration to be successful.

Chapter 2: Literature Review

The literature referenced for this report helped provide insight into how cooperation currently works in the world and what the climate may be for cooperation in the US. Journal articles and organizational publications were the primary resources, along with government reports and guidelines.

COOPERATION

With an increased interest in HSR in Europe over the past decade, a variety of papers have been written on the subject of cooperation between HSR and air travel, or more simply the integration of air and rail facilities. The primary arguments for air and rail integration appear to be logistical and environmental. The reduction of airport congestion by transferring short-haul passengers onto HSR is touted as the most practical benefit of integration, while notes of potential environmental improvements have also been presented for using HSR over airplanes. The idea behind congestion reduction is that large airports, especially hubs, may run into expansion constraints due to limited space or public protest. In such cases HSR could help transfer passengers who are traveling a route 500 miles or less (the typical line of competitiveness for HSR versus air), thus opening up slots for long-haul trips that tend to be more profitable. Givoni and Banister in their "Airline and Railway Integration" article (2006) point out that short-haul routes can be lost because of congestion in favor of more profitable long-haul routes, thus cutting service to a nearby region. HSR could help keep these markets connected to the hub airport. Furthermore, they point out that congestion is one of the largest criticisms of the hub and spoke system, which HSR can help alleviate. They note in their "Role of the Railways in the Future of Air Transport" article (2007) that such substitution of service is

already happening in some European markets, and even goes as far as code-sharing between air and rail operators or actual train cars operated by airlines.

However, complete substitution is not always likely. The Joint Transport Research Centre notes that low-cost airlines are unlikely to integrate due to their business structure, and may even increase frequency on HSR routes in order to provide some of the same benefits of HSR (2009). Arnaud Chi's "Do High-Speed Trains Really Promote Airports?" further argues that slots saved must come during peak periods in order to be impactful, and airlines may simply reduce the size of the aircraft versus eliminating a flight along a route. Furthermore, he states that such interconnectivity benefits international hubs more so than other large airports because of the potential for substituting long-haul routes (2004). Although this can happen, he does not take into account the various factors of why an airline would not implement integration outside of economics, such as incompatible communication systems or poor connectivity between the airport and the HSR station. However, the main point Chi makes is integration alone does not solve the congestion problem, rather a wholly integrated system must be present.

And a wholly integrated system is perhaps the most discussed element of successful cooperation. Givoni and Banister claim passengers typically do not care how they get from point A to point B as long as it's seamless. Thus a plane switch versus a plane-to-train connection, all other variables equal, is the same if there is no additional hassle to get on a train rather than a connecting flight. Therefore they conclude that station location is vital to cooperation. They note that stations need to be a part of the airport facility, whether adjacent or underneath. But more importantly, the rail station must be connected to the airport's baggage system to enable complete integration, therefore eliminating the extraneous step of transferring luggage between modes by the passengers themselves. Based on surveys conducted, they conclude that this element of

connectivity is the primary reason for a failure of cooperation between the two modes (2007). Stubbs and Jegede suggest this connectivity issue is historical, pointing out air and rail usually have not been co-located since rail has traditionally served the city center and airports have been constructed outside of the city to avoid compatibility issues (1998). Givoni and Banister continue further by noting that once the two modes are connected, the rail network must treat the airport as an essential stop versus operating as a branch line. Otherwise, time savings could be lost, and other non-airport ridership that helps support the line is missed as well (2007).

US POTENTIAL

Even though many US HSR plans discuss stations located at airports, very little has been mentioned about the potential for cooperation between HSR and air travel. As this section will show, many discussions surrounding the two modes look at the potential for HSR to assist air travel problems (congestion, delays, etc.), while US HSR plans look at competition and substitution between them in terms of market share potential. Although these types of analyses are important for potential relationships between the two modes, they only form the first phase of how the relations could develop.

In 2010 the New Mexico Public Interest Research Group published a report that likely comes closest to suggesting cooperation, as it uses many of the European case studies found in this report to promote HSR as a viable substitute for short-haul flights (Dutzik, Schneider, Baxandall, and Steva, 2010). For example, it notes that about 97% of the air-rail market[5] between Frankfurt and Cologne is captured by HSR, and that most of those passengers make a connecting flight. The report also provides the basis for why HSR should be looked at for replacing short-haul flights. It notes that almost 50% of

[5] This number has increased to 100%, as there is no more air service between the two cities.

flights in the US are <= 500 miles (the standard distance of competitiveness for HSR versus air travel), and that 30% of passengers travel within that distance during the twelve month period starting in April of 2008. The report also notes that some of the busiest flight corridors are within this boundary. *Table 2.1* displays three of the corridors that the report uses (Dutzik, Schneider, Baxandall, and Steva, 2010). Lastly, the report references a 2009 Brookings Institute finding that those airports with the most flights of a distance <= 500 miles account for over 40% of delays in the US.

Air Corridor	Passengers per Year
San Francisco – Los Angeles	6.3 million
Dallas/Ft. Worth – Houston	2.9 million
Chicago – Minneapolis	2.0 million

Table 2.1: Busy Air Corridors in the US of a Distance <= 500 Miles

The America 2050's report in 2009 also states that air congestion is a primary reason for HSR service in the US. Although it does not go so far as to suggest integration or cooperation, it does note that 1/3 of aircraft in the US go through the New York City area, meaning that any delays in the region cause major issues for the rest of the country. The report also ranks the top fifty city pairs for HSR based on a variety of factors. Unfortunately air travel is not a factor, but many of those city pairs are within the 500 mile boundary of competitiveness.

Federal documents provide similar approaches, stopping short of suggesting actual cooperation, but promoting integration. In 1997, the Federal Railroad Administration (FRA) produced a major report on HSR's future in the US. In the report, the FRA noted that the Federal Aviation Administration (FAA) viewed HSR as a legitimate option to help combat aviation congestion. Furthermore, the report stated that

given ISTEA's emphasis on intermodalism, airport stations should be implemented at major hub airports where such locations did not impede trip-time goals. The FRA also acknowledged the presence of low-cost airlines in the US, and that they may provide a unique competitor that needs further specialized, and perhaps market-specific, analysis.

Subsequent publications from the FRA did little to suggest that HSR should interact with air travel. In its 2005 *Railroad Corridor Transportation Plans* guidance manual, the FRA only mentions that stations should be intermodal, but does not specifically list airports as an important intermodal link. Furthermore, its *Vision for High-Speed Rail in America* publication in 2009 had no mentioning of airport connections as an option to consider. However, the FRA's HSR program notice a year later does note airports as an intermodal connection, though rather briefly. In the FRA's 2010 progress report on the national rail plan, a return to an emphasis on linking airports is found, with stronger language used to emphasize a need for incorporating other modes into the HSR network. The report even states that the "high-speed and intercity passenger rail network will complement existing transportation choices". However, the extent to which HSR will complement air travel is not specified, at least not in terms of cooperation.

The Government Accountability Office (GAO) has been commissioned several times over the years to report on both air travel capacity and passenger rail. Although the GAO has not promoted European-like cooperative relations between airlines and other modes, its reports have generally been more frank in suggesting HSR as a solution to air congestion. Its *Long-Term Capacity Planning Needed Despite Recent Reductions in Flight Delays* report in 2001 noted that many of the most congested airports could not expand to reduce congestion and delays, and that efforts to reduce congestion at the time were not enough. Furthermore, the report promotes the idea of providing HSR connections at the most congested airports, such as at Los Angeles and Boston. It also

proposes the idea of wayports, which are airports built strategically between major population centers, but not next to any particular one. The airport is then linked to the major cities via HSR. Thus the airport simply acts as a node in an intermodal system, similar to a transit line, where flights simply provide connections to other flights and HSR. Meanwhile, HSR provides the connection to the cities surrounding the wayport. Locating a wayport like this would allow ample room for expansion and help avoid noise complaints. However, the report admits that such an idea has not been implemented, and it is outside the scope of this report to analyze such a proposal. The GAO echoed its capacity concerns in a 2009 report on passenger rail as well, further promoting airport and HSR integration in the US. It noted an added benefit of airports already having infrastructure and logistics in place to accommodate visiting passengers who may not have transportation for getting around the city. Most US cities are still very auto-based, so even if an HSR line has a station in the city center, passengers may still need to access areas that are beyond reasonable transit service. Airports already have large car rental facilities to help passengers with this issue, and thus having an HSR station at the airport allows those passengers to benefit from existing facilities. Although this does not help facilitate the reduction of auto trips within cities, and is not a major reason to link HSR at airports, it addresses the reality that it is often difficult for visitors to get around US cities without a personal vehicle.

Lastly, the Airport Cooperative Research Program's (ACRP) Report 31 in 2010 documents the idea of cooperation, but concedes that there is a lack of information surrounding the idea. However, the report does suggest that such a relationship could be successful and that it has not been adequately discussed within the HSR discourse in the US. The report also notes that providing HSR service between markets does not alone reduce the number of flights. It has been shown to reduce the number of air passengers

along the northeast corridor, but the flights are often transferred to a smaller aircraft rather than eliminating the service. This is likely to retain service frequency, suggesting that current rail frequency along the northeast corridor may not be sufficient.

In summary, HSR has been discussed as a solution to airport congestion and other air travel issues, but generally with no discussion of the relationship between the two, or only within a competitive context. Federal documents have mentioned linking HSR and airports at varying magnitudes, but have fallen short of proposing cooperation. Other studies follow a similar history and primarily focus on legitimizing HSR by using issues air travel is experiencing or predicted to experience. Thus the discussion of cooperation in the United States remains limited to nonexistent, with only ACRP 31 making any true mention of its existence as a possible option.

Chapter 3: Stakeholder Benefits of Cooperation

Cooperation does not happen naturally, and therefore there must be reasons for a conscious effort of cooperating to occur. Each stakeholder within the process has an array of potential benefits that makes cooperation attractive as a whole. The following are the major stakeholders of HSR and air travel cooperation, and how they might benefit from cooperation.

AIRLINES

Although initially it may seem that HSR is purely a competitive force against airlines, there are real benefits that airlines can obtain from cooperating with HSR, both in the short-term and long-term. Airlines have a set number of gates out of which they can operate from an airport. If available, they can purchase more gates, but this might not be a viable option from both a financial and physical perspective depending on the airport. Airlines could use HSR service from an airport to transfer passengers off of short-haul flights and open gates they already own to new markets or heavily traveled markets already served, ideally on long-haul routes in order to maximize profitability (Givoni and Banister, 2007). For example, American Airlines could open up gates at Chicago O'Hare that are dedicated to short-haul flights to places like Minneapolis by offering that route via HSR, and then use the open gate to offer more flights to long-haul routes such as New York and Los Angeles. Or perhaps they could enter a new direct route market, such as Spokane.

HSR can also allow an airline to expand its coverage of a limited-service area. Smaller airlines often focus on particular regions or specific routes. For example, an airline may focus its coverage on the east coast, but serve strategic west coast markets from the east coast. Or an airline may focus on providing trans-Atlantic flights between

major business centers. In order to expand its customer base, the airline could form a partnership with HSR in order to reach markets that may be outside of its model for which airports to serve. For example, AirTran focuses primarily on the east coast, with long-haul flights to places like Seattle and Los Angeles on the west coast. AirTran could expand its customer base and network reach by utilizing HSR from Seattle to perhaps Portland or Spokane, or from Los Angeles to San Diego. This is all done without adding infrastructure and operations at another airport, while still attracting customers to its established network.

Lastly, having a relationship with HSR could allow airlines to more easily handle situations where major delays and large amounts of cancelations are creating logistical difficulties. This is especially attractive in an era where flights are managed to ensure their fullness, which leaves little room for handling emergencies involving stranded passengers. For example, major snow storms in the northeast can lead to passengers being stranded for days waiting for an open flight. Although HSR may experience delays as well, it can eventually provide relief to airlines scrambling to accommodate stranded passengers. Although passengers could do this on their own, having an established relationship could help reduce costs of facilitating passengers changing their travel plans, and also allow airlines to offer better customer service in assisting passengers in getting to their final destination versus leaving customers to fend for themselves.

AIRPORTS AND THE NATION'S AIRSPACE

Airports and the nation's airspace could utilize HSR to tackle the ever prevalent issue of congestion, both on the ground and in the air. Airports and highways have long coexisted and benefited from each other, but little more can be gained. Meanwhile, airports and rail have a mostly untapped potential. Freeing up gates by transferring

passengers via HSR could help reduce the need for facility expansion, which can be a major undertaking politically, or even almost impossible due to physical constraints. HSR service can also bring more customers to an airport that is underutilized, allowing markets too far away for driving to be easily connected and allow passengers to take advantage of potentially cheaper flights.

There is also a real concern over the volume of traffic in the air in particular regions. Much of New York's congestion and flight delays are attributed to the fact that the area contains such a large volume of flights in the air (Dutzik, Schneider, Baxandall, and Steva, 2010). HSR could help assist these capacity issues by reducing the number of short flights between the major metropolitan areas, allowing for the airspace to be less congested or give the opportunity for the space to serve demands from other markets.

Lastly, if airlines help passengers utilize HSR in emergencies, airports will be able to better handle crowding that occurs in such situations. Weather emergencies have been known to force hundreds of people to sleep in airports, putting a strain on their facilities and makes for a tense environment. HSR could be a player in helping to prevent situations like these, or at least reduce their impact.

HSR OPERATORS

Integrating with airports and cooperating with airlines opens HSR to a major market of passengers that is fairly constant. It can help in making HSR service viable by providing a constant flow of passengers using a packaged service rather than only relying on latent demand and switchovers from auto travel. Not providing a link, and cooperation, essentially eliminates a large market that has a constant demand.

PASSENGERS

The primary benefit to passengers is greater choice. Cooperation gives them another means to get to their destination quickly and affordably. Rather than being forced to fly an airline that a passenger does not want to fly, they may now be able to use their preferred airline who can now serve a destination not served before. Or passengers can use HSR in cases where their flights are canceled or severely delayed. Furthermore, when cooperation is done in a manner to be as seamless as possible, there are less obstacles that passengers will have to endure in order to use both modes. Lastly, passengers may be able to avoid the small regional jets that are often used on short-haul routes, which would be especially beneficial to larger passengers[6].

[6] Although if an airline does not remove all of its flights on a route with HSR, it's possible that regional jets would replace larger planes that were previously used due to reduced flight ridership.

CASE STUDIES & PRACTICES FROM ABROAD

Passenger rail systems exist all over the world in different shapes and forms, from local transit to international networks. However, the primary form that cooperates with air travel to provide comparable service is rail that travels at great speeds and frequency. The fastest echelon of train travel primarily exists in two regions: Western Europe and Eastern Asia. Websites of airports, airlines, and rail operators in these two regions were investigated in order to document the current state of air and rail cooperation[7].

[7] All relationships and programs documented in this chapter are current as of 2/11/2011.

Chapter 4: Cooperation in Europe

For this report, five countries were the focus for researching how HSR cooperates with air travel (France, Germany, Italy, The Netherlands, and Spain), while other countries provided additional relevant information via non-HSR links with airports. *Table 4.1* summarizes the levels of cooperation of the surveyed countries.

Country	Cooperative Elements
HSR	
France	combined purchasing, physical integration, code-sharing
Germany	combined purchasing, physical integration, code-sharing, airline operated HSR cars
Italy	separate facilities that are linked[8]
The Netherlands	combined purchasing, physical integration, code-sharing
Spain	combined purchasing, separate facilities that are linked, code-sharing
Non-HSR	
Switzerland	combined purchasing, physical integration, code-sharing, automated baggage transfer
United Kingdom	combined purchasing[9]

Table 4.1: Overview Cooperative Elements in Surveyed European Countries

FRANCE

Perhaps one of the best known examples of HSR and air cooperation exists in France, where the state-owned SNCF operates an extensive HSR network throughout the country branded as TGV[10]. Two of France's airports are directly served by this service, with a major operation at the Charles de Gaulle Airport (CDG) in Paris and another linkage at the Saint-Exupéry International Airport in Lyon. CDG is often used as the

[8] Milan's airport has direct HSR service, but it is a spur line that has infrequent service. Other airports require a transfer via some other form of transit.
[9] Limited to phone bookings with points.
[10] SNCF also has part-ownership stakes in other HSR operators that provide links between France and other countries, such as Eurostar and Thalys.

prime example of air and rail cooperation in France, with 19 destinations and 9 airlines[11] utilizing a ticketing relationship, and a host of other destinations accessible from the station through purchasing a ticket on-site. *Illustration 4.1* shows the stations available using CDG's station and TGV AIR service, while *Table 4.2* compiles airlines found to coordinate with TGV at CDG as documented by their websites. Of course, if an airline does not promote the use of TGV for a passenger to reach another destination, users can still purchase tickets on-site.

Illustration 4.1: Stations Available for TGV AIR Service via CDG

[11] Continental ended its code-share agreement with TGV on 8/15/2010. American Airlines lists TGV rail stations in their reservations system, but all attempts to form a trip to TGV stations were unsuccessful.

Airline	Stations
Air Austral	All 19, plus Brussels
Air France	9
Air Madagascar	15
Air Tahiti Nui	17
Cathay Pacific	10
Gulf Air	All 19, plus Brussels
KLM	9
Middle East Airlines	18
Qatar Airways	17

Table 4.2: Airline Code-Share Agreements with TGV at CDG

These routes lead directly to their destination's central city, generally giving the passengers better access to public transportation, activity centers, and denser land uses that allow walking as an acceptable mode of transportation.

There are a variety of reasons why airlines have arrangements with TGV at CDG. First and foremost, the TGV network is extensive and serves a large number of destinations that are within a competitive range for HSR versus air travel. Given CDG's status as a major international transfer hub, this allows additional gates for airlines that otherwise may not have been able to enter the CDG market or gives established airlines more of their gates to utilize on longer routes entering markets they otherwise would not be in. For example, Air France has its hub at CDG, so it can transfer some of its short routes onto TGV while expanding its global network and giving better access for already established markets to the new destinations[12]. This is how hub and spoke airlines operate most efficiently and at the highest level of profitability (Givoni and Banister, 2007). It can also give new airlines access to additional routes from Paris. For example, although OpenSkies doesn't fly to CDG, it utilizes the TGV AIR service to add Nantes and Lyon

[12] Air France serves some markets with only TGV code-sharing, but most routes utilizing this service also have comparable flights from CDG.

to its limited network[13]. Many of the smaller international airlines that code-share with the service at CDG use TGV AIR in a similar manner, as many do not fly to TGV destinations in France.

Another reason for why integration at CDG is attractive is because its TGV station is well positioned to the airport. The TGV station is located below an airport terminal, giving it greater accessibility than a close but off-site station, and also provides a shorter travel time from airline gates. Users can transfer to/from the TGV station via escalators or elevators, which also makes the transfer easier for young children, elderly, handicapped, and anyone else who may have difficulty walking long distances. This sort of configuration is generally preferred by the literature reviewed, while it also gives the user a perception of a well integrated multimodal system (Givoni and Banister, 2007). Such a perception can impact assumptions made by travelers and thus increase their comfort with using such a system, especially if it is the first time they have been on HSR service and/or have not been to France before.

Despite CDG's well integrated TGV station, it does not offer a completely seamless transition between the two modes. Although passengers flying on airlines participating in TGV AIR can purchase their entire trip in one place and on one ticket, they must obtain a train ticket when arriving at the station by showing their plane ticket[14], which notes a ride on the train was included in the purchase. Furthermore, there is no automatic luggage transfer between the station and the airport, leaving passengers to collect their luggage after their flight or train ride and transfer it to the other mode manually. Lastly, for passengers riding the train to CDG, check-in at the airport for their

[13] Two airlines (Air Caribbean and OpenSkies) participate in the TGV AIR service, but do so from Paris-Orly Airport. According to their websites, this involves a shuttle transfer to the Massy TGV station in Paris.
[14] Based on instructions from the airlines utilizing TGV AIR service.

flight is still required (unless boarding passes have already been printed and there is no checked luggage), along with security clearance. No check-in system is available at the train stations. Even if there was such an arrangement, the lack of luggage coordination would render such a service relatively pointless.

As previously mentioned, Lyon's airport also has a TGV station on-site. However, it has not seen the success like that of CDG, which may have to do with Saint-Exupéry's status as a destination airport versus a hub airport. A session at the 2011 Transportation Research Board's annual conference noted that the lack of success was caused by passengers having to make two transfers[15] versus only one at the hub airport if they had traveled from their local airport or train station to the hub (Coogan, Diridon, and Van Beek, 2011). Although the airport claims it's connected to 120 direct destinations, and its TGV station accesses 16 destinations, no airlines could be found to code-share with TGV from Lyon, other than to CDG. Furthermore, TGV's website does not promote such a connection, although it is technically feasible.

GERMANY

Like France, Germany is a leader providing an HSR network, and may offer some of the best examples of cooperation between HSR and air. Four of its airports have HSR stations served by Germany's HSR provider Deutsche Bahn (DB) on-site – Frankfurt International (FRA), Düsseldorf (DUS), Leipzig/Halle (LEJ), and Cologne/Bonn (CGN) – with Frankfurt offering perhaps the best example of cooperation in the world. Like at CDG in Paris, Frankfurt's airport contains its HSR station underneath the main terminal, making it easy to access by passengers. However, Frankfurt goes further by providing separate check-in counters for over three dozen airlines directly in the HSR terminal and

[15] One from the HSR station to the airport, and another at the hub airport that their flight likely would be heading to, unless that hub airport was their final destination.

dedicated baggage claim area nearby for passengers using HSR after their air travel, which minimizes the manual luggage transfer process.

DB offers two different services for air travelers to use HSR from airports: AIRail and Rail&Fly. AIRail is currently the best example of cooperation between an airline and HSR. This service is exclusively for Lufthansa, the largest carrier in Germany and largest airline in Europe by passengers carried. The service is offered to/from Frankfurt, Lufthansa's main hub, to Stuttgart, Cologne, and Siegburg/Bonn and has replaced many of Lufthansa's air service between these destinations by coordinating with Lufthansa's flight schedule in Frankfurt. The service to/from Cologne is often referred to as one of the most successful cooperative examples to date. As of 2008, all of the flights via Luftansa were replaced by the joint relationship service (Resource Systems Group Inc. et al, 2010). AIRail offers guaranteed reserved seats in a variety of classes, of which are part of a quota of seats that are kept exclusively for Lufthansa. The Cologne and Siegburg/Bonn routes go beyond this advanced code-sharing arrangement with a dedicated Lufthansa area that offers the same services a passenger on a Lufthansa flight would receive. Lufthansa attendants serve customers just like on a plane, plus there is a free porter service that helps with baggage on either end of a train trip. Unfortunately this means that passengers are ultimately responsible for their luggage when moving between modes, but the dedicated AIRail counter at Frankfurt and porter service helps make this transition a little less cumbersome. Lastly, passengers using the AIRail service earn frequent flier miles with Lufthansa since the airline is essentially treating AIRail as a flight.

The other cooperative service, Rail&Fly, is DB's program that allows airlines, including Lufthansa, to facilitate HSR use by its passengers to/from any DB station in

Germany[16] – both HSR and non-HSR. Currently six airlines were found to take advantage of Rail&Fly[17], which are listed in *Table 4.3*. Passengers buy the Rail&Fly voucher through the airline they're flying and receive a Rail&Fly ticket, which is good through one day after arriving in Germany and one day before and after departure from Germany. Rail&Fly is only available for international flights to/from Germany and are per leg of the journey. It is similar to the TGV service in France, but there is no code-sharing, the passenger only confirms their airport destination through the booking process, and the passenger is free to pick any train they wish since it is a flat fee per leg.

Airlines		
Aeroflot	airberlin	Emirates
germanwings	Lufthansa	Qantas

Table 4.3: Airlines Using DB's Rail&Fly Service

American Airlines also operates a code-share agreement with DB to/from 18 locations and Frankfurt, which is different than the AIRail and Rail&Fly programs. Passengers can simply board the DB train from the code-shared cities as long as they have their American Airlines boarding pass. Passengers using this service can also earn American frequent flier miles.

THE NETHERLANDS

Amsterdam's Schiphol Airport also has a HSR station below the terminal. Both Thalys and the national railroad (NS) operate from the station to a variety of locations in The Netherlands, Belgium, and to Paris. KLM passengers can use this HSR service to Antwerp and Brussels by showing their KLM ticket to the NS desk at the station. KLM

[16] Rail&Fly also allows travel to/from Basel Bad in Switzerland and Salzburg in Austria when flying Lufthansa.
[17] Each airline has slightly different restrictions. Please see each airline for their specifics.

also has a formal code-share with Thalys, which operates some of the NS HSR trains that KLM passengers can use. Just like at Frankfurt and CDG, passengers are responsible for their luggage when transferring between modes.

SPAIN

The only example of HSR and air cooperation that could be found in Spain was with Air Europa and the state-owned rail company RENFE's AVE HSR service. According to Air Europa's website, the service links nine cities to Madrid, from which passengers must take a shuttle to transfer between Madrid's Barajas Airport and the Madrid-Atocha rail station. This is likely the reason for there being only one example despite Spain's expansive HSR network. In fact, Spain's primary carrier Iberia promotes on its website their frequency and quality of air service between Madrid and Barcelona as an apparent response to other modes, including HSR. Despite this need for a transfer, the service is code-shared and is noted during the purchase of a ticket with "TR" next to the "flight". The locations covered by this service are pictured in *Illustration 4.2*.

Illustration 4.2: Cities Served by the Air Europa and AVE Code-Share

ITALY

In the early 1990's, Italy was home to one of the first cooperative arrangements between HSR and air. Alitalia had an agreement with the Italian Railway to replace its flights between Rome's Leonardo de Vinci Airport and the cities of Naples and Florence with HSR service similar to DB's AlRail in Germany. Unfortunately the service did not meet Alitalia's expectations, with speculation that the arrangement cost too much and did not have enough ridership (Givoni and Banister, 2007). Furthermore, Rome's airport is not integrated into Italy's HSR system, instead requiring a 30 minute express rail ride to the main train terminal. Milan's airport does have direct HSR service, but it is a spur line that runs only a couple times a day on two routes.

OTHER RAIL AND AIR COOPERATIVE EXAMPLES

Virgin Atlantic (VA) in the United Kingdom has implemented a variety of programs that utilize rail. VA states that it offers e-ticketing services with Eurostar, a major operator between London, Brussels, and Paris, but passengers must book over the phone. VA customers can also exchange frequent flier miles for Eurostar tickets by calling VA as well. VA has a similar program with Virgin Trains, which runs trains that may be considered HSR in the US, but are slower by European standards.

Switzerland also has integration services with rail that would be considered HSR in the US, but is not so in Europe. The Swiss Federal Railways (SBB) offers a variety of programs, including a code-share route called the Airtrain between Zurich Airport and Basel on Swiss International Air Lines (Swiss Airlines). Swiss Airlines passengers can purchase the route directly as part of their overall ticket, plus they can earn frequent flier miles on the journey. Like other code-shares, the Airtrain service does not offer any baggage handling, thus baggage is the responsibility of the passenger.

However, SBB does offer two other programs aimed at eliminating the need to worry about baggage. The first is an innovative idea called Fly Rail Baggage, which allows any passenger traveling to Switzerland to have their baggage checked through to their final rail station destination. This service is available from any airport in the world on any airline and can be arranged to almost 79 rail stations[18] in Switzerland. Some restrictions apply based on available times for pick-up at the destination station, but otherwise the baggage will arrive around the time the passenger arrives. The cost is currently $15 USD per luggage item, with reduced prices for first and business class Swiss Airlines passengers and Swiss Airlines frequent flier members.

[18] SBB maintains an active list of participating stations, with scheduling information for each station.

The second service provided by SBB builds upon the Fly Rail Baggage program, essentially providing the same service for passengers originating from Switzerland. The same Fly Rail Baggage rail stations allow passengers to drop off their luggage a day beforehand if they are headed to Zurich or Geneva airports, with the cost being the same as the Fly Rail Baggage service. The key difference between this service and the Fly Rail Baggage service is that there is a list of participating airlines, and their level of participation varies. Swiss Airlines and Lufthansa both fully incorporate this service, while SBB's website documents the long list of other airlines and their level of integration. Of the stations providing baggage service, 23 also allow for passengers to check-in at the rail station as well, with restrictions for each participating airline also listed by SBB.

Chapter 5: Cooperation in Asia

Despite HSR's success and prominence in Asia, few examples of cooperation could be found. This is somewhat surprising given the expansive HSR networks in places like Japan and China. However, few HSR airport links exist in Asia, as most airports are served by dedicated transit rail systems that link HSR stations to the airport. This disconnection likely plays a fundamental role in the lack of cooperation. Even so, some examples of cooperation were found in Japan and Hong Kong.

All Nippon Airlines (ANA), one of the largest airlines in Japan, used to offer code-shares with HSR operators in Europe, but these were all discontinued in 2010. In 2009, ANA allowed for customers to use frequent flier miles to purchase Eurostar tickets, but this appears to have been a promotion that has ended. ANA also announced a partnership with JR East[19] in 2007, but the agreement did not include any sharing of services. Rather, it allowed for point earning, website links to each other, credit card synergy, and travel packages[20]. In fact, ANA stated it has added more flights to a route in order to compete with HSR's frequencies, such as between Tokyo and Kyushu. This may be why ANA ended its code-sharing program, as press releases targeted to stakeholders appear to suggest a renewed drive to have a larger domestic presence and show stakeholders that ANA could compete against HSR (All Nippon Airlines, 2011).

Japan Airlines (JAL) has been somewhat more receptive to cooperation with HSR. JAL promotes the use of air and HSR to travel in Japan as part of vacation packages for international arrivals/departures. This is done through offering a Japan Rail Pass, or "Air & Rail" service. Passengers must contact JAL in order to take advantage of

[19] JR East is a major rail operator in Japan.

[20] There is no indication these packages utilized a cooperative arrangement. This may have been similar to a vacation package one might purchase in the US.

this multimodal vacation package, and it is billed as a program for visitors to Japan rather than for Japanese citizens. JAL also allows the transfer of frequent flier miles to obtaining Suica awards, which is an awards card that can be used to purchase a variety of things, including HSR tickets.

Hong Kong has a service similar to the Airtrain in Switzerland, called the Airport Express. Although it is not HSR, it does travel up to 80 mph and takes passengers to the distant airport. Passengers on over sixty airlines can use free check-in services at the Hong Kong city center station no later than 90 minutes before their flight, with their baggage being checked through from the station to their final destination.

COOPERATIVE RELATIONSHIPS IN THE UNITED STATES

With air travel experiencing major congestion, and HSR plans in the works, the conditions are favorable for the US to aim for a cooperative arrangement between HSR and air travel. This section will cover current and past cooperative agreements in the US between Amtrak and airlines at US airports, dissect current HSR plans for cooperative elements, analyze current and future flight data to recommend locations for HSR integration in airports, and provide best practices for fostering cooperation.

Chapter 6: Current and Past Examples of Cooperation

The United States has only one HSR line in operation, Amtrak's Acela, which currently has no cooperative agreements with any airlines. The line could potentially have arrangements at its Baltimore-Washington Airport (BWI) station, but the transfer requires a lengthy shuttle transfer that is roughly 2.5 miles long. Thus, the setup diminishes the return of having a cooperative connection since coordinating and guaranteeing timely transfers with flight schedules would be problematic. Furthermore, Acela's track is not a dedicated HSR route, and thus must coordinate with slower conventional rail along the busy eastern corridor.

The only example of cooperation in the US is the code-sharing agreement between Continental Airlines and Amtrak at Newark Liberty Airport (EWR) via conventional passenger rail service. Much like code-sharing agreements in Europe, this cooperative allows Continental customers to purchase one ticket, with one of the legs being aboard an Amtrak train. Passengers must transfer their luggage between modes, and check-in with each mode before boarding. *Table 6.1* lists the current destinations under this agreement as documented by Continental. With the exception of Philadelphia[21], all destinations are only served by Continental through this code-share and do not have any competing flights on Continental.

Cities Served to/from EWR	
Philadelphia, PA	Stamford, CT
New Haven, CT	Wilmington, DE

Table 6.1: Cities Served by Continental's Code-Share with Amtrak

[21] Continental also flies from Newark to Philadelphia's airport, but its code-share with Amtrak to Philadelphia goes to/from the 30th Street Rail Station.

Continental's code-share was not the first to be made with Amtrak. Icelandair implemented a similar agreement in 2001 between one of its major US airports, BWI, and the cities of Philadelphia and Washington DC. This was the first such agreement with Amtrak, and it was somewhat turbulent. There were reservation system issues in the beginning, and sales never truly reached expectations afterward (The Daily Record, 2001). It's unclear when the service was suspended, but it is no longer listed by either Amtrak or Icelandair.

Chapter 7: Review of Current High-Speed Rail Plans

There are a variety of HSR projects and proposals in the works across the country, with a handful of well established efforts. These HSR projects (California, Florida, Midwest, Northeast Corridor, and Southeast) were researched in order to see if current plans are attempting to link HSR with airports and how they are doing so.

CALIFORNIA

California has one of the more extensive HSR programs in the US, stretching from Sacramento all the way to San Diego, including San Francisco, San Jose, and various stops in the Los Angeles metro area. Its extensive level of planning makes it likely that California will be the first state to have new HSR service in the somewhat near future, as long as funding is secured. The state is also home to some of the busiest hub airports in the country with Los Angeles International (LAX) and San Francisco International (SFO), and one of the busiest non-hubs in San Diego (SAN).

There are ten segments currently in the plans for California's HSR system, and not all of the stops have officially been selected within these segments (California High-Speed Rail Authority). It is known that there will be an SFO stop, but it is currently slated to be near the airport rather than integrated (Coogan, Diridon, and Ban Beek, 2011). Thus a people-mover will need to be implemented to transfer passengers between the airport and the HSR station, which could reduce the chances for airline cooperation. Given SFO's designation as a major hub for United Airlines and the new Virgin America, along with being one of the busiest airports in the US, this could be an opportunity lost. However, at least the airport will be serviced by the HSR line.

That cannot be said for San Jose International (SJC) and LAX. The line is expected to come very close to SJC, but require some other means to get to the airport at

a farther distance than for SFO, perhaps via San Jose's light rail system. However, this connection isn't as important as SFO, as SJC is at most a focus city for Alaskan Airlines. Since Europe has generally shown that an airport really needs to be a hub in order to best support HSR, a lack of a connection at SJC may not be a significant loss. But if SFO continues to grow even with HSR service, SJC may become more attractive as a hub or major service city for other airlines, in which case a direct link could prove to be more useful. LAX on the other hand is a major hub, and in the top five busiest airports in the US. A variety of airlines call LAX a hub or major focus city, including American Airlines, and it is also a major gateway for international flights. As of right now, the plan is to have HSR run through Union Station, with transit rail providing a link to LAX (Coogan, Diridon, and Ban Beek, 2011). Like SFO, this could discourage some of the benefits seen with HSR integration and cooperation. Ontario's airport could see an HSR stop, but like SJC, this airport is not a hub[22] and in fact has a variety of restrictions on operations.

Lastly, the line has the potential to stop at SAN, which is one of the busiest non-hub airports in the country. SAN could also see increased demand should LA's airport system see capacity issues, as the two cities are relatively close and would be quickly linked if HSR provided a connection. SAN is not a hub, but it does have a variety of airlines serving it and the station would be close to downtown since the airport is already nearby. Thus the station could have dual purpose, and its success wouldn't be fully dependant on SAN, but could provide an interesting case study for non-hub airport linkages with little risk compared to other non-hub airports.

[22] Southwest Airlines uses Ontario as one of its LA-area destinations.

FLORIDA

Florida was probably the closest challenger to California when it comes to who would implement HSR first. However, early in 2011 the governor of Florida denied continuation on the first phase of HSR, which was to run from Orlando to Tampa. This line would have a direct station at the Orlando airport, which acts like a hub for JetBlue and AirTran, and served by a large list of airlines from most of their hubs due to Orlando's designation as a major tourist spot year-round. A second phase project would aim to link Orlando to South Florida (Florida Department of Transportation), but has yet to reach a level of detail that determines if stations would be at any of the area's airports.

MIDWEST

The Midwest's proposed system centers around the region's largest city: Chicago. In this multi-state planned network, Chicago serves as the HSR hub and could branch out to places like Minneapolis, St. Louis, Indianapolis, and Detroit. Additional major cities are also listed as potential destinations, but the rejection of funds by Ohio and Wisconsin has eliminated cities like Milwaukee, Cincinnati, and Cleveland from consideration for the time being.

Although the project seems well researched and constructed, the Midwest's system has not come as far as California and Florida in terms of a truer version of HSR[23]. For starters, there are several proposals being considered by various entities, including SNCF. However, they all show the potential major cities listed as destinations from the Chicago area to have predicted travel times under three hours via HSR, thus giving potential for HSR and air to cooperate in Chicago. One of the sure stops in the plans gives Chicago one of the best plans for integration at one of the busiest airports in the

[23] The Midwest has made progress in upgrading existing rail to accompany higher speed trains, but has not made any advancement towards implementing a "bullet" train system.

US: Chicago O'Hare (ORD). ORD's station is planned to be well integrated into a new airport expansion project that would also bring other forms of rail to the airport. The plan recognizes the importance of linking HSR with airports, and aims to have a European-style station integration in place at ORD (Midwest High Speed Rail Association, 2011). The downside to the ORD proposal is that the new development would be on a side of the airport that currently has no air terminal. The new terminal would be linked to the other terminals, but a fair amount of travel will still be required of passengers to move from the main sections of the airport to the HSR station, especially if they are traveling on the major airlines that have hubs at ORD and utilize the existing terminals. Expansion at the airport is underway; however, the new terminal is currently on hold after protest from American Airlines and United Airlines (Keen, 2011).

Chicago's second airport, Midway (MDW), has also been mentioned as a potential stop, but would likely be on one of the region's "regional fast trains", which could be classified as HSR to some extent in the US, but are not on the level of the labeled HSR trains being referred to as "bullet trains" in the plan.

Lastly, the small Gary Airport in Indiana is listed as being a potential stop. Little information is available as to why Gary's airport might have a station, but there has been talk and efforts to build a third airport in the Chicago area (FAA, 2009), and putting a station at Gary may be an attempt to utilize an existing airport as that third option. However, unless airlines go along with such a move and someone establishes it as a hub, the station could follow in the footsteps of Lyon's airport/HSR integration, which has underperformed.

The stations discussed so far have been widely accepted as being part of the overall strategy of the Midwest's system, but individual plans have gone even further with airport integration. Unsurprisingly, SNCF's proposal provides the largest number of

other airport stations, which include Milwaukee's Mitchell Airport, Cleveland's Hopkins Airport, Detroit Metro Airport, and Cincinnati's airport (CVG), which are all hubs for large airlines (SNCF, 2009). Zip Rail's proposal for Minnesota's HSR suggests a stop at Minneapolis-St. Paul's airport (MSP), but other plans do not mention MSP (Southeast Minnesota Rail Alliance).

NORTHEAST CORRIDOR

Amtrak's Acela is currently the only HSR line in operation in the US, running within what is known as the Northeast Corridor (NEC). In September of 2010, Amtrak unveiled its plans to significantly expand HSR services within the NEC and to utilize what it calls "nextgen" HSR trains and routing. In other words, it hopes to turn the NEC into a European-like HSR corridor with a variety of HSR services, including linkages at airports.

The plan repeatedly notes the importance of HSR as a solution to air space congestion in the northeast. Although it does not explicitly promote mode cooperation, the plan proposes to have four airport connections, which are outlined in *Table 7.1* (Amtrak, 2010).

Planned Airport Stations	
Newark, NJ (EWR)	Philadelphia, PA (PHL)
Baltimore, MD (BWI)	White Plains, NY (HPN)

Table 7.1: NEC HSR Proposed Airport Connections

The plan does not outline the location of airport stations relative to airport terminals, but does mention that the BWI station is assumed to be located near the current NEC rail terminal. If that is the case, this station would be similar to the one outlined for the SFO station in California's plan. The rail line at BWI is currently far enough away from the

airport that it requires a circulating shuttle to transfer passengers. In order to better facilitate mode sharing, a better people-mover system would have to be implemented. However, even a more efficient transfer system would not likely facilitate cooperation between the two modes, as European case studies suggest seamless integration of HSR stations with their respective airport is needed for such operations. The plan also states other airports could be involved, but their involvement with HSR is stated to likely be through transit linkages, which again would limit the potential for cooperation.

Despite a significant emphasis on airport linkages, the primary assumption of the plan is that HSR will compete with air travel. The plan outlines markets from which HSR is believed to draw ridership from, and these markets include major airports that are not assigned a connection. Furthermore, cooperation is not mentioned within the plan as a benefit to help facilitate a diversion of users from airports to HSR for short-haul connection trips. Rather, the plan appears to target the intraregional travel between the large metropolitan areas, which are also home to the heavily congested airports in the region. This would tackle air travel congestion, but does not allow airlines to take advantage of other benefits that cooperation allows.

SOUTHEAST

Like the Midwest, the Southeast is still in the early planning and decision stages when it comes to line alignment. However, this region is home to two large hub airports, including the world's busiest in Atlanta. Preliminary plans discuss HSR integration at a list of airports, most notably Atlanta's Hartsfield-Jackson International and Charlotte's Douglas Airport, but also at smaller airports Raleigh-Durham (RDU) and Greensville, SC (The Volpe Center, 2008). Like previous plans, it is somewhat puzzling why the smaller

airports are being proposed as stops, though RDU does operate a lot of short-haul flights as a hub for American's connection flight subsidiary American Eagle.

OTHER HSR PROJECTS WITH POTENTIAL FOR INTEGRATION

Outside of the projects discussed so far, very little exists in terms of tangible plans in other parts of the country. Initial planning for HSR in the Denver area shows Denver International as a stop, but likely as a spur given its location within the region (Transportation Economics & Management Systems, Quandel Consultants, and GBSM, 2010). In Las Vegas, a new international airport 30 miles from the city was on the verge of construction until the economic decline that started in 2008 put plans on hold (Clark County Department of Aviation, 2010). The airport was discussed to have a HSR station that would link with Los Angeles, possibly including Ontario Airport (California-Nevada Super Speed Train Commission and American Magline Group).

Chapter 8: Factors for Cooperation

There are a host of factors that can impact cooperation, but as the European examples show, cooperation varies heavily and there is no set guide on what does and does not make it work. However, there are some pieces of analysis that can help point to where cooperation may have the best chance of being successful and help reduce airport congestion. This chapter will outline these factors that led to a selection of airports for analysis and how they were analyzed.

AIRPORTS STUDIED

HSR requires a large base of potential riders, and for it to have an impact on reducing short-haul flights, it also needs airports with a significant amount of flights to divert if HSR is integrated into an airport. Thus the rankings of airports[24] in current enplanements and number of flight operations, along with congestion predictions by the FAA, were analyzed to see where HSR might best assist in the movement of air passengers. This data formed the basis of which airports would be the focus of analysis for this study.

Enplanements involve the number of passengers boarding a plane at a given airport. This data gives an idea as to which airports are the busiest in terms of handling passengers, which can hint to which airports are the likely candidates to be congested in terms of the number of passengers it can handle. Determining if an airport is congested based on the number of passengers handled is difficult and complex, if possible at all, as the facility size, planes serving the airport, number of runways, and a variety of other factors impact the capacity of an airport. Enplanements also point to which airports could

[24] Only airports designated as large or medium by the FAA were considered. The FAA defines a large airport as one that accounts for at least 1% of the annual national passenger enplanements, while a medium airport must account for between 0.25% and < 1%.

have the greatest number of potential riders for HSR should a connection and route be provided. Based on 2009 data from the FAA, it's no surprise that the airports with the highest number of enplanements are major hub airports. Of the top airports in the continental US, the first 25 are airports with hub operations by at least one airline. In fact, of the top 35 airports, only four are non-hub airports (San Diego, Tampa, Chicago-Midway, and Oakland). A full listing of airport enplanements for selected airports in the continental US can be found in Appendix A.

Another indicator of the potential for congestion is the number of flights an airport handles. This also shows which airports may have the greatest potential for reducing short-haul flights, opening the airport to more long-haul markets. Taking the airports found in the enplanement rankings, flight operations data from the FAA's *Air Traffic Activity System* for 2009 shows that hub airports also predominantly account for the top busiest airports in terms of flights. This data closely follows the order of top enplanement airports, with only two non-hub airports in the top 30 (Chicago-Midway and Houston-Hobby). As a note, this data also includes general aviation and military flight operations. This is important, as these operations contribute to an airport's congestion level and capacity, although they likely occur during off-peak time periods. This data also includes both flights landing and taking off. A full listing of airport flight operations for selected airports in the continental US can be found in Appendix B.

The last factor in selecting airports for analysis was the FAA's 2007 capacity report, which lists airports that it believes will have capacity concerns in 2015 and 2025. The report splits its findings into two categories: with planned improvements built, and without planned improvements built. The report takes into account a variety of factors, including spatial and other restraints to airport expansion. It also concludes that some markets will be congested no matter what due to airspace congestion in places like the

northeast. Again, this data generally aligns with the top airports in enplanements and flight operations. However, some airports are influenced by the potential for other nearby airports to have congestion. For example, John Wayne Airport near Los Angeles is expected to have capacity concerns in both 2015 and 2025, with or without planned improvements. This could be due to passengers looking for alternatives to LAX and/or San Diego. Oakland is predicted to experience the same issue as well, while other much larger airports are not predicted to experience issues in either year, such as DFW, Denver, Orlando, and Miami. A full listing of capacity concerns by selected airports in the continental US by the FAA can be found in Appendix C.

Based on the enplanements and flight operations data, and the FAA's capacity predictions, the following airports were selected to analyze further:

Airport	Location
Hubs	
Hartsfield - Jackson Atlanta International	Atlanta, GA
Baltimore/Washington International Thurgood Marshal	Baltimore, MD
General Edward Lawrence Logan International	Boston, MA
Charlotte/Douglas International	Charlotte, NC
Chicago O'Hare International	Chicago, IL
Cincinnati/Northern Kentucky International	Cincinnati, OH
Cleveland-Hopkins International	Cleveland, OH
Denver International	Denver, CO
Detroit Metropolitan Wayne County	Detroit, MI
Fort Lauderdale/Hollywood International	Ft. Lauderdale, FL
Dallas/Fort Worth International	Dallas, TX
George Bush Intercontinental/Houston	Houston, TX
Kansas City International	Kansas City, MO
McCarran International	Las Vegas, NV
Los Angeles International	Los Angeles, CA
Memphis International	Memphis, TN
Miami International	Miami, FL
General Mitchell International	Milwaukee, WI
Minneapolis-St Paul International/Wold-Chamberlain	Minneapolis, MN
John F Kennedy International	New York, NY
La Guardia	New York, NY
Newark Liberty International	Newark, NJ
Orlando International	Orlando, FL
Philadelphia International	Philadelphia, PA
Phoenix Sky Harbor International	Phoenix, AZ
Portland International	Portland, OR
Salt Lake City International	Salt Lake City, UT
San Francisco International	San Francisco, CA
Seattle-Tacoma International	Seattle, WA
Lambert-St Louis International	St. Louis, MO
Washington Dulles International	Washington, DC
Ronald Reagan Washington National	Washington, DC
Non-Hubs	
Chicago Midway International	Chicago, IL
Metropolitan Oakland International	Oakland, CA
San Diego International	San Diego, CA
John Wayne Airport-Orange County	Santa Ana, CA
Tampa International	Tampa, FL

Table 8.1: Selected Airports for Analysis

For the most part, this list reflects those airports with the largest passenger demand. However, future capacity concerns also played a significant role, especially with the selection of Santa Ana and Oakland. San Diego was included because of its proximity to Los Angeles and notoriety as the busiest non-hub airport. Tampa was included because of past discussions of having HSR service to/from Orlando, while Chicago-Midway does as well (along with being in a large market). The last pick that strays away from the norm is Milwaukee, which is slowly becoming more prominent given Chicago's congestion and airlines putting focus on the airport, such as Southwest, AirTran, and Frontier[25].

ORIGIN-DESTINATION PAIRS WITHIN SPATIALLY-COMPETITIVE MARKETS

As documented earlier, HSR is generally competitive with air travel within 500 miles from the origin. This range is based on the typical speeds found on HSR networks, as the more important factor is time. However, because there are a variety of train types and the average speed depends on the route, this distance benchmark was used to see what markets[26] fall within or near the 500 mile ring of the selected airports. These cities were then matched with their accessible airports to see where feeder service with their respective hub occurs.

Once feeder airports for each selected airport were identified, origin-destination data from the Bureau of Transportation Statistics' TransStats database for 2009[27] was analyzed to see how many flights operate between the airport pairs. Flight operations were chosen over passenger enplanements for a few reasons. First, one of the goals with cooperation is to reduce the number of flights. Studying the flight pairs shows which airports have the greatest potential for flight reduction. If an airport pair has a large

[25] Midwest Airlines operated a hub in Milwaukee, which Frontier has maintained since purchasing Midwest.
[26] Cities with a population of 100,000 or greater as of the 2000 Census were considered.
[27] Most current year with complete data during this report's timeframe.

number of passengers, that does not directly translate into a large number of flights because aircraft size varies. Thus reducing the number of passengers does not directly mean the number of flights will be reduced, as aircraft size may be reduced instead. However, if there is a large volume of flights between an airport pair, whether they are small or large aircraft, generally means there is a significant market of passengers between the two. Thus it was deemed that the number of flights was a better indicator of how airlines viewed a market pair. Secondly, studying the flight volumes for airport pairs allows for a percentage of flights that are short-haul for the hub airport to be calculated. This gives a sense as to how much of an impact HSR may have in alleviating congestion at an airport. If an airport has 50% of its flights operating within 500 miles, and a large percentage of that volume going to specific markets, there could be a significant opportunity to implement a cooperative relationship. On the other hand, if an airport only has 10% of its flights operating within 500 miles, reducing those flights would likely have little impact on congestion. Lastly, passenger flows between markets have been extensively documented for the purpose of studying diversion rates from air travel to HSR as a substitute mode. The aim of this report is to find where HSR service could replace flights in a complimentary role like that of Frankfurt and Cologne. Having this data easily documented could later help in analyzing the impact of HSR and cooperation should it come to fruition. A sampling of this data can be found in Appendices D and E.

Chapter 9: Potential for Cooperation

Based on the factors for cooperation explored in the last chapter, along with forecasted flight operations for the next 10-20 years and the FAA's capacity concerns, a list of the best airports for integration (and subsequently cooperation) were identified. A second list of airports provides other locations that could be integrated given future trends and lessons learned from other integrated airports. Lastly, this chapter will review airline networks in order to see how airlines could utilize cooperation. The data presented in this chapter was obtained from or based on the following sources:

- Enplanements data came from the FAA's 2009 *Primary and Non-primary Commercial Service Enplanements* data file
- Flight operations were based off of the 2009 Bureau of Transportation Statistics' TransStats *T-100 Domestic Segment (U.S. Carriers)* database
- Capacity concerns came from the 2007 FAA report *Capacity Needs in the National Airspace System (2007-2025)*
- Predicted flight operations were modeled in 2010 by the FAA's *Terminal Area Forecast* and obtained from its database

BEST AIRPORTS FOR COOPERATION

The following airports stood out in a variety of ways given the data analyzed. Most of the airports have concerning outlooks when it comes to projected capacity, while also having substantial short-haul flights. This list is not meant to propose that all these airports have stations implemented, but rather which airports might be the top locations overall. *Table 9.1* lists these airports, and highlights their flights within or near 500 miles. Appendix B lists total flight operations for all studied airports.

Airport(s)	Flights	% of Total
Atlanta (ATL)	361,724	37%
Chicago-O'Hare (ORD)	262,616	32%
Los Angeles (LAX)	147,491	27%
Las Vegas (LAS)	148,209	29%
Phoenix-Sky Harbor (PHX)	124,863	27%
San Francisco (SFO)	105,483	28%
Charlotte (CLT)	219,049	43%
Detroit (DTW)	200,422	46%
Philadelphia (PHL)	183,528	39%
New York-La Guardia (LGA)	150,521	42%
Washington-Reagan (DCA), or Baltimore (BWI)	153,512 125,726	56% 48%
Cleveland (CLE)	120,251	60%

Table 9.1 Recommended Airports and Flight Operations Within or Near 500 Miles

Atlanta (ATL)

ATL is the busiest airport in the world, with over 11 million more passengers and 150,000 more flights per year than Chicago-O'Hare, the next busiest US airport. In 2009, 37% of those flights went to airports within 500 miles, which happens to translate into the largest total number of flights from one airport to airports within 500 miles (361,724). These two figures show that ATL has ample room to transfer flights onto HSR via cooperation. Furthermore, ATL's two largest markets in terms of flights served rank in the top 25 when looking at hub airport-to-major metro pairs (Washington DC and Orlando), and seven of its airport-to-airport pairs are in the top 30: Orlando (2nd), Tampa (13th), Charlotte (15th), DC-Reagan (20th), Baltimore (25th), Jacksonville (29th), and DC-Dulles (30th). Many of these destinations also happen to fall along a fairly linear path, allowing for connectivity between all markets, and is currently discussed in plans for HSR in the southeast. Lastly, ATL is predicted by the FAA to have capacity issues by 2025, regardless of planned improvements being built.

Illustration 9.1: ATL and Major Markets Within or Near 500 Miles

Chicago-O'Hare (ORD)

ORD is already slated as a centerpiece to the Midwest's HSR plans, and rightfully so. It is the second busiest airport in the US next to ATL in both passengers and flights, and also has a fair amount of those flights going within 500 miles (262,616 or 32% of total flight operations). It also draws a significant amount of air traffic from major metropolitan areas in the region, of which four rank in the top 30 airport-to-airport pairs for flights: Minneapolis (7th), Detroit (18th), St. Louis (23rd), and Cincinnati (28th). Unlike ATL, ORD could be a hub of HSR service rather than a spoke within a broader transportation network. This is due to its dominance within the Midwest as a transportation hub overall. Lastly, ORD is also anticipated to have capacity issues in the

next 5-10 years if no additionally planned projects are carried out. Such a scenario could exist, as ORD has had conflicts arise with proposed expansions in the past.

Illustration 9.2: ORD and Major Markets Within or Near 500 Miles

Los Angeles (LAX)

LAX is the main airport amongst five that provide commercial service to the LA metro area. It is the third busiest airport in the US in terms of passengers and fifth in terms of flights, though the FAA forecasts that it will jump to third in flights by 2020. LAX has the largest hub airport-to-major metro flight volume in the county with over 55,000 flights going to/from the San Francisco area annually, which includes Oakland and San Jose. LAX is also part of five airport-to-airport pairs in the top 30, including three of the top five: San Francisco (1st), San Diego (4th), Las Vegas (5th), Phoenix (14th),

and San Jose (22nd). Although the FAA does not anticipate capacity issues arising until 2025 if no improvements are built, other predictions have shown that if capacity constraints arise at LAX, the region's airports would become congested given their limited capacities to begin with (Coogan, Diridon, and Van Beek, 2011). LAX currently does not have a planned HSR station within California's plans, as it is planned to be linked via transit at Union Station. This could be a large missed opportunity for cooperation with HSR, as having a transit link eliminates the seamlessness ideal for cooperation. That's not to say flights couldn't be removed since most of the travel is intrastate travel, but this does not account for the large volumes between Los Angeles to Las Vegas and Phoenix. Currently these corridors do not have any serious HSR plans.

Illustration 9.3: LAX and Major Markets Within or Near 500 Miles

Las Vegas (LAS)

LAS is within the top 10 busiest passenger and flight operations airports in the country, and is anticipated by the FAA to jump significantly in its flight rankings over the next 10-20 years from its current 7th place status all the way to 5th. That is a substantial climb, which explains why the FAA also notes that LAS is anticipated to have major capacity concerns over that same timeframe. LAS has the 4th largest hub airport-to-major metro volume of flights in the country with its services to the five Los Angeles airports, and the 11th largest such volume with its services to the San Francisco area. It also has significant flight volumes to Phoenix, Salt Lake City, and San Diego. In this respect, LAS is similar to Chicago-O'Hare in that it could potentially be a hub HSR location for the southwest. Unlike Chicago, little lies in between these markets, meaning there would be little pressure to have stations in between. This would make the service more direct and thus more viable. LAS also suffers from some physical restraints when it comes to expansion given its central-city location. Providing major HSR services could help keep the airport close to the casino strip, relieve congestion, and even bring in more people to take part in the city's entertainment-based economy.

Illustration 9.4: LAS and Major Markets Within or Near 500 Miles

Phoenix-Sky Harbor (PHX)

PHX is also one of the top airports in the country when it comes to passengers and flight operations. Although it is predicted to lose some spots in terms of flight operation rankings over the next 10-20 years, this is likely due to capacity concerns, which the FAA notes as being unavoidable by 2025. PHX also has the third largest hub airport-to-major metro flight volume with its services to the five Los Angeles airports, with nearly 50,000 flights between the airport and LA on an annual basis. It also has four connecting airports within the top 30 airport-to-airport pairs, all of which are within separate metro areas: Las Vegas (11th), LAX (14th), Salt Lake City (24th), and San Diego (26th). Like Las Vegas, little lies between Phoenix and these destinations, making for more direct connection and thus a more viable network for cooperation.

Illustration 9.5: PHX and Major Markets Within or Near 500 Miles

San Francisco (SFO)

SFO, like LAX, LAS, and PHX, carries significant volumes of passengers within the southwest. Its services to Los Angeles make it the second highest hub airport-to-major metro flight volume pair in the country with nearly 50,000 flights annually. It also suffers from land constraints for expansion. SFO is planned to have an HSR station link within California's HSR system, but it not planned to be onsite. Rather, it is proposed to have a people-mover connect the nearby station to the airport. As will be noted in the best practices chapter, this is not ideal for cooperation to exist.

Illustration 9.6: SFO and Major Markets Within or Near 500 Miles

Charlotte (CLT)

Although CLT is not within the top 10 passenger airports in the US, it ranks 8th for flight operations and is predicted to climb to 6th. Furthermore, the FAA anticipates there to be capacity issues within the next 5-10 years if no planned improvements are constructed. Although CLT does not have as many of the high ranking airport-to-airport or hub airport-to-major metro flight volume pairs as perhaps some of the other airports, it does have a substantial portion of its flights going to airports within 500 miles – 43%. It is also strategically located between the northeast corridor and Atlanta, which are its major markets. Stops between CLT and Washington DC could help eliminate flights from smaller airports in those areas as well, which could further help Atlanta and the Washington DC areas in reducing their congestion.

Illustration 9.7: CLT and Major Markets Within or Near 500 Miles

Detroit (DTW)

Although Detroit is predicted to drop to 11th in flight volume by 2020 and 12th by 2030, it is well positioned geographically to connect some of the largest population centers in the country. Within its 500-mile boundary it has two of the largest cities in the US, Chicago and Philadelphia, and almost has the New York City metro as well. It also has a very high percentage of its flights going to this range and one of the higher total volumes as well (46% and 200,000+ respectively). These factors could make Detroit an attractive place for airlines to utilize in order to get passengers to congested metros such as Chicago and New York if direct HSR service was provided. The airport does not have

capacity issues, though this could be a positive in that it could handle more flights coming into the airport for passengers to use the HSR service.

Illustration 9.8: DTW and Major Markets Within or Near 500 Miles

Philadelphia (PHL)

PHL ranks in the top 10 in flight volume, has a high percentage of regional flights – 39% – and is to be one of the most capacity-strained airports in the country according to the FAA's projections. Most of those flights are going to high-population centers such as Washington DC, Boston, and New York City, all of which are along the northeast corridor and PHL is a center point to. This is likely why PHL is planned to have HSR connectivity in Amtrak's recent proposal for the region.

Illustration 9.9: PHL and Major Markets Within or Near 500 Miles

New York-La Guardia (LGA)

Although both Newark and JFK have more passengers and flights, LGA has more flights within 500 miles than either of those airports. *Table 9.2* outlines the regional flight numbers and percentages for New York City's three major airports.

Airport	Flights	% of Total
JFK	90,633	21%
Newark (EWR)	97,419	23%
La Guardia (LGA)	150,521	42%

Table 9.2: 2009 Flight Volumes within a 500-mile Radius for New York City Airports

Over 40% of its flights are within that range, while noted by the FAA as being one of the most capacity-constrained airports. This is likely why it is anticipated to drop in flight

volume rankings over the next 10-20 years. But as it has been noted, LGA is the primary regional airport for the New York City area, thus removing flights from those locations would help with New York City's airspace congestion issues. Lines to Boston, Washington DC, and further south – Raleigh-Durham is major market – could help reduce the number of short-haul flights in the New York City area better than at other airports. However, it is understood that linking LGA via HSR could be very expensive and difficult, thus Newark is listed within the next section. The recommendation of LGA is purely statistical and states the ideal selection for the New York City area.

Illustration 9.10: LGA/New York and Major Markets Within or Near 500 Miles

Washington DC-Reagan National (DCA) or Baltimore (BWI)

Although BWI already has a rail connection and is slated within Amtrak's plans to have more HSR service, DCA handles an even larger percentage and volume of regional flights (56% and 150,000+ respectively) and serves many of the same markets as BWI. However, DCA is restricted by law in how far flights can fly and how late the airport operates, limiting its role as a connecting airport. BWI does not have these restrictions and also has a high percentage of regional flights – 48%. BWI is also connected to Washington DC, though DCA has better and faster connection via the Washington Metro rapid rail transit line. Either airport would be a desirable connection, with BWI likely receiving a linkage given that it already has heavy rail access.

Illustration 9.11: DCA/BWI and Major Markets Within or Near 500 Miles

Cleveland (CLE)

Cleveland ranks towards the bottom of the top airports in passengers and short-haul flight volumes, but it does have several redeeming qualities that should be considered. First, it has the highest percentage of 500-mile or less flights amongst the airports analyzed (60%) and a respectable total volume (120,000+ flights annually). Like Detroit, Cleveland is situated such that it has access to Chicago, Philadelphia, and New York City, but also has access to Washington DC. In fact, its geographical location may even be better than Detroit in this respect. Thus the same suggestions listed for Detroit apply to CLE.

Illustration 9.12: DCA/BWI and Major Markets Within or Near 500 Miles

OTHER AIRPORTS TO CONSIDER

There are numerous other airports that may be candidates for HSR connectivity should some factors change, trends continue, and/or other airports cannot have linkages. The first is Dallas-Ft. Worth (DFW), which is the 4th busiest airport in the US in terms of passengers. Unfortunately it does not serve as large of population centers as east coast, west coast, and Chicago airports do, but does have substantial flight traffic between Austin, San Antonio, and Houston. Although the Houston market has the highest number, if Austin and San Antonio are combined they would hold that distinction. Either route, or both, could be considered in the future. The same logic is in play for IAH in Houston as well, with similar frequencies to Austin, San Antonio, and Dallas, though not quite as high as DFW.

Denver, Seattle, and Salt Lake City also suffer from the fact that they do not have as many metropolitan areas within a 500-mile radius. However, they do already have substantial flight volumes between themselves. Seattle is probably the best candidate, as the Seattle-Portland corridor has the 6th highest flight volume for airport-to-airport pairs, while Seattle-Spokane surprisingly is the 17th largest. Thus Seattle could serve as a HSR hub for the northwest. Salt Lake City has substantial volumes to Phoenix and Denver, while Denver provides a lot of service back to Salt Lake City and to Colorado Springs. However, its outlying location compared to Salt Lake City's central location to large population centers may be to its disadvantage. It's possible that Denver could include Kansas City as a destination, but this would require very high-speed service since the two cities are roughly 600 miles apart.

As previously mentioned, Newark would be the next best option if LGA was not capable of HSR integration, as it carries more regional volume than JFK. Like BWI, it already has rail linkages, though better integration would be preferred. Like all New York

City area airports, it too has capacity issues that could be aided by HSR. Washington-Dulles similarly could be an option for the DC area as well. Both airports could also be on another HSR line if such a plan were ever developed to have multiple parallel routes linking the northeast. Far into the future, this may be necessary, as there are too many markets that could use HSR connectivity along this corridor, which could inhibit higher speeds due to excessive stop frequencies.

Minneapolis (MSP) has one of the busiest airport-to-airport flight volume pairs and hub airport-to-major metro area pairs in the country (7^{th} and 13^{th} respectively) with Chicago, a volume high enough that could sustain cooperative service between the two areas. There is also substantial travel to Milwaukee and St. Louis as well. St. Louis has a similar situation, plus has access to the Kansas City area. Both airports have a fair amount of capacity and, like Detroit and/or Cleveland, could provide relief to Chicago.

Lastly, two non-hub airports could be interesting cases for HSR connectivity. San Diego's airport lies near downtown, thus offering city center and airport service all in one stop. Although it is not a hub, it has a significant amount of direct flights and could develop into a hub-like airport if Los Angeles airports max out their capacity. Furthermore, San Diego has run into ground access issues with how the freeways are situated near the airport (Leiter, 2011), thus HSR could help increase access to the airport, especially for passengers using the airport from Los Angeles. Meanwhile, Chicago-Midway may not be as large of O'Hare, but it is closer to the city center and provides significant service to many of the same airports within the 500-mile radius that O'Hare has frequent service to.

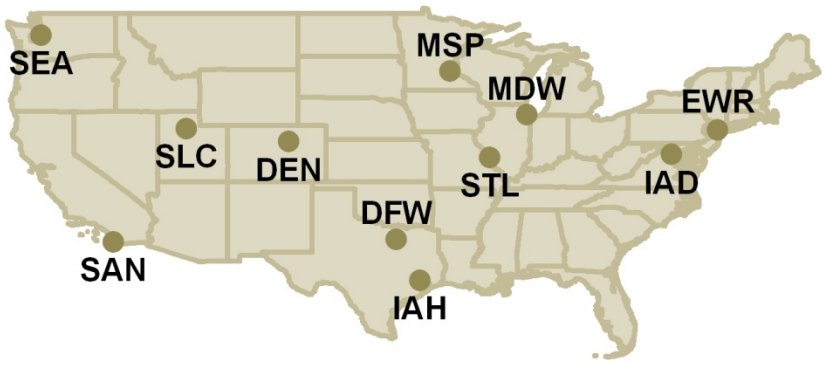

Illustration 9.13: Other Airports to Consider for HSR Cooperation

WHY SOME MAJOR AIRPORTS WERE NOT SELECTED

Although JFK in New York City is the 6th busiest airport in handling passengers, and faces major capacity issues as well, it does not have the volume or percentage of flights going to regional locations as do the other New York City airports, which are also experiencing the same capacity constraints. *Table 9.2* earlier in this chapter highlights the regional service of the three major airports in the New York City area.

Orlando was planned to have an integrated station before Florida's HSR program came to a halt. However, despite MCO being one of the busier airports in the county, it does not have a lot of regional flight traffic (only 16% and less than 50,000 flights annually) and its major markets that are within range do not meet the levels seen elsewhere in the country. The exception is ATL, which overall appears to be a better option for HSR connectivity, including to Orlando.

Lastly, Boston, Portland, Miami, and Ft. Lauderdale were not recommended due to their physical location and proximity to other airports that are better suited to have connectivity. Boston is the northern edge of the northeast corridor, and thus does not have the central location that places like New York City or Philadelphia have. Furthermore, most of its 500-mile or less trips are likely produced from Boston itself and would not

benefit as much from a cooperative situation that depends on connecting passengers. Miami and Ft. Lauderdale suffer from not having anywhere to connect its passengers to, as they are mainly coming to the area. Thus southern Florida would more likely benefit from HSR service coming from Atlanta and/or Orlando versus being a cooperative link. Portland is in a similar situation, with Seattle providing a more central hub location and more flights to connect with HSR.

HOW US AIRLINES COULD UTILIZE HSR ON THEIR NETWORKS

Because the airports selected for HSR integration are hub airports, certain airlines who are the primary carrier at those airports may be able to divert flights to HSR and expand their long-haul operations. Airlines with non-hub operations may also be able to take advantage of certain airports with HSR connections to quickly expand their network's reach. The following is a look at some of the airlines in the US that may benefit from cooperating with HSR. Primarily airlines that are based in one part of the country, or airlines with substantial operations from major hub airports, are the most likely to benefit. Airlines that are mostly long-distance and fly throughout the US without significant hub operations will likely see less of a benefit from HSR connectivity and cooperation.

AirTran

With Atlanta being AirTran's main hub, there is ample opportunity for cooperation. Should a line be built connecting ATL with Charlotte, Raleigh-Durham, and on to DC, AirTran could put many of those flights on HSR service, along with places like Richmond or Newport News if they are connected as well. Similar moves could also be done for its Orlando base connecting Jacksonville and Tampa, and perhaps even to southern Florida. Its base in Baltimore could also help divert flights onto trains, and open

up the New York City market from the DC area via HSR, which currently does not have AirTran service.

These moves could open AirTran's hubs to longer distance markets, such as Austin, Salt Lake City, and Portland from the east coast. However, many of the longer distance places AirTran does not serve are served by Southwest, which recently bought AirTran. Given Southwest's stance on HSR in the past, and its business model's conflict with HSR, cooperation with AirTran may not occur.

Alaska Airlines

Alaska Airlines is predominately a west coast airline, with some Midwest and east coast destinations. Alaska could utilize HSR connections in California to open slots at its LAX and San Jose hubs, which in turn could allow them to fly more cross-country routes from those locations. A similar situation could occur at its Seattle hub between Portland and Spokane, allowing for expansion from Seattle and Portland. But Alaska's greatest gain may be from east coast HSR, where it could enter smaller markets that may be connected via a line between DC and south to Atlanta. Places like Charlotte, Raleigh-Durham, and Jacksonville could be added via flights to Atlanta and Washington DC-Reagan. The same is true for Chicago, where places such as Milwaukee, Detroit, and Cleveland could be added to its network.

Frontier

Frontier would likely benefit greatest by having HSR service to Denver, its primary hub, but would likely not need it since DIA does not currently have congestion issues. That said, United is the primary player at DIA, and Frontier could use HSR service to Salt Lake City and/or Colorado Springs to open up more slots to travel to more international or east coast locations. Otherwise, Frontier is primarily a long-distance flyer

to many of the airports best suited for HSR links, with exceptions at its hubs of Denver and Milwaukee from which many short-haul flights to small markets occur. If Milwaukee was added to a line between Minneapolis and Chicago, Frontier could possibly put some routes on HSR to places like St. Louis, Minneapolis, and Ohio cities and subsequently have more west coast flights from MKE, but Milwaukee's airport as a whole does not appear to be a great priority for integrating HSR as other airports in the region.

JetBlue

JetBlue's hubs were not identified as good candidates for HSR connections. However, some of its destination airports could help it expand throughout the Midwest and Ohio River region. JetBlue currently flies to Chicago-O'Hare from Boston, JFK, and Los Angeles-Long Beach, from which it could use HSR to expand to Minneapolis, St. Louis, Detroit, Cleveland, and other cities in the area. It also does not fly to Atlanta, but does serve Charlotte from Boston and JFK. It could add Atlanta via HSR, along with places like Raleigh-Durham and other mid-Atlantic destinations that could end up on a HSR line. If additional HSR service to the New York City and/or Boston areas open more flights in those markets, JetBlue could use those slots to fly to more of the middle section of the country, such as Memphis, Cincinnati, Dallas, and Kansas City.

Spirit Airlines

Spirit is predominantly an airline that focuses on bringing visitors from the major east coast markets to Florida, the Caribbean, Central America, and the northern portion of South America. Thus it will likely not be looking to transfer flights onto HSR in the northeast; however, its west coast service is very limited, with only LAX and Las Vegas being served. It could look to add San Diego and San the Francisco area to its network via LAX and LAS, along with Phoenix as well. Other Midwest markets could be added

through Chicago-O'Hare, such as Minneapolis and St. Louis. It could also benefit from HSR at DTW, from which it flies to the east coast, and fly more flights to the west coast if it wanted those markets via Detroit.

Sun Country

Sun Country is primarily a seasonal, vacation-oriented airline with most of its operations (both regular and seasonal) out of MSP. However, its few regular routes go to airports that would be good candidates for HSR. Sun Country could utilize HSR from LAX, San Diego, and/or Las Vegas to regularly provide service to San Francisco and Phoenix via a connection and then retain seasonal trips for more direct routes from MSP during the peak season. The same strategy could help provide regular access to New York City and Boston via Washington-Reagan National as well.

USA 3000

USA 3000 is also a primarily vacation-oriented airline, serving limited Midwest and northeast markets and connecting them to Mexico and the Caribbean. It could take advantage of HSR via Chicago-O'Hare and Cleveland to bring markets such as Minneapolis, Detroit, and New York City to its operations that fly to those popular vacation destinations. Furthermore, USA 3000 could easily add a few flights to LAX or another west coast city and provide access to places like Phoenix, Las Vegas, San Francisco, and LA, which are all popular vacation destinations.

US Airways

US Airways has hubs at some of the busiest airports in the country. It could use HSR at PHX, CLT, and PHL to take flights off of routes such as Los Angeles, Las Vegas, Atlanta, and the northeast corridor and in turn fly more cross-country, Midwest, and

southern routes. It could expand to places like Austin, Oklahoma City, and Little Rock, while expanding service to the locations in those areas that it already serves.

Virgin America

Virgin primarily focuses on long-haul, cross-country routes, but does do some regional flights in and around California, where it is based at SFO and LAX. Flights between these two markets could be diverted to HSR, along with flights to Las Vegas, allowing for additional long-distance markets to be captured, such as Denver, Atlanta, and Houston. It could also add markets from destination airports such as Chicago-O'Hare, where it could go to Minneapolis, Detroit, Cleveland, and St. Louis. Portland and Spokane could also be added via its service to Seattle, and Dallas could help add Austin and San Antonio should HSR service ever be added along that corridor.

Large Legacy Carriers

The large legacy carriers[28] pretty much serve all of the proposed hub airports for HSR connections. Where they could benefit from HSR is to remove redundant flights between these airports and replace them with more frequent service to long-haul destinations, giving those destinations greater access and flexibility. For example, if a passenger wants to fly from Appleton, WI to Austin, TX, flights to Austin may be limited from hubs such as MSP and ORD. If short-haul flights at those airports were replaced with HSR to eliminate frequent trips between places like Detroit, Cleveland, St. Louis, and between MSP and ORD, more flights could be assigned to places like Austin – ones that are farther away and have low service frequency. This would give the passenger more options in terms of time of day for travel and cost of their trip. The primary airports

[28] Primarily considered American, Continental, Delta, and United, although US Airways could be added to that list. Continental and United are currently in the process of merging.

that could see such a benefit are LAX, ORD, EWR, LGA, and ATL, as these are all major hubs for large airlines.

Southwest

Southwest is difficult to analyze in terms of how it could utilize HSR, which may explain its past opposition to HSR. It has developed a model that has made short-haul travel profitable by turning them into segmented long-haul operations. So rather than flying a flight from Chicago to Minneapolis and back during a day, it may fly from Chicago to Minneapolis, then on to Denver or Salt Lake City. The passenger from Chicago would not have to get off the plane, and would only have about 30-45 minutes added to their trip for the stopover on their way to a farther destination. Thus Southwest does not have true hub operations, while covering most of the country. Therefore, it's unclear where it might want to best use HSR, if at all, since it does a lot of route-chaining. And the one major market it has yet to enter is Atlanta, which it will do with its purchase of AirTran. Doing so would also give it access to other smaller markets as well, further eliminating the potential desire to use HSR to either open gates or add new destinations. However, given the immense volume of flights traveling up the coast of California, Southwest could use HSR to supplement some of its operations, opening up gates to fly to further distances. For example, it could add direct service from any of its California cities to places like Milwaukee, Minneapolis, Kansas City, Indianapolis, etc.

Chapter 10: Best Practices to Ensure Beneficial Cooperation

Europe and Asia have had HSR service for decades, and given the case studies explored, a variety of lessons have been learned from existing integration between air travel and HSR when it comes to cooperation. The following are the primary lessons learned, and should be given great consideration when considering potential linkages with airports. A failure to do so, and too great of focus on cost, could dramatically reduce the likelihood of cooperation, leading to greater competition and underutilization of airport stations as a feeder service.

SEAMLESS INTEGRATION

As ACRP Report 31 notes, "[Customers] want to have smooth and reliable transfers between two segments of their journey without paying attention to the 'modes' involved" (2010). The level of integration between the airport and the HSR station is crucial for this seamless intermodal success. As the case studies showed, the airports with the greatest level of cooperation – namely Frankfurt and CDG – have some of the most seamlessly integrated HSR stations of the airports surveyed. This intuitively makes sense, as why would a passenger choose to exit the airport, ride a shuttle or other people-mover to a train station, go through more security (although likely less obstructive than at the airport) and wait for a train that is not scheduled according to the flights at the airport when instead they can simply move a few gates down and take a connecting flight. Of course this comparison is heavily simplified and ignores the fact that the HSR service might give better access to the destination city, but the pain of transfer cannot be ignored. Like water or electricity, humans generally travel the path of least resistance, and that is precisely what the International Air Transport Association (IATA) found in a survey of Europeans using integrated HSR services at airports. When passengers were asked why

they were not using HSR before/after their flight (other than the fact that there was no HSR service), the top response was connectivity issues. Furthermore, connectivity was the top response for what could be best improved with air and HSR integration services (Givoni and Banister, 2007).

The general theme amongst the top integrated airports in the world is that the station is a part of the airport. Thus there is no connection service that the passenger must use. The top airports have their station located under the main terminal, making the time and effort to transfer even shorter. This also benefits those with mobility limitations, as elevators and escalators can more easily and quickly transfer those passengers. *Illustration 10.1*, obtained from Frankfurt airport's website, highlights Frankfurt's airport layout as a model setup below the terminal.

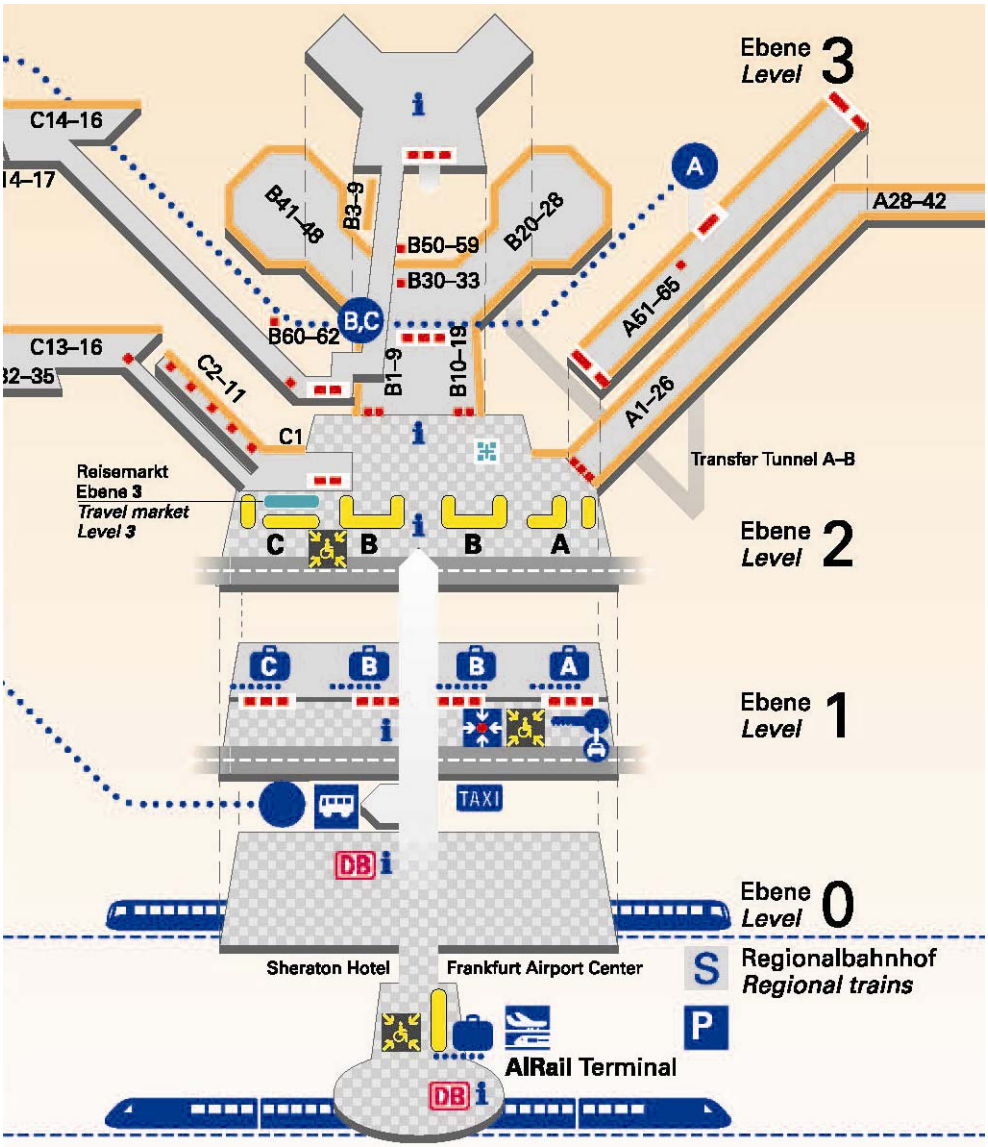

Illustration 10.1: Frankfurt Airport Terminal

Another ideal practice is to integrate baggage operations, although this is even rare in Europe. The likely issue here is that HSR trains normally do not have baggage compartments, rather the passenger is responsible to place the luggage in the riding area. Only Zurich and Hong Kong have such integration, but it is something that could be addressed at the very start of developing HSR in the US. Doing so would make the

transfer feel even more like a connecting flight, which is the ultimate goal when aiming for cooperation.

Last is the issue of security, which has not been addressed much in the current literature, and will not be heavily dissected in this report, as it could be a stand-alone topic itself. The primary reason for this lack of study is that it is unclear how security will be handled in the US. For cooperation, the ideal situation is that HSR service has the same level of security assurance that airports have, as this would allow stations to be built beyond the security check-point. This, plus baggage integration, would give the ultimate level of seamless integration between the modes, creating little to no difference in transferring versus a feeder flight. However, one of the prominent benefits marketed by many of the HSR plans is that HSR will have shorter security waits than at airports. This seems to suggest a different security practice for HSR. Or it could simply mean that there will be shorter waits at non-airport stations because most passengers would not be bringing on large amounts of complex luggage. This would be the ideal scenario, as it would allow for no additional security clearance for transferring passengers at airports.

FREQUENT SERVICE

Simply providing HSR service to an airport is not sufficient to reducing flight volumes at airports and facilitating cooperation. As ACRP Report 31 points out, frequent train service was one of the main reasons why the Frankfurt-Cologne route saw HSR take 100% of the air-rail market (2010). Furthermore, many of the European airports that do have cooperative air-HSR services have a large number of trains providing service. Again, this is somewhat intuitive, as passengers would not choose HSR over air if they must wait longer for a train versus a connecting flight. Furthermore, the HSR service should be coordinated with the flight schedules as much as possible in order to mimic the

same sort of coordination with feeder flights, making the change of modes even less noticeable to passengers.

CUSTOMER PERCEPTION

Givoni and Banister point out that the appearance of integration is important to passengers, as they do not want it to seem like they are being inconvenienced in making a transfer. Thus they suggest that the best location for an airport station is below the airport (2007). Placing the station in the airport essentially makes the transfer less noticeable, giving the perception that it is more or less a connecting flight. The less the passenger notices means that the passenger is less likely to feel inconvenienced.

Marketing is also a major element of cooperation. The two most successful cooperation efforts (Germany and France) heavily promote their services on their HSR websites and on the airport websites. Furthermore, the airlines involved at those locations also heavily promote their cooperative services and typically make it easy to purchase an integrated flight-rail itinerary. Buying a ticket on Lufthansa to Cologne appears just like any normal purchasing operation. Just like connections at airports being a point of conflict due to additional energy and thought needed to transfer, it's important that purchasing an integrated itinerary does not differ from purchasing a normal all-air ticket. However, it is probably best to inform the passenger that a segment is via train, as this will help with making the transfer less confusing.

NETWORK ALIGNMENT

Givoni and Banister also point out that where the airport station lies on the overall HSR network is important for cooperation. The reason is that the passenger should not have to make a transfer at an intercity station in order to reach their final destination. In that case, the HSR is acting more like a transit line to an HSR station than an HSR line

itself. They point out that HSR lines likely converge at a central city station, and that this convergence should occur at the airport and remain consolidated through the city's station before diverging to different markets. This way all of the HSR servicing the city is also available at the airport, making additional transfers unnecessary. Thus, branch lines to airports are highly discouraged (2007). Preliminary plans for Denver's HSR system has DIA as a spur station, which could hurt its chances as a cooperative system should it become a viable market to do so. *Illustration 10.2* depicts a converging network versus a spur line.

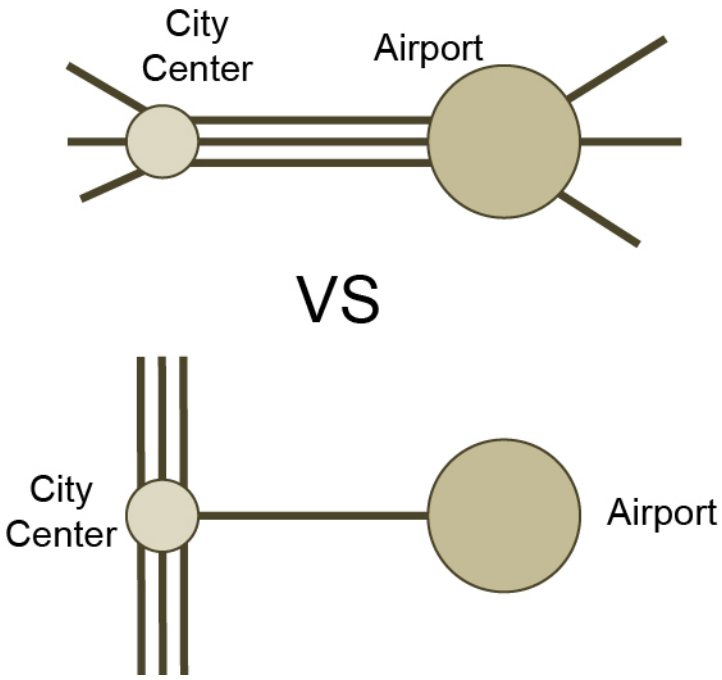

Illustration 10.2: Converging Network vs. Spur Line

AIRPORT SELECTION

Essentially all of the literature noted that cooperation can only truly be expected and encouraged at large hub airports. This is further supported by the stark differences in success between CDG in Paris and the integration at Lyon. When it comes to

cooperation, HSR service at airports essentially needs to operate like a spoke of the hub's feeder network, or be a hub itself. Passengers will not ride to a non-hub airport (A to B), transfer, and then fly to a hub only to transfer again when they can instead travel from their local airport or train station to the hub (A to Hub) and make the connection. *Illustration 10.3* depicts this scenario (Coogan, Diridon, and Ban Beek, 2011). The only time this might work is if the non-hub airport has so many direct flights due to a large number of servicing airlines that it almost acts like a generalized hub airport.

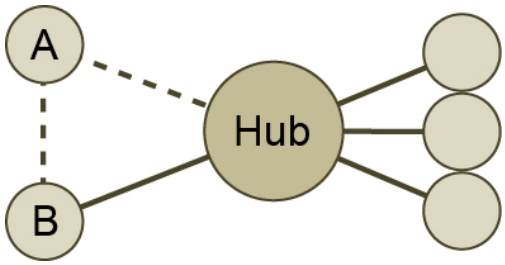

Illustration 10.3: Example of the Airport Selection Problem

CONCLUSION

The US has a unique opportunity at hand. It is currently planning and developing a completely new mode of travel, but one that has existed in other parts of the world for decades. This poses an unusual opportunity to observe how other locations have successfully implemented HSR service, and more specifically, how air travel and HSR service can provide complimentary operations.

Europe has displayed that air travel and HSR can have successful cooperative relationships. Both Frankfurt and Paris have shown that HSR can provide relief to congested airports, while giving users another modal choice without losing any level of service. However, some key factors must be involved in order for such a relationship to be successful. Elements such as station location, network alignment, and train frequency all must be addressed in order to achieve the primary successful factor for cooperative relations: customer ease of use. Without this, the demand and use of programs such as code-sharing with airlines will not work.

Furthermore, analysis of airports in the US has shown that HSR could in fact help with congestion, while giving travelers more choice. Places such as California, the northeast, and Chicago could utilize HSR to supplement their long-haul flights, while other airports could establish themselves as a larger transfer node to large metros. Cooperation could also help airlines expand their network, whether it's creating a hub-like system by using HSR or adding more long-haul flights in place of short-haul flights, thus increasing their profitability.

This report has laid the groundwork for further analysis of the potential cooperation between the two modes. Additional research could look at passenger flows, how many flights and passengers are using major airports for connections and where

those connections are, the potential rate of passengers that would use HSR as a connector service, and what cost savings exist for each stakeholder – notably the airlines. This report initially set out to interview the airlines to find out their opinion on the possibility of cooperation, but the topic's current climate appears to be too controversial, and thus there were no responses. However, this may change as HSR projects eventually get built, and further attempts at discussions with the airlines should be attempted. Lastly, further analysis of the potential impacts of the FAA's NextGen program should be better considered in any modeling and assumptions when it comes to predicting usage rates of HSR with air service, as it is still unclear how much NextGen might benefit US air travel.

In the end, the key to a successful cooperative relationship between air travel and HSR will require dedication from the airline industry and those planning HSR's future in the US. Federal guidance over the years has varied in terms of integrating the two modes, while many of the HSR plans that do this usually fail to incorporate either the best airport choice or do not fully integrate the station with the airport. This has been shown in Europe to limit the success of airport-HSR integration. A failure to not court airline passengers, and make their transition to or from the train/plane seamless, could leave a large user group out of the pool of potential HSR riders. Given recent contention over whether HSR will work in the US, the need to target all potential passengers is ever more important. Incorporating air travelers rather than only trying to divert them will open HSR up to passengers from areas away from the HSR network, and provide a steady and sustainable passenger base rather than hoping for travelers to divert their travel patterns. This in turn will help HSR travel be successful overall in America, and hopefully lead to an even more extensive network than what is currently planned, giving citizens more choice in how they travel.

APPENDICES

The following appendices provide the relevant data used to help determine which airports would best enable cooperation, and benefit from it.

Appendix A: 2009 Enplanements for Selected Airports

(FAA, 2009)

Airport	Enplanements	Airport	Enplanements
Atlanta (ATL)	42,280,868	Washington-Dulles (IAD)	11,132,098
Chicago-O'Hare (ORD)	31,135,732	New York City-La Guardia (LGA)	11,084,300
Los Angeles (LAX)	27,439,897	Baltimore (BWI)	10,338,950
Dallas-Ft. Worth (DFW)	26,663,984	Ft. Lauderdale (FLL)	10,258,118
Denver (DEN)	24,013,669	Salt Lake City (SLC)	9,903,821
New York City-JFK (JFK)	22,710,272	Washington-Reagan National (DCA)	8,490,288
Las Vegas (LAS)	19,445,952	San Diego (SAN)	8,453,854
Houston-Intercontinental (IAH)	19,290,239	Tampa (TPA)	8,263,294
Phoenix-Sky Harbor (PHX)	18,559,647	Chicago-Midway (MDW)	8,253,620
San Francisco (SFO)	18,467,908	Portland (PDX)	6,430,119
Charlotte (CLT)	17,165,376	St. Louis (STL)	6,084,070
Newark (EWR)	16,659,441	Cincinnati (CVG)	5,194,214
Orlando (MCO)	16,371,016	Memphis (MEM)	5,054,191
Miami (MIA)	16,187,768	Kansas City (MCI)	4,894,349
Minneapolis-St. Paul (MSP)	15,551,206	Cleveland (CLE)	4,704,329
Seattle (SEA)	15,273,092	Oakland (OAK)	4,612,631
Detroit (DTW)	15,211,402	Los Angeles-Santa Ana (SNA)	4,311,329
Philadelphia (PHL)	15,002,961	Milwaukee (MKE)	3,822,542
Boston (BOS)	12,566,797		

Appendix B: Flight Operations for Selected Airports

(FAA, 2009 and 2010)

Airport	2009 Flights	% w/in 500 Miles	2009 Rank	2020 Rank	2030 Rank
Atlanta (ATL)	978,084	37%	1	1	1
Chicago-O'Hare (ORD)	881,566	32%	2	2	2
Los Angeles (LAX)	622,506	27%	5	3	3
Dallas-Ft. Worth (DFW)	655,306	23%	3	5	7
Denver (DEN)	625,844	14%	4	4	4
New York City-JFK (JFK)	446,968	21%	13	10	9
Las Vegas (LAS)	578,946	29%	7	7	5
Houston-Intercontinental (IAH)	578,288	23%	6	8	8
Phoenix-Sky Harbor (PHX)	500,525	27%	10	12	14
San Francisco (SFO)	387,970	28%	15	15	15
Charlotte (CLT)	537,598	43%	8	6	6
Newark (EWR)	442,097	23%	14	16	18
Orlando (MCO)	343,400	16%	23	18	16
Miami (MIA)	371,519	6%	20	17	17
Minneapolis-St. Paul (MSP)	449,972	24%	11	14	13
Seattle (SEA)	345,057	13%	22	21	21
Detroit (DTW)	463,784	46%	12	11	12
Philadelphia (PHL)	492,038	39%	9	9	10
Boston (BOS)	375,390	32%	18	22	23

Airport	2009 Flights	% w/in 500 Miles	2009 Rank	2020 Rank	2030 Rank
Washington-Dulles (IAD)	391,626	32%	17	13	11
New York City-La Guardia (LGA)	384,080	42%	19	23	26
Baltimore (BWI)	272,516	48%	26	25	24
Ft. Lauderdale (FLL)	295,665	7%	25	24	22
Salt Lake City (SLC)	389,457	18%	16	19	20
Washington-Reagan National (DCA)	277,921	56%	24	28	30
San Diego (SAN)	226,157	47%	35	30	29
Tampa (TPA)	237,885	24%	34	29	28
Chicago-Midway (MDW)	267,520	26%	27	26	25
Portland (PDX)	252,053	21%	28	27	27
St. Louis (STL)	247,639	47%	30	32	35
Cincinnati (CVG)	286,068	50%	29	40	42
Memphis (MEM)	362,978	36%	21	20	19
Kansas City (MCI)	176,703	41%	44	44	45
Cleveland (CLE)	235,969	60%	33	33	32
Oakland (OAK)	227,025	32%	38	41	38
Los Angeles-Santa Ana (SNA)	226,478	25%	31	34	33
Milwaukee (MKE)	183,175	39%	43	36	34

Appendix C: Airports with FAA Predicted Capacity Concerns With and Without Anticipated Improvements

(The MITRE Corporation and FAA, 2007)

Airport	2015	2015 (w/out)	2025	2025 (w/out)
Atlanta (ATL)			■	■
Chicago-O'Hare (ORD)		■		■
Los Angeles (LAX)				■
Dallas-Ft. Worth (DFW)				
Denver (DEN)				
New York City-JFK (JFK)		■	■	■
Las Vegas (LAS)		■	■	■
Houston-Intercontinental (IAH)		■		■
Phoenix-Sky Harbor (PHX)		■	■	■
San Francisco (SFO)			■	
Charlotte (CLT)		■		■
Newark (EWR)	■	■	■	■
Orlando (MCO)				
Miami (MIA)				
Minneapolis-St. Paul (MSP)				■
Seattle (SEA)				■
Detroit (DTW)				
Philadelphia (PHL)	■	■	■	■
Boston (BOS)				■

Airport	2015	2015 (w/out)	2025	2025 (w/out)
Washington-Dulles (IAD)				■
New York City-La Guardia (LGA)	■	■	■	■
Baltimore (BWI)				
Ft. Lauderdale (FLL)		■	■	■
Salt Lake City (SLC)				
Washington-Reagan National (DCA)				
San Diego (SAN)			■	
Tampa (TPA)				
Chicago-Midway (MDW)		■	■	■
Portland (PDX)				
St. Louis (STL)				
Cincinnati (CVG)				
Memphis (MEM)				
Kansas City (MCI)				
Cleveland (CLE)				
Oakland (OAK)	■	■	■	■
Los Angeles-Santa Ana (SNA)	■	■	■	■
Milwaukee (MKE)				

Appendix D: 2009 Top 20 Flight Volumes Between Selected Airports and Their Regional Airport Pairs (<= 500 miles)

(Bureau of Transportation Statistics – TransStats, 2009)

To/From ATL		To/From ORD		To/From LAX		To/From DFW	
MCO	22,716	MSP	20,581	SFO	29,019	SAT	11,150
TPA	16,522	DTW	15,589	SAN	22,046	AUS	11,145
CLT	16,325	STL	14,211	LAS	21,423	IAH	11,093
DCA	15,305	CVG	13,405	PHX	16,507	LIT	8,282
BWI	13,914	CLE	12,719	SJC	14,353	MEM	7,143
JAX	12,931	IND	12,110	OAK	12,149	HOU	6,704
IAD	12,825	CMH	10,887	SMF	8,960	SHV	6,621
MEM	12,633	CID	9,496	FAT	8,189	LBB	6,549
STL	11,939	MEM	9,215	TUS	6,969	ELP	6,126
RDU	11,452	MSN	9,212	RNO	4,532	JAN	6,041
MSY	11,238	DSM	9,138	BFL	1,974	CRP	5,999
IND	10,114	MCI	8,752	STS	1,370	TUL	5,899
RSW	10,043	MKE	8,449			BTR	5,800
RIC	9,974	SDF	8,286			MCI	5,730
PIT	9,727	GRR	8,282			SGF	5,655
DAY	9,384	BNA	8,193			AMA	5,531
PHF	9,226	OMA	7,706			OKC	5,229
BHM	8,568	PIT	6,952			ABI	5,111
BNA	7,946	GRB	6,612			MSY	4,557
SDF	7,738	BUF	6,338			ACT	3,199

To/From DEN	
SLC	20,022
COS	12,370
MCI	11,534
OMA	9,221
ABQ	9,216
OKC	7,521
TUL	5,176
ICT	4,734
FSD	2,798
LNK	2,083
PUB	1,773
AMA	1,409
GRI	162

To/From JFK	
BOS	16,133
DCA	9,103
BUF	9,086
RDU	8,883
IAD	8,867
ROC	6,061
SYR	5,280
PIT	5,125
RIC	4,765
DTW	3,383
BWI	3,104
CLE	2,788
ORF	2,549
CMH	2,140
BDL	1,599
PHL	1,563
PVD	180

To/From LAS	
LAX	21,423
PHX	17,408
SFO	17,147
SAN	10,914
SLC	10,901
BUR	9,671
SNA	8,434
RNO	8,092
SJC	7,451
OAK	7,277
SMF	6,978
ONT	6,224
ABQ	4,306
FAT	4,228
TUS	3,529
LGB	1,621
BOI	1,460
STS	730
SCK	412

To/From IAH	
DFW	11,093
MSY	8,039
SAT	7,365
MEM	7,254
AUS	7,237
CRP	6,858
BTR	6,687
LFT	6,437
OKC	5,981
TUL	5,916
DAL	5,713
MFE	5,134
SHV	4,980
LIT	4,051
BRO	3,902
MOB	3,689
HRL	3,520
JAN	3,324
LBB	3,303
BPT	3,269

To/From PHX	
LAS	17,408
LAX	16,507
SLC	14,049
SAN	13,571
SNA	10,886
ABQ	10,500
ONT	9,966
BUR	8,895
ELP	7,610
TUS	7,323
LGB	2,939
FAT	2,879
BFL	2,330

To/From SFO	
LAX	29,019
LAS	17,147
SAN	15,577
SNA	11,751
SMF	5,091
FAT	4,693
EUG	4,462
BUR	3,965
RNO	3,624
MOD	3,367
ONT	2,747
LGB	2,144
BFL	1,827

To/From CLT	
ATL	16,325
EWR	11,651
BWI	9,110
IAD	7,603
DCA	7,524
PHL	7,511
DTW	7,458
MEM	7,384
MCO	6,691
RDU	6,527
CLE	6,427
CVG	6,110
ORF	6,006
IND	5,962
GSO	5,848
RIC	5,732
TYS	5,724
SAV	5,697
BNA	5,691
TPA	5,659

To/From EWR	
CLT	11,651
DTW	8,651
BOS	7,837
IAD	7,642
PHL	5,320
DCA	5,189
PIT	5,094
RDU	4,730
CLE	4,138
BWI	4,006
CMH	3,962
BUF	3,942
ROC	3,596
ORF	3,493
RIC	3,399
SYR	3,142
PVD	3,108
BDL	2,902
MHT	2,786
GSO	2,764

To/From MCO	
ATL	22,716
MIA	7,234
CLT	6,691
FLL	5,563
RSW	2,796
TLH	1,727
BHM	1,494
CAE	347

To/From MIA	
MCO	7,234
TPA	6,488
JAX	3,250
TLH	2,109
RSW	1,522
SAV	730
FLL	216
PBI	195

To/From MSP	
ORD	20,581
MKE	12,387
MDW	10,923
DTW	8,715
STL	8,111
OMA	4,852
FSD	4,838
MCI	4,802
DSM	4,506
IND	4,364
MSN	3,775
GRR	3,762
CID	3,465
GRB	3,399
LNK	2,574
PIA	2,064
SBN	730
FNT	599
LAN	485
FWA	458

To/From SEA	
PDX	20,655
GEG	15,797
BOI	3,136
EUG	2,128

To/From DTW	
ORD	15,589
PHL	10,152
LGA	10,074
EWR	8,651
MDW	8,223
DCA	7,830
CLT	7,458
BWI	6,706
IAD	6,007
GRR	5,625
BNA	5,559
STL	5,494
IND	5,476
CVG	4,809
CMH	4,267
FNT	4,216
LAN	4,176
PIT	3,882
MKE	3,754
SBN	3,679

To/From PHL	
BOS	12,329
DTW	10,152
LGA	10,128
PIT	9,764
RDU	9,257
MHT	8,787
PVD	8,725
DCA	7,846
CLT	7,511
CLE	7,299
CVG	6,722
BWI	6,095
ORF	5,991
BDL	5,596
RIC	5,330
EWR	5,320
CMH	5,283
BUF	5,219
SYR	5,154
ROC	4,491

To/From BOS	
LGA	22,629
DCA	18,815
JFK	16,133
BWI	13,422
PHL	12,329
IAD	8,334
EWR	7,837
BUF	4,575
PIT	4,411
RIC	2,771
ROC	2,132
SYR	1,971
PHF	1,717

To/From IAD	
ATL	12,825
JFK	8,867
BOS	8,334
EWR	7,642
CLT	7,603
DTW	6,007
LGA	5,278
ORF	3,932
PIT	3,642
RDU	3,626
CMH	3,488
CAE	3,096
RIC	2,953
PHL	2,936
BUF	2,917
PVD	2,915
ABE	2,876
IND	2,871
GSO	2,816
ROC	2,589

To/From LGA	
BOS	22,629
DCA	18,708
RDU	14,467
CMH	10,310
PHL	10,128
DTW	10,074
CLE	6,747
BUF	6,376
BWI	6,355
PIT	6,321
IAD	5,278
SYR	5,169
RIC	4,987
ROC	4,760
ORF	4,530
GSO	3,980
PVD	3,299
MHT	2,894
CAK	1,739
PHF	1,700

To/From BWI	
ATL	13,914
BOS	13,422
CLT	9,110
PVD	6,822
DTW	6,706
MHT	6,556
LGA	6,355
PHL	6,095
BDL	5,385
CLE	5,260
BUF	4,636
ROC	4,356
ISP	4,314
RDU	4,175
EWR	4,006
DAY	3,867
CMH	3,366
SDF	3,270
JFK	3,104
ORF	3,079

To/From FLL	
TPA	7,390
MCO	5,563
JAX	3,354
TLH	2,580
MIA	216

To/From SLC	
DEN	20,022
PHX	14,049
LAS	10,901
BOI	8,193
ABQ	4,423
RNO	4,030
SMF	3,493
COS	1,732
FAT	1,588

To/From DCA	
BOS	18,815
LGA	18,708
ATL	15,305
RDU	9,666
JFK	9,103
PHL	7,846
DTW	7,830
CLT	7,524
IND	5,513
EWR	5,189
PIT	3,926
CVG	3,703
CLE	3,590
PVD	3,422
CMH	3,368
BDL	3,275
SYR	2,637
DAY	2,418
HPN	2,418
ORF	2,317

To/From SAN	
LAX	22,046
SFO	15,577
PHX	13,571
LAS	10,914
OAK	9,495
SJC	9,155
SMF	8,340
TUS	2,368
RNO	1,455
ONT	232

To/From TPA	
ATL	16,522
FLL	7,390
MIA	6,488
CLT	5,659
TLH	3,012
PBI	2,667
MSY	2,123
JAX	1,954
BHM	1,445

To/From MDW	
MSP	10,923
DTW	8,223
MCI	6,971
STL	6,774
BNA	5,051
CLE	4,712
CMH	4,689
OMA	3,943
PIT	3,942
SDF	3,354
BUF	2,751
IND	2,668

To/From PDX	
SEA	20,655
SMF	7,148
EUG	5,929
GEG	5,872
BOI	4,870
RNO	2,222
STS	730

To/From STL	
ORD	14,211
ATL	11,939
MSP	8,111
MDW	6,774
DFW	6,248
DTW	5,494
DAL	5,159
MKE	3,833
MCI	3,434
IND	3,062
CLE	2,806
CVG	2,724
OKC	2,699
MEM	2,677
TUL	2,275
BNA	2,105
DSM	2,088
OMA	2,022
SDF	1,975
MSN	1,347

To/From CVG	
ORD	13,405
PHL	6,722
CLT	6,110
DTW	4,809
ATL	4,769
MEM	3,748
DCA	3,703
CMH	3,548
SDF	3,523
IND	3,442
LEX	3,199
BWI	2,916
RDU	2,804
PIT	2,770
STL	2,724
MKE	2,596
BNA	2,579
IAD	2,514
RIC	2,274
GSO	2,169

To/From MEM	
ATL	12,633
ORD	9,215
CLT	7,384
IAH	7,254
DFW	7,143
IND	3,887
SDF	3,858
CVG	3,748
MSY	3,523
TYS	3,340
DSM	3,269
MCI	3,265
TUL	3,159
SHV	3,131
ICT	3,042
OKC	2,938
TLH	2,899
BHM	2,894
BNA	2,775
STL	2,677

To/From MCI	
DEN	11,534
ORD	8,752
MDW	6,971
DFW	5,730
DAL	5,401
MSP	4,802
MKE	4,338
STL	3,434
MEM	3,265
BNA	2,361
IND	1,766
OKC	1,573
GRI	1,445
SDF	517
TUL	258

To/From CLE	
ORD	12,719
ATL	7,837
PHL	7,299
LGA	6,747
CLT	6,427
BWI	5,260
MDW	4,712
EWR	4,138
MKE	4,126
IND	4,019
DCA	3,590
DTW	3,484
ERI	2,862
STL	2,806
JFK	2,788
SDF	2,779
PIT	2,754
CMH	2,553
BUF	2,549
GRR	2,444

To/From OAK	
LAX	12,149
BUR	9,938
SAN	9,495
ONT	7,698
LAS	7,277
SNA	5,923
RNO	2,652
LGB	2,187
BOI	1,327
STS	653
FAT	537
EUG	119

To/From SNA	
SFO	11,751
PHX	10,886
SJC	9,379
LAS	8,434
OAK	5,923
SMF	4,761

To/From MKE			
MSP	12,387	GRR	2,605
ORD	8,449	CVG	2,596
MCI	4,338	CMH	2,558
CLE	4,126	GRB	2,221
STL	3,833	FNT	2,164
DTW	3,754	DSM	1,969
PIT	2,809	BNA	1,838
IND	2,663	DAY	1,150
MSN	2,616	SDF	1,018
OMA	2,609		

Appendix E: 2009 Top 25 Airport-to-Airport and Hub Airport-to-Major Metro with More than One Airport Flight Volume Pairs

(Bureau of Transportation Statistics – TransStats, 2009)

Airport-to-Airport			*Hub Airport-to-Major Metro*		
Airport 1	**Airport 2**	**Flights**	**Hub**	**Major Metro**	**Flights**
LAX	SFO	29,019	LAX	San Francisco	55,521
ATL	MCO	22,716	SFO	Los Angeles	49,626
BOS	LGA	22,629	PHX	Los Angeles	49,193
LAX	SAN	22,046	LAS	Los Angeles	47,373
LAS	LAX	21,423	BOS	New York City	46,599
PDX	SEA	20,655	ATL	Washington DC	42,044
MSP	ORD	20,581	BOS	Washington DC	40,571
DEN	SLC	20,022	OAK	Los Angeles	37,895
BOS	DCA	18,815	SAN	San Francisco	34,227
DCA	LGA	18,708	DCA	New York City	33,000
LAS	PHX	17,408	LAS	San Francisco	31,875
LAS	SFO	17,147	MSP	Chicago	31,504
ATL	TPA	16,522	LGA	Washington DC	30,341
LAX	PHX	16,507	SNA	San Francisco	27,053
ATL	CLT	16,325	CLT	Washington DC	24,237
BOS	JFK	16,133	DTW	Chicago	23,812
SEA	GEG	15,797	SAN	Los Angeles	22,278
DTW	ORD	15,589	DTW	New York City	22,108
SAN	SFO	15,577	IAD	New York City	21,787
ATL	DCA	15,305	JFK	Washington DC	21,074
LGA	RDU	14,467	STL	Chicago	20,985
LAX	SJC	14,353	DTW	Washington DC	20,543
ORD	STL	14,211	DFW	Houston	17,797
PHX	SLC	14,049	CLE	Chicago	17,431
ATL	BWI	13,914	PHL	New York City	17,211

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