The Vital Role of Metropolitan Access in Intercity Passenger Transportation

From the Traditional Limited-Stop Express to the 21st Century Ring Railroad

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1. ABSTRACT

Carriers in intercity passenger transportation markets employ a different set of technologies with diverse characteristics. Potentially, the ease of access is an important competitive advantage for rail carriers. In major metropolises, the downtown business district is physically too large to be served effectively with a single station. Thus, a series of stations are required for effective rail service, just as an urban expressway requires more than a single exit downtown to be effective. The local distribution mechanisms can be an important driver in intercity mode choice, since it affects the utility of the overall "trip experience", especially in a competitive situation where the overall origin-to-destination time for a selection of intermodal itineraries are similar. A loop is an effective layout for servicing the demand and for operational reasons, although in some cities other layouts are more effective. The conventional wisdom of concentrating passenger operations at a union station is misleading since in the typical city of more than two million population, much demand originates from suburban business districts and homes – where the airport is more accessible. Case studies show that effective downtown rail loops may reduce origin-to-destination journey times on the order of 15~20 minutes, which is roughly equivalent to increasing average line-haul speed from 120 to 168 km/h (80mph to 105mph) over a 160-km (100-mile) segment. Effective downtown access may be much more leveraged than increasing maximum permissible speed.

2. INTRODUCTION

Intercity Passenger Transportation is, at best, a limited commodity market. Carriers employ various sets of technologies – railroad, highway, aviation, hovercraft – each with different characteristics and addressing the needs of a different market segment. Besides speed or cost, there are a multitude of performance measures all of which can be turned into a competitive advantage for a given mode or carrier. This paper examines the circumstances under which the accessibility to a given mode can become one such advantage. Specifically, how can the layout of railroads and location of intercity stations within the high-density downtown area contribute towards the railroad's ability to compete for intercity passengers?

Traditionally, intercity trains have departed from a single downtown 'union' station while airplanes have departed from an out-of-town airfield. The inherent technological constraint in aviation is that while they offer low end-to-end journey times, much land is required for a terminal and thus it is impractical to site them in high-density areas. The consolidated downtown terminal offered good access for high-density central business districts in large cities of up to perhaps 1 million in population. However, with the development of suburban business districts and multi-clustered downtown centers in major metropolises such as Tokyo or Los Angeles, the downtown terminal may be unable to realize the full market potential. There is widespread recognition within the industry that access to the city-centre can be an important part of any high-speed rail scheme. In Britain, it is documented *(1)* that upgrades to the "classic" lines which provide access from the downtown to new high-speed cut-offs are an expensive but necessary part of the passenger rail vision. What is not widely recognized is that a large proportion of intercity trips originates from the greater metropolitan area, thus urban distribution can be just as important as downtown access. Traditionally, urban distribution has been left firmly in the domain of local transit authorities and private bus operators. This institutional divide often led to counter intuitive routings by public transportation, making the do-it-yourself private auto approach much more attractive than it otherwise would be.

Already, airports are taking advantage of the sheer size of some cities to provide a distributed service. London's Gatwick, Heathrow and Stansted airports all feature services to Edinburgh, and those residing north of London are more likely to fly via Stansted than those residing in the south. Distributed rail terminals in a congested city may be provided by railroads in a variety of layouts: lines travelling through the city independently, lines joining an inner urban ring, or a combination of both. Ultimately, the constraining geographic features in a city and the distribution of densely populated areas will determine which scheme is the best, although the ring railroad concept offers good performance for relatively low cost. This is not a suburban ring – the ring must have a small radius. The inherent advantage of downtown access to rail terminals disappear if the stations on the ring are not within walking distances of the densely packed city centers. Station amenities are critical – luggage stowage, taxicab services, stores and restaurants are available at most airports. Multiple full-service downtown stations are needed.

In the suburban "non-walkable neighbourhoods", there is insufficient density for effective rail service *(2)*. Thus, strategically-located Park & Rides (parkway stations) are more important. Parkway stations should be located such that they are closer to the demand generators than the airport, even if it means detouring the rail line. Car-hire and car-sharing facilities are needed. Conceivably, an argument could be made that every city with a relatively high urban density and a population of more than two million should have a downtown rail distribution mechanism – a ring railroad, or simply a series of stations on one common trunk route through the city.

Effective local distribution mechanisms are a leveraged area with respect to performance of intercity passenger systems. Experience with the South Shore Line in Indiana demonstrates that decreasing terminal accessibility (elimination of street-running and local drop-off) can have dramatic negative impacts on intercity ridership *(3)*. Conversely, despite longer journey times, the North Shore Line remained competitive against the Hiawathas as it offered much better access to downtown Chicago via the elevated loop *(4)*. As with overnight services, the vehicle costs are insignificant when compared with the infrastructure costs (in many cases the service plan would utilize turn-around times in the existing fleet). Thus, the leveraged technologies are infrastructure related. New construction methods are needed to allow cheaper tunnels and elevated rail lines with lesser environmental impacts, so that infrastructure could be retro-fitted to congested downtown areas. New rolling stock technologies, such as distributed power & brake, higher power-to-weight ratio, and lower emissions from diesel power plants may allow intercity express trains to perform better in start-stop runs and underground. High-performance switches and crossings could allow greater stability and higher speeds in highly constrained geometries, e.g. a novel method of vehicle guidance over turnouts, such as a third contact point or a non-contact system. Cheaper and more reliable train-control technologies will allow increased train-densities on congested downtown distributor lines. Rapid-transit type signalling principles adapted for compatibility with the traditional railroad systems may hold promise.

On the marketing side, enhanced decision-support and data-collection systems can assist service design and analytically determine optimal stopping patterns for local and express trains. Seamless ticketing technology for intermodal trips will allow easier transfers, making high-speed rail an integral part of the wider transportation network. Finally, innovative door designs and luggage handling facilities will minimize station dwell times – which will become increasingly important due to the additional station stops the intercity passenger train would make on a loop.

3. COMPETITIVE UTILITY ANALYSES – HOW TO BEAT 'EM AT THEIR GAME

Before embarking on a detailed utility analysis, it is useful to conduct a strategic analysis for each type of intercity passenger transportation technology. Given a reasonable "high-speed" intercity rail system with average speeds between 144 and 200 km/h (90mph and 125mph), it is clear that in the corridor market (320-960 km, 200-600 miles), the aviation industry will always have a speed advantage, while the private auto will continue to be more accessible. How can rail operators defend its market position?

Table 1 catalogues the historical development of urban railroad layouts throughout the 20th century and beyond, and compares the competitiveness of rail service against the state of the art in other modes. The union station is largely a product of the pre-war era, when the only effective competition was the electric interurban. Against present-day auto and air, it has little advantage. As the railroads progressed towards the parkway station concept, shorter access time for those living near the parkway station resulted, gaining a competitive advantage for a limited market segment.

Technology changes that will reduce the airplane's advantage in journey times are likely to be very expensive, but rail can succeed by attacking the technology's inherent weakness of requiring a large airfield by advancing towards a multi-hub network. The enhanced accessibility for rail also happens to reduce the private auto's strength in offering convenient access. Although the intercity train will never be as convenient as the auto, an intermodal solution based on short-distance feeder limousines can reduce the auto's advantage to virtually nothing. Then, with the interstate highway system (both autos and buses), rail is able to compete on the grounds of lower overall journey time and comfort; while competing on the grounds of cost and accessibility with the aviation industry.

3.1 In Vehicle Time Versus Out-of-Vehicle Time

It has long been known in transit demand modelling that in-vehicle time is preferable to out-of-vehicle time, especially where the terminal amenities are either nonexistent or excessively expensive *(5)*. In an origin-to-destination trip analysis for an intercity traveller, the trip may involve many modes and multiple transfers. If some of these transfers and the associated waiting times can be eliminated, the utility of the intercity trip (and thus the competitiveness of the mode) could be dramatically improved. In addition, allowing the passenger to board the "line-haul" mode closer to the origin reduces the total trip time. Recent professional testimony suggested that the concept of one-seat-ride in Commuter Rail has a dramatic positive impact on ridership *(6)*. In addition, there are intangible effects of providing a sense of presence for the railroad, which can induce changes in trip generation and mode choice *(7)*. In short, better access for intercity trains offers a way for undesirable access time to be converted into more desirable in-vehicle time and reduces overall journey time.

3.1.1 The Base Case

Consider a typical leisure trip from an outer suburban home to an inner suburban destination in a nearby city (160~480 km, or 100~300 miles away). With a traditional, TGV-style point-to-point service, the typical trip would involve a drive (or a transit-ride) to a downtown union station (between 30 minutes to 1½ hours), some buffer time for access unreliability, a point-to-point ride (one to three hours), followed by a cab or transit ride from the rail terminal in the destination city (30 mins to 1½ hours). For trips of less than 300 miles, the extra time required for checking in and security screening offset the higher speed of the airplane. Here, the accessibility of rail and air are roughly equal. The airline has a slight advantage for origins and destinations closer to the airport (and the lesser-congested suburban areas), and the railroad has a slight advantage for origins and destinations closer to downtown (and the more congested city neighbourhoods). Most of the competition takes place on the line-haul leg, and customers make their mode-choice based on line-haul time and amenities offered. In this situation, rail technology is disadvantaged due to the high costs of infrastructure required to attain line-haul speeds competitive with the aircraft. The same argument also applies to a business trip from a suburban business office, even if the destination is close to downtown.

3.1.2 Why is Non-Stop Rail Competitive at All?

Why is rail competitive at all in those circumstances, as demonstrated by such flows as London-Edinburgh and Paris-Lyons? *(8)* The reason lies with different values of time associated with different modes *(9)*. Although rail takes longer, the greater degree of comfort offered by rail and the lower price-per-mile in some cases mean that a number of people will choose rail. In addition, crucially, rail allows the time spent on-board to be used productively; a business traveller can in fact generate value during this time, potentially giving rise to a higher utility despite the longer in-vehicle time. For the leisure traveller, this argument is less compelling, although most passengers ordinarily classified as "leisure" travellers for their lower willingness-to-pay are actually able to utilize the time productively. For instance, a college student may choose to review course materials, and a person visiting a friend may choose to write a letter or read a book en-route. All of the above activities may be preferable to making many transfers, waiting up to half-hour for each transfer, and spending time standing in line to clear security at an airport.

3.2 Parkway Stations and Their Impact

Parkway stations, usually located in the suburbs featuring drop-off drive-thrus and ample parking, was rail's first attempt to capture suburban travellers. Situated conveniently on an interstate beltway, the parkway station enlarges the market reach for rail out towards the suburbs on one side of the city. The parking is easier and cheaper (in terms of opportunity cost of land consumed). Certain parkway stations also serves as interface for the local transit system to reduce journey times for certain trips by allowing an outbound transit connection, rather than forcing everyone to connect through the downtown hub. This is the first step towards a decentralized network of stations to serve a large and congested metropolitan area.

3.2.1 Parkway is Quicker than the Base Case

Reconsider the trip discussed in the base case. Instead of having a difficult and possibly time-consuming drive (or transit ride) downtown, some travellers choose to drive along the beltway to the parkway station, avoiding downtown congestion and utilizing high-performance expressways, resulting in time savings. In addition, the line-haul journey time would be shorter because of reduced distance to travel. For its target market, parkway stations reduce access time, in-vehicle time, and may provide a better quality service on the access leg. (Table 2) It is therefore likely to expand the market reach of the intercity train.

However, from the perspective of utility analyses, the parkway station does the exact opposite of what we want to accomplish. The parkway station (out of town) exchanges comfortable line-haul time in a traincar for uncomfortable driving time. The total journey time is not reduced significantly except for a small sector of the metro area close by. With a taxicab, it can increase out-of-pocket costs considerably, due to increased mileage. The loss of the haul between the city center and the parkway station represents a lost business opportunity for the railroad. Had the railroad been more accessible from the origin, a longer haul and potentially more revenue could be attained (realizable from the decreased length-of-haul in the taxicab or the private auto, and thus less out-of-pocket costs for the traveller). Ideally, from a competitive standpoint, the nearest parkway station to every destination in the city should be more accessible than the nearest airport, to the extent permitted by the railroad alignment. Parkway stations offer airport-type ground access to those low-density parts of the city that could not be effectively served directly by rail. Nonetheless, many parts of megacities besides the downtown can support direct rail service, and this represents a business opportunity for the intercity rail carrier.

3.3 Accessibility of High Speed Rail in the Downtown Area

Many large cities[1], especially those with extensive commuter rail operations, have already realized that a single downtown terminal per line is insufficient to serve the diverse range of possible destinations for travellers. Consolidating rail travel demands at a single union station results in less competitive access times, except for a small market segment whose origins or destinations happen to fall within a relatively small radius of the downtown rail station. On the other hand, by having several downtown rail terminals, not only does the rail operator provide a larger geographic area with direct high speed rail service, it also remove some of the problems traditionally associated with a concentrated terminal – e.g. parking shortages and vehicular access congestion. Instead of merely providing intermodal transportation through connections to the local transit system, high speed rail may remove the transfers altogether and offer near door-to-door service in large cities with high demands. This is particularly important in the "walkable" neighbourhoods in the downtown area *(10)*. Although there are additional costs associated with providing multiple full-service union-style stations, there will also be higher revenues.

In a sense, the idea of making high speed rail more accessible in the downtown by installing additional stations is not new. The basic proposal is to match the supply of rail stations to the demand for rail stations by opening additional stations where the demand is concentrated, and closing stations where the demand isn't significant. The innovation lies with the realization that the conventional wisdom of consolidating demands for intercity travellers can cause more problems than it solves for rail. While the aviation industry is limited by the nature of its technology to consolidate demands from a metro area to an airport and a region to a hub, the railroad is not subject to the same limitations, and rail ought to exploit this competitive edge to the maximum extent possible.

4. THE RING RAILROAD (AND OTHER DOWNTOWN DISTRIBUTORS)

[1] Examples include Boston South Station and Boston Back Bay Station; Edinburgh Waverley Station and Haymarket Station (Scotland), Philadelphia 30th Street, Suburban, and Market East stations.

Why is downtown distribution important? Many transit (and intercity passenger transportation) professionals have come to believe that a consolidating approach to intercity services is a good thing. Many cite the union station's downtown location (an intercity rail "hub") as a great attraction. The downtown location is actually an impediment, not an attraction, to suburban dwellers and suburban business travellers. In contrast, the out-of-town airport offers much better access. Some business trips have non-downtown destinations, e.g. hotels and business parks. Moreover, the originating demands for intercity travel from the suburbs and the non-downtown city neighbourhoods, when integrated across the entire metropolitan area, dwarfs the originating demands within easy walking distance of the downtown station. Although the downtown remains a significant demand generator and requires direct service, it is no longer dominant.

A simple analogy with the interstate highway network demonstrates why more than one downtown station is required. An intercity railroad terminating only at the union station and beltway parkway is akin to an urban interstate expressway with only three exits, requiring the traveller to proceed through the city on slow arterial streets (akin to feeder transit systems or feeder buses). Services designed for shorter-haul passengers using a downtown distributor makes the service much more attractive than a point-to-point, airplane-like service.

The goal of such downtown distributors is to bring the intercity train to within about 10 minutes' walk or taxicab ride of most parts of the city, including suburban business districts and the downtown area. The scale is extremely important. Access time of less than 10 minutes makes a 45-minute taxicab-ride to the airport plus an hours' waiting in line for check-in seem much less attractive. With just one downtown station, the congestion in the downtown could make airport and union station access time similar in a taxicab from most suburban locations and city neighbourhoods.

4.1 The Inner Ring Railroad for Intercity Trains

The inner ring railroad is a particularly efficient layout for providing access to the downtown area. An "inner ring" is a smallish ring with a diameter between two to five miles with up to about six stops, designed to be traversed by a high speed train in less than about 30 minutes (inclusive of the station dwell times). The goal of such a ring is distinct from suburban ring transit schemes which have recently become fashionable. Instead of aiming at transit-dependent neighbourhoods to build ridership, the intercity ring aims at serving commercial and business districts as well as affluent parts of the downtown to maximize convenience for those who are likely to afford intercity travel. The ring will offer station spacing of between one to three miles – within comfortable walking distance for most, and a less-than-10 mins taxicab ride away for everyone in the city center.

The ring provides better access downtown, and serves distant city neighbourhoods and some suburban areas better than other layouts (Figure 1). The relatively small diameter of the ring results in less construction costs and relatively little additional mileage for trains leaving the city. Where many radiating lines converge, the ring offers an alternative to constructing independent "crosstown" tunnels for each line, potentially avoiding a huge expense while offering a better level of service. In addition, the ring is the only layout to guarantee a single cross-platform or same-platform transfer connexions between any lines. It allow departures to virtually any direction from any station, removing the need to navigate to a specific line for suburban auto travellers; they simply traverse the suburb, and board a train to go through the downtown to their intercity destination directly. The most congested and difficult to navigate neighbourhoods for the private auto are often the most pedestrian friendly, encouraging walk-up riderhsip. The railroad, with its exclusive right of way, is much less susceptible to congestion. If travellers are headed "back out" passing their residence, the total trip time would be shorter than a transfer at the union station in the heart of downtown (Table 2). Alternatively, they could elect to use a parkway station. If the travellers are heading in a different direction, the in-vehicle time is lengthened, but this can result in more productive work done compared to driving downtown, and there is still an overall trip-time reduction.

Consider the trip discussed in the base case (3.1.1). With a suitable parkway station, rail becomes competitive for a sector of the metropolitan area. However, with a ring, an auto-rail or cab-rail intermodal trip can potentially become competitive in most of the suburbs, except for the neighbourhoods immediately adjacent to the airport. Those neighbourhoods tend to be lower-income, and not a major originator of intercity travel. Instead of driving 15 to 40 minutes through the downtown or round the beltway, the driving is now no more than twenty minutes from any suburb. The element that varies, is the productive in-vehicle time, depending on the locations of the origin and destination relative to the downtown.

4.2 The London, England Case Study

How can the idea of an inner-ring railroad be applied to an actual situation to benefit local and transfer passengers? To illustrate the concept, a scheme was designed for the City of London to evaluate the potential benefits and feasibility:

- Estimate journey time savings for connecting and terminating passengers.
- Is a double-track ring railroad sufficient to carry all the trains arriving during the off-peak hours?
- Are reasonable turn-around times for intercity trains attainable?

This is purely a hypothetical scheme, intended to demonstrate the concept and illustrate the scale of the ring in question. London is of particular interest because, like Chicago, it is a national transportation hub and a large metropolis. A significant number of intercity travellers arriving in London will need to make a short-haul interurban trip to reach their final destination. Of course, there are many constraints on London's radiating intercity lines which will prevent interlining between them in the short term. However, as a long term proposition, the idea has potential. The proposed route closely mirrors London Underground's Circle line, linking all of London's mainline stations. Importantly, the line will be constructed to mainline railroad standards, and will thus permit intercity through-trains. A key assumption is that the ring replaces all crosstown railroads, current or proposed.

4.2.1 Running Time & Capacity Analysis

The amount of time it takes for an intercity train to travel around the ring was calculated using a formula calibrated from existing run-time data and other infrastructure assumptions. The distance around the ring was estimated and an average speed achieved between any two station-stops was calculated. This running time analysis also determines whether the vehicle time spent traversing the ring results in a saving over the turn-around time at a stub-end terminal.

It was impossible to stop at all BR London Terminals yet maintain a reasonable running time. However, if skip-stop service was introduced, overall time savings are possible and the majority of passengers could still make an effortless transfer to an interurban or commuter service. Most parts of Central London remains directly accessible from the ring. The run-time around the ring in the skip-stop scenario was 30 minutes. Using the existing Train Service Database information maintained by Railtrack and the running times, arrival times for all services was extrapolated to King's Cross station to determine if a capacity shortage would occur on the ring. The result demonstrates that at off-peak times, theoretically, most of the long-distance arrivals at the London terminals could be handled with 20 tph signalling on the ring. During peak hours, some trains would be refused access to the ring and short-turned at their terminal.

4.2.2 Transfer Time Model

To calculate the cross-London tranfer time under different scenarios, the transfer time was broken down into different components, populated using current Railtrack data, and then altered accordingly to reflect the hypothetical ring-railroad. The three components of the transfer time are:

- Walking time to and from the station platform
- Expected waiting time plus running time on the London Underground (the Tube)
- Expected waiting time for the next mainline train to your final destination

The average cross-town transfer time with a London Underground connexion was 58 minutes. The ring-railroad reduces that time to 47 minutes *(11)*. The reduction in access time for certain passengers are much larger (up to 25 minutes is possible), despite London's transit-orientation. Time savings would be even more dramatic in a congested city without transit. Many of these passengers would be likely to choose rail for intercity travel, even without line-haul time reductions. Table 3 shows a typical sample of actual journeys, along with estimated access and in-vehicle times. The majority of journeys show a decreased total trip time, and a greater % of in-vehicle time.

A simple benefit analysis assuming a value-of-time of $15 per hour, a passenger mix of 25% transfer, 55% downtown terminating and 20% metro-area terminating passengers suggest such a scheme would generate $350 million per year of consumer surplus in access time saved alone. There are much external benefits not explicitly accounted for in this model. This case study simply serves as an illustration that the ring-railroad can be a viable option to reduce access time and through journey time for some cities with more than about 2 million population.

4.3 Is an Inner Ring Railroad Always Necessary?

In certain cities, the city neighbourhoods have grown in such a way as not to lend itself easily to the planning of an inner ring route. Local geographical features are usually the reason. In Boston, the densest and most affluent neighbourhoods happened to wind through the city in an U shape, roughly following the banks of the Charles and Mystic Rivers. The lower-income neighbourhoods filled the gap on the South side and the Northeast, and the very low density suburbs are towards the West *(12)*. Thus, a reasonable alternative to an inner ring would be a "trunk distributor" roughly following the U-shape *(11)*, similar to previous proposals *(13)*. Although the journey time for through-trains would be increased due to additional mileage, it is not a major concern as Boston is a stub-end city with most intercity destinations to the South or the West. Also, in Boston, the walkable downtown is not sufficiently large to justify a complete ring, and the more affluent neighbourhoods are already covered by high-quality rail transit with convenient connections. Thus, the trunk distributor may be better than a ring.

In a city such as Cleveland, where the through traffic is as important as the originating traffic, segregation of through and originating/terminating traffic would be necessary. Many passengers are inconvenienced if every through train went around a ring. The segregation can be accomplished with smaller, modular trains. In a hypothetical New York-Cleveland-Chicago corridor, the westbound express trains may call at Cleveland Heights, where it will drop off a small high-speed EMU (e.g. 127-seat Metroliner) before proceeding around a by-pass and continuing towards Chicago. The Metroliner would traverse the ring in Cleveland to distribute local passengers, and continue to Columbus and Cincinnati. Demand-driven fleet allocation models similar to ones used in the aviation industry could benefit operations by calculating optimal fleet size and vehicle schedules.

Critically, with longer in-vehicle time, the on-board amenities becomes comparatively more important than the terminal services. The Pennsylvania Railroad's Metroliner owed much of its success to an unprecedented level of on-board service, despite a moderate service speed *(14).* The comfort is an important part of the rail advantage. Although terminal amenities are less important, they must remain competitive with airports. An underground island platform is clearly insufficient.

The ring is not for every city. In older cities such as New York, there may be implementation issues arising from local opposition and the lack of suitable space. However, multiple access points remains a central need; unfortunately, the glory days of Penn Station are no more.

5. ARE AIRLINKS ALWAYS A GOOD IDEA?

Airlinks appear to be an extension of airlines to the downtown. Non-stop rail service from downtown is distinct from a transit connection; obviously aimed at the affluent downtown clientele, it is specifically designed to erode point-to-point high-speed rail's downtown advantage. The schemes were often designed with the airport as a goal – a destination in itself, with the associated retail and hotel operations, rather than simply a transit hub where transfers take place. As previously demonstrated, the alleged "downtown advantage" may not be all that significant and is based on the probably mistaken popular notion that high speed rail service has to follow a point-to-point, airplane-like business model. In the context of integrated intercity rail service, airports can be logical stations in some, but not all, circumstances – depending mainly on the competitive threat of air shuttle services.

5.1 High Speed Rail Connection to the Regional Airport

Airport rail links have become increasingly popular, with a variety of different schemes proposed and implemented by cities worldwide. Most schemes had been local in nature *(15)*, built to enhance the airport access from the city center (and sometimes from the metropolitan area). They are often sponsored by the airport authority, and charge a premium to recover the likely loss in revenue from airport parking. In some locations in Europe, such as Amsterdam Schipol and Frankfurt, the airport has indeed become a center of commerce. There, the local transit system would of course connect the airport the same way it would any other centers of activity in the metro area *(16).* In other cases, despite strong retail developments, the airport remains mainly a transportation facility, e.g. in Chicago and in London Heathrow. Then, the decision to construct a high-speed rail link must be based on commercial considerations, and strict intermodal utility analysis, to create an efficient transportation system with the airport playing an appropriate role.

5.2 The Distinction between Shuttle Airports and Regional Airline Hubs

In a non-hub city airport, where the traffic is predominantly local shuttle flights to airline hubs or nearby destinations, it may not be in the interest of intercity rail carriers to enhance access to the airport. Rail has an inherent advantage in collecting passengers from the metro area; these passengers would generate the most revenue by travelling long-haul. Collecting passenger efficiently then delivering them to a local airport is giving the store away! With a shuttle flight, the passengers would still be saddled with the need to clear security, board the aircraft, and subject to any airside congestion effects at the connecting air hub or a popular shuttle destination. Despite the shorter journey time, the air shuttle may result in higher disutility than travelling by rail directly to destination *(17).* Here, the intercity rail carrier and the air shuttle operator are in direct competition and better rail-air access should not be promoted. Removal of short-haul passengers from the air carrier's network could increase its overall network revenue by allowing it to focus on longer-haul passengers with the limited airport capacity available. Institutionally, the two operators do not necessarily have to compete – the air shuttle operator and the high speed rail operator could be jointly owned by the same transportation company.

In a regional hub airport, where the traffic is mostly transcontinental and international flights, direct access to the airport from a high-speed rail corridor is vital. Rail cannot generally compete in transcontinental markets, thus it should focus on delivering passengers from the region and the metro area to the hub. More airport capacity could then be released for transcontinental flights. The key is for rail to act as 'spokes' on the regional scale, and not just a metropolitan mass-transit system, delivering passengers to a truly world-class air hub rather than the nearest airport. For the vast majority of passengers making the local city-to-city trip, accessible direct high-speed rail represents a much more attractive option than an auto-air-transit tri-modal trip.

6. WHY EXPAND THE MARKET REACH? (IS HSR REALLY A NICHE PRODUCT?)

There are good reasons for high-speed rail to expand its market reach. Although rail had recently been marketed as a niche product in specialized point-to-point corridors, the fact remains that rail technology enjoys enormous economies of density. The airline industry has long discovered that in a given origin-destination corridor market, the carrier that provides the larger frequency share gains a disproportionately larger market share *(18)*. Since rail often operate in such corridor markets where travel is generally unplanned, it is doubly important for rail to offer extremely frequent service. Rail needs to reach out to the mass market with a Southwest-like business model. Enlarging the competitive areas covered, with trains perhaps as small as 200-seats, can help to justify more frequent service. A critical ridership must be reached before rail will be truly competitive or cost-effective. A seat departed empty is a full-fare revenue loss, and the marginal cost of adding seats by adding vehicles is low. With an effective revenue-management system, rail may stimulate highly elastic discretionary travel demand much better than an air shuttle. Fares competitive with bus carriers could easily be offered on night-time corridor trains, while daytime walk-up fares would be more in line with airline fares. All of these suggest the rail carrier ought to focus much more on better, multi-point metropolitan access rather than the traditional point-to-point approach hereto adopted by the Japanese Shinkensen and the French TGV.

7. CONCLUSIONS

In the past thirty or so years, high-speed rail has pursued a limited-stop express business model. There are good logic behind this:

- Customers prefer not to stop en-route.
- Short point-to-point times are required to compete with the airlines.
- High speed rail is perceived as a niche product serving the downtown-to-downtown business travel market.

Such a business model has not generally proven to be profitable without government subsidies. Some of this must change in future, to ensure a more sustainable basis for intercity passenger rail. Rail technology, by nature, enjoys greater economies of density, scope, and scale (in seats per vehicle, number of stops en-route) than air technology. Thus, it is in the rail advocate's interest to serve the mass-market, recovering capital costs through Ramsey-pricing.

Better downtown distribution is one way to expand rail's market reach and market share, while realizing potentially cost-saving economies. Having multiple rail terminals in the walkable neighbourhoods of large cities is not only a good competitive response to cities with multiple airports, it is also a good way to serve the large suburban population currently in a better position to access the out-of-town airfields. A downtown railroad loop happens to be an effective layout for servicing the demand and for operational reasons, although other layouts are possible. The main emphasis should be matching the supply of rail terminals to the originating travel demands within the immediate locale, enabled by technology changes over the last century (Figure 2). Ideally, the "nearest rail terminal" should always be more accessible in any part of the city except for the communities immediately adjacent to the airport. The rail depot could then once again return as the focus of the community in an urban landscape, in a way that airports simply cannot – in addition to providing good transportation services.

The detailed analysis demonstrates that in principle, a ring-railroad or a semi-circle with multiple stations around the downtown centre can decrease access time for travellers originating from the city and combat congestion at a single downtown union station. The London and Boston case studies show that a practical routing could indeed be designed to give a total journey time reduction. A downtown ring may be less expensive than many through-routes which criss-cross the city, but deliver similar benefits. Thus, a downtown ring railroad is something that the passenger rail industry ought to study closely as an option for enhancing its performance in terms of access time thus the overall customer utility of the journey experience. The rail industry must seize this opportunity to regain its prominence as a part of the passenger transportation system.

8. ACKNOWLEDGEMENTS

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9. REFERENCES

1. Johnston, Howard. *A 190mph Railway: Serious Talk, or Just Window-Dressing?* RAIL 434, emap Publications, Peterborough (2002).
2. Le Clercq, Frank and de Vries, Jaap S. *Public Transport and the Compact City.* Transportation Research Record 1735, Paper 00-0899.
3. Levinson, Herbert S. and Hoey, William F. *Interurban Electric Railway – a Tale of Two Centuries.* Transportation Research Record 1762, Paper 01-0356.
4. Middleton, William D. *North Shore – America's Fastest Interurban.* Golden West Books, San Marino CA (1964).
5. Manheim, Marvin L. Chapter 3 – The Demand for Transportation, in *Fundamentals of Transportation System Analysis.* MIT Press, Cambridge MA (1979).
6. Warsh, Jeffery. *TEA 21 Success Stories*, Testimony to the Highway and Transit Subcommittee. The United States House of Representatives, Washington D.C. (2001). http://www.house.gov/transportation/highway/11-01-01/warsh.html. Accessed May 22, 2002.
7. Arentze, T., Timmermans H. et al. *Assessing Urban Context-Induced Change in Individual Activity Travel Patterns – Case Study of New Railway Station.* Transportation Research Record 1752, Paper 01-2728.
8. MIT and Charles River Associates. *Mobility 2001*, Report to World Business Council for Sustainable Development. Cambridge MA (2001).
9. Small, Kenneth A. and Winston, Clifford. The Demand for Transportation: Models and Applications, in *Essays in Transportation Economics and Policy: A Handbook in Honor of John Meyer*, Brookings Institution, Washington, D.C. (1999).
10. Konheim, Carolyn S. and Ketcham, Brian. *Effective Transit Requires Walkable Communities.* Transportation Research Record 1722, Paper 00-1064.
11. Martland, Carl; Sussman, Joseph and Lu, Alex. Appendix H: Role of Metropolitan Access in Intercity Passenger Systems, in *Performance-Based Technology Scanning for Railroad Passenger Systems.* Massachusetts Institute of Technology, MIT/UIC-WP-2002-01-H, Cambridge MA (2002).
12. Bowen, William A. *Digital Atlas of Boston.* California Geographical Survey (1997). http://130.166.124.2/bospg1.html. Accessed April 13, 2002.
13. Central Artery Rail Link Task Force. *Building for an Intermodal Future: The North-South Rail Link.* Final Report. Executive Office of Transportation and Construction, Commonwealth of Massachusetts. Boston, MA (1993).
14. Schafer, Mike. *Classic American Railroads.* MBI Publishing Company, Waukesha, WI (1996).
15. Coogan, M. A. *Airport Access: Case Study in Intermodalism.* Special Report 240. Transportation Research Board, Washington D.C. (1993).
16. Widmer, J.-P. and Hidber C. *Effects of Rail Stations at Airports in Europe.* Transportation Research Record 1703, Paper 00-0222.
17. Martland, Carl; Sussman, Joseph and Shi, S. Dalong. Appendix G: Intermodal Systems Analysis, in *Performance-Based Technology Scanning for Railroad Passenger Systems.* Massachusetts Institute of Technology, MIT/UIC-WP-2002-01-G, Cambridge MA (2002).
18. Morrison, Steven A. and Winston, Clifford. Chapter 1 – The Remaining Role for Government Policy in the Deregulated Airline Industry, in *Deregulation of Network Industries: What's Next?* Brookings Institution, Washington D.C. (2001).
19. Horowitz, Alan J. and Thompson, Nick A. *Evaluation of Intermodal Passenger Transfer Facilities.* Federal Highway Administration, DOT-T-95-02, Washington D.C. (1994).

Figure 1: Location of an Inner Ring Relative to City Neighbourhoods

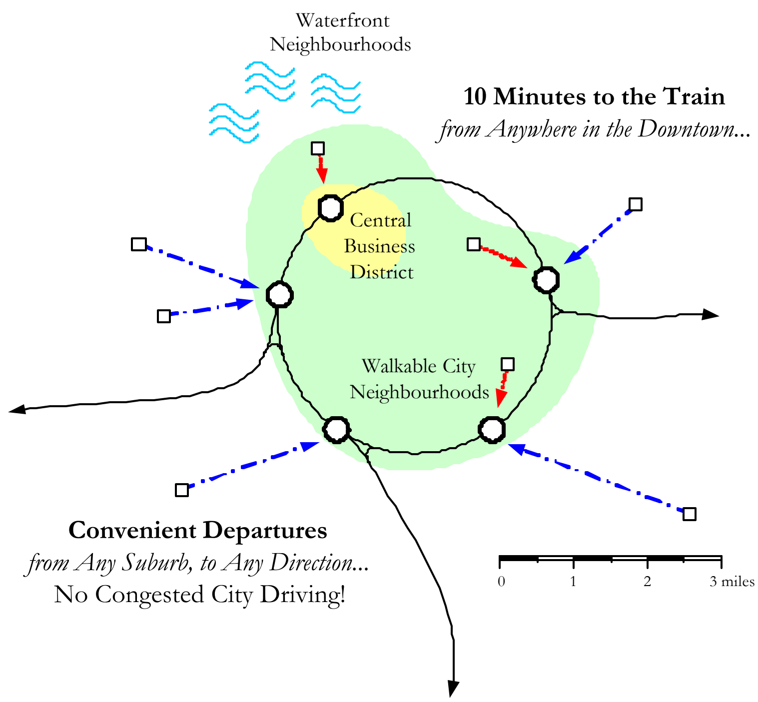


Figure 2: The Evolution from a Supply-Driven to a Commercially Focused, Market-Driven Railroad

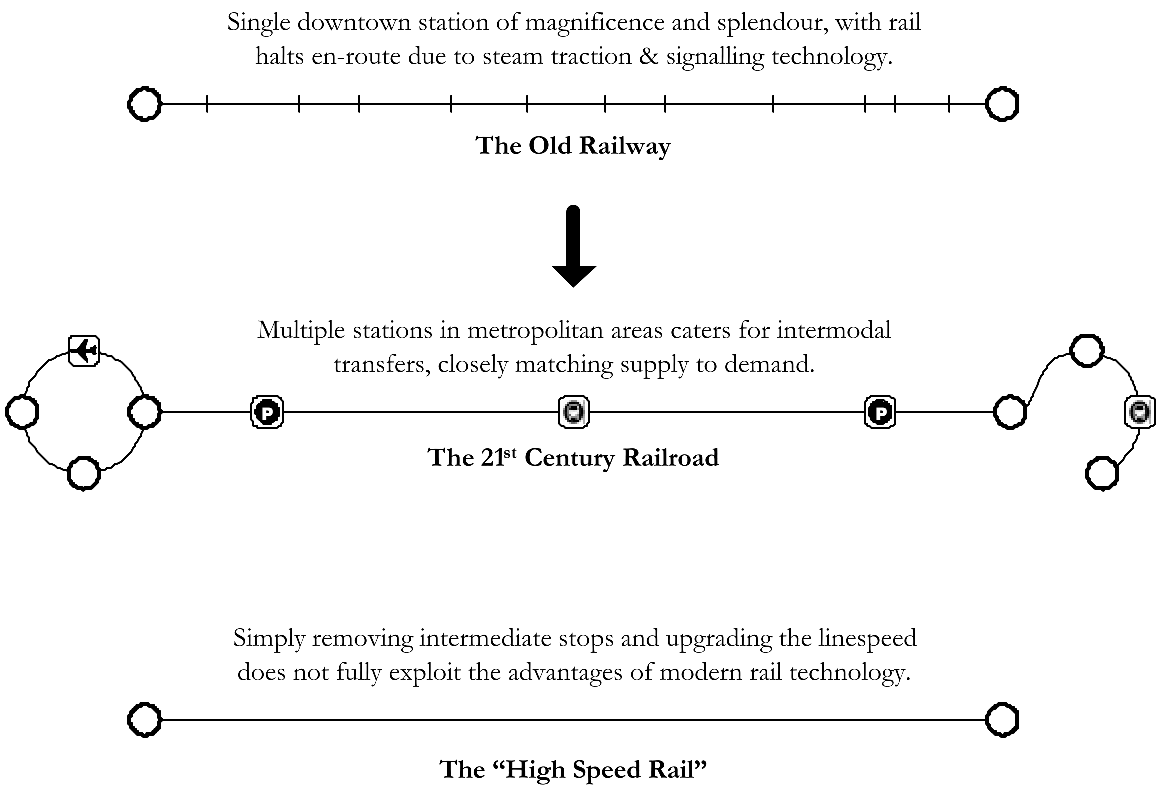


Table 1: Competitive Analysis of the Intercity High Speed Passenger Travel Market

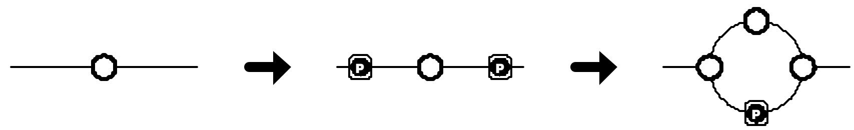
	Market Segment: Intercity Corridor Rail (320~960 km, 200-600 miles)		
Rail Station Type	*Union Station (1900's)*	*Parkway Station (1980's)*	*Multi-hub/Ring (The Future)*
			
Stations per Metro-Area	One	2 to 3	Many
Mode			
Private Auto			
Strength	Easy Access	No Transfer	—
Weakness	Long Journey Time	Long Journey Time	Long Journey Time
Scheduled Air			
Strength	Short Journey Time	Short Journey Time	Short Journey Time
Weakness	—	Longer Access Time (local effect)	Longer Access Time (citywide)
Intercity Bus/Electric Interurban			
Strength	Low Cost	Low Cost	Low Cost
Weakness	Long Journey Time	Long Journey Time	Long Journey Time

Table 2: Typical Journey Time Estimates by Urban Railroad Layout and Market Segment

	Union Station				Parkway				Multi-hub/Ring			
Origin/Market Segment	*Access*	*Buffer*	*En-train*	*Total*	*Access*	*Buffer*	*En-train*	*Total*	*Access*	*Buffer*	*En-train*	*Total*
Urban Dweller												
(Downtown Office)	0:10	0:05	2:00	2:15	(use Union Station)				0:10	0:05	2:05	2:20
(City Residence, Central Neighbourhood)	0:15	0:05	2:00	2:20					0:15	0:05	2:05	2:25
(City Residence, Transit-Accessible Neighbourhood, Right-side)	0:25	0:20	2:00	2:45					0:15	0:15	1:55	2:25
(City Residence, Transit-Accessible Neighbourhood, Wrong-side)	0:25	0:20	2:00	2:45					0:15	0:15	2:15	2:45
Suburbanite, Off-peak												
(Right-side)	0:35	0:10	2:00	2:45	0:15	0:05	1:45	2:00	0:10	0:05	1:55	2:10
(Off-side)	0:35	0:10	2:00	2:45	0:30	0:10	1:45	2:25	0:10	0:05	2:05	2:20
(Wrong-side)	0:35	0:10	2:00	2:45	0:45	0:15	1:45	2:45	0:10	0:05	2:15	2:30
Suburbanite, Rush Hour												
(Right-side)	1:00	0:30	2:00	3:30	0:30	0:15	1:45	2:15	0:20	0:10	1:55	2:25
(Off-side)	1:00	0:30	2:00	3:30	0:45	0:20	1:45	2:50	0:20	0:10	2:05	2:35
(Wrong-side)	1:00	0:30	2:00	3:30	1:05	0:25	1:45	3:15	0:20	0:10	2:15	2:45

Multi-hub structure impacts journey times in the following way:

- Increase journey times by 5-minutes for city-center travellers
- Decrease journey times by 20-minutes for some connecting passengers (from transit)
- Decrease journey times by 5- to 15- minutes for off-side and wrong-side suburbanites in the off-peak
- Decrease journey times by 15- to 30- minutes for off-side and wrong-side suburbanites in the rush hour
- Increase journey times for right-side suburbanites, who may choose to use the parkway station instead

Note: Off-side and wrong-side suburbanites are in fact the majority, compared to the right-side suburbanites. Although some journey times from the city center have become worse, running non-stop expresses from the downtown at periods of peak intercity travel demand can mitigate the impact.

Table 3: Projected Journey Times, Before and After a Ring-Railroad is Constructed around London

	Before						After				
Origin/Destination	*Local Access Time*	*Tube Time*	*Exp. Wait Time*	*Line-haul Time*	*Total Journey Time*	*Routing*	*Access Time*	*Exp. Wait Time*	*Line-haul Time*	*Total Journey Time*	*Routing*
Urban Dwellers											
Big Ben/Westminster to The North East (Newcastle)	0:10	0:38	0:15	2:35	3:38	Circle Line/East Coast Mainline	0:20	0:15	2:50	3:25	Victoria BR/Ring/ East Coast Mainline
Imperial College (Paddington) to Scotland (Edinburgh)	0:20	0:24	0:15	3:59	4:58	Hammersmith & City/East Coast	0:20	0:15	4:11	4:46	Paddington BR/Ring/ East Coast Mainline
Heathrow Airport to The Anglia Region (Cambridge)	0:15	0:59	0:15	0:45	2:14	Piccadilly Line/ Cambridge Flyer	—	—	—	—	—
Heathrow Airport to The Anglia Region (Cambridge)	0:32	0:34	0:15	0:45	2:06	Heathrow Express/ Cambridge Flyer	0:32	0:15	0:57	1:44	Paddington BR/Ring/ Cambridge Flyer
Harrow-on-the-Hill to The South (Southampton)	0:25	0:29	0:15	1:25	2:34	Chiltern/Bakerloo /South West Trains	0:44	0:15	1:46	2:32	Bakerloo/Ring/ South West Trains
Suburbanite, Off-peak											
Henley-on-Thames to Scotland (Glasgow)	1:24	0:34	0:15	5:15	7:28	Thames Trains/ East Coast	1:24	0:15	5:27	7:06	Thames Trains/Ring/ East Coast
Henley-on-Thames to Scotland (Glasgow)	1:24	0:36	0:20	5:24	7:44	Thames Trains/ Virgin West Coast	1:24	0:20	5:33	7:17	Thames Trains/Ring/ Virgin West Coast
Chelmsford to The South West (Plymouth)	0:47	0:43	0:20	3:54	5:44	Great Eastern/ Great Western	0:47	0:20	4:11	5:18	Great Eastern/Ring/ Great Western
Portsmouth to The North West (Manchester)	1:44	0:33	0:20	2:46	5:23	South Central/ Virgin West Coast	1:44	0:20	3:01	5:05	South Central/Ring/ Virgin West Coast

- **Local Access Time** is the time to get from origin to a London BR Station, including any buffer time, etc required for any transfers.
- **Tube Time** is the time taken to make the cross-London transfer from the inbound London BR Station to the appropriate London BR Station for outbound travel, including the expected wait time for the London Underground train.
- **Expected Wait Time** is half of the headway on the outbound services from the London BR Station. For longer distance journeys with lower headways, this is decreased to reflect some planning.
- **Line-Haul Time** is the advertised trip time between the outbound London BR Station and the final destination.

Geographical Notes:

Westminster is the seat of the British Parliament in Central London, on the banks of the River Thames, at the Big Ben.
Imperial College is a nationally-renowned technical college of the University of London.
Harrow-on-the-Hill is an affluent neighbourhood of Greater London.
Henley-on-Thames is a town in the affluent Berkshire/Buckinghamshire/Oxfordshire suburbs (known as Thames Valley), where an annual regatta takes place on the River Thames.
Chelmsford is a medium-sized city in the industrial Essex suburbs, where many people commute to London.
Portsmouth is a port city on the South Coast of England, within reasonable commuting distance of London.