EUROPE’S HIGH SPEED RAIL NETWORK: MATURATION AND OPPORTUNITIES

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ABSTRACT

High speed rail is a good example of a complex social-technical system, it combines high technology with social institutions to provide transport service. However, in spite of advances in HSR technology, HSR service is operated in much the same manner as traditional passenger rail service – an unsuccessful long-term business model. This research argues that HSR needs disruptive innovation to create attractive and efficient new services tailored for today’s transport demands. Since HSR technology is already well developed, the key to creating these new services is overcoming institutional barriers to innovation in service design, pricing strategies and integration with other transport networks. European HSR operators have spent many years developing technology and building infrastructure thus creating a nascent international HSR network. The question is, how can this network be operated to create a truly innovative new transport service? The paper summarizes development of Europe’s HSR network. Next, it describes innovation theory in the railway context. Third it describes ideas for transforming HSR into an innovative new service. Implementing these ideas will require overcoming institutional barriers. Finally, the paper presents conclusions.

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1. INTRODUCTION

Is high speed rail a mature technology or are there innovations possible that could transform it into a new type of transport, one that provides attractive and efficient new services tailored for today’s transport demands? This research argues that high speed rail is at a major crossroads. It faces two different development paths: sustaining innovation, i.e. minor technology improvements and traditional operations, or disruptive innovation, i.e. creating and implementing new services designed to better meet society’s changing needs.

As a complex social-technical system, HSR combines high technology vehicles and infrastructure with institutions and practices that have been in place for almost 200-years. From the perspective of technology, HSR is a mature system, the technology is highly developed and the network covers a major portion of Western Europe. From the perspective of social systems this paper argues that HSR is also a mature system – it is not operated significantly differently than traditional railway lines. However, disruptive innovation in the way HSR is operated could transform it into a new transport service ideally suited to today’s complex transport needs. Such a system could provide attractive and efficient service while reducing energy use and environmental impacts. However, this possibility must be balanced against strong institutional forces preventing innovation and change.

This paper discusses the issue of high speed rail innovation in the context of Europe’s nascent international network. It begins with a summary of the European network and its development. Next it outlines innovation theory and innovation in the railway sector. Third, it outlines potential HSR innovations focusing on service design, pricing strategies, integration with other transport networks and overcoming institutional barriers. The final section presents conclusions and recommendations.

2. EUROPEAN HIGH SPEED RAIL NETWORK

2007 was an important year for high speed rail in Europe. According to The Economist, "Europe is in the grip of a high-speed rail revolution.” [1] The most visible element was the new rail speed record of 574.8 kph set on April 3 on the TGV Est line. [2] However, more important for high speed rail’s future, new infrastructure and operating strategies introduced this year set the stage for creating a fully integrated European high speed rail network. This section briefly outlines European HSR, developments in 2007, and creation of an integrated European HSR network.

2.1 Historic Background

The first high-speed rail line was Japan’s Shinkansen (bullet train) between Tokyo and Osaka; it began operation in 1964. The Shinkansen line was built to relieve capacity problems on parallel lines and was built especially for high-speed trains.

The first commercial high speed service in Europe was the French TGV line between Paris and Lyon opened in 1981. The line was a great technological and financial success. It proved that high-speed rail could attract a large share of airline passengers in medium distance markets. Based on this success, France embarked on an extensive program of building high-speed lines and technological development. TGV services now carry 100 million passengers annually generating a turnover of almost six billion euros and a profit margin of 10%. [3]

Today the SNCF considers TGV service as a product combining the benefits of high speed with comfortable travel for a wide variety of customers. [4] In this regard the SNCF has introduced several interesting service ideas (e.g. iDTGV) and continues to extend its network.

Commercial high-speed operations began in Germany in 1991. During 2007 Germany opened a new 300-kph line between Nuremberg and Ingolstadt and construction is continuing on several additional segments. The total network served by ICE trains is now 6,865 km, on a combination of dedicated high speed lines (1,330 km) and shared lines. However, while ICE trains are faster than competitors on direct routes, door-to-door travel times are often no faster than driving. The dedicated lines are too short and there are too many stops on many lines. Faster travel times will require more dedicated lines and more efficient scheduling. [5]

Spain, Italy and the Benelux countries have also developed high speed rail systems during the last several years. Spain’s system is noteworthy because they adopted the European-standard rail gauge in order to be compatible with a pan-European high speed network. The Benelux countries initially were served by high speed trains from France and Germany that ran at reduced speeds, they have gradually built dedicated tracks for true high speed service. Italy focused initially on service on the between major cities on the Milan – Naples corridor, but is extending the service today into a “T” shaped network. The value of HSR will increase as national lines are gradually linked into an integrated European network.

2.2 High Speed Infrastructure and Service Innovations in 2007

This section outlines infrastructure and service innovations introduced in 2007.

TGV Est

The TGV Est began commercial service in June 2007. The service is noteworthy for two important reasons. First, it provides an important connection to central and southern German’s rail network. International services are operated by a new SNCF/DB joint venture. The operators share revenues and have bi-lingual and bi-national crews on board. It is interesting to note that cultural and institutional issues (including serving food on non-plastic plates and crew responsibilities for serving meals) were major discussion points in the agreement allowing French TGVs to operate on German tracks and German ICEs to operate on French tracks. The fact that these issues had to be discussed shows the importance of overcoming institutional barriers to innovation in the railway sector.

Second, as part of the TGV Est project, a wide range of regional service is also being introduced in Eastern France (boosting service by up to 30% in some areas). This is important because it will help maximize the benefits of the new TGV by reducing the number of local HSR stops but still providing good accessibility to markets. The SNCF has learned that HSR cannot be successful in a vacuum; local service and multimodal connections are needed to support HSR.

Swiss Alpine Basis Tunnels

Switzerland’s Loetschberg alpine base tunnel was also opened in June 2007. While Swiss voters rejected construction of an HSR line in 1978, they did approve Bahn-2000, a comprehensive program to improve and speed-up rail service, as well as the construction of two basis tunnels under the Alps: the 34.6-km Loetschberg and the 57-km Gotthard (expected to open in 2016). The main justification for these tunnels is to remove truck traffic from Alpine highways. However, the tunnels are designed for 250 kph passenger train service, and since they replace winding routes over the Alps they will reduce travel times by up to an hour on major routes (e.g. Zurich to Milan).

The alpine basis tunnels will link Italy’s HSR system to the rest of Europe. Three other major tunnel projects are currently being planned, or are in the introductory construction stages (Brenner, Lyon-Turin, and Koralpe-Simmering). The success of the Loetschberg tunnel will significantly effect plans for these other tunnels. An especially important part of the Swiss projects has been financing. The tunnels have been financed by the introduction of a weight-distance charge for all trucks using Swiss roadways. Implementing a similar charging scheme is more problematic in European Union countries. (AlpNet)

Channel Tunnel High Speed Line

On November 14, 2007, a new rail link connecting London’s St. Pancras station to the English Channel Tunnel high-speed line opened for passenger service, 13 years after the first Eurostar service. [6] The new line reduces travel time by 20-minutes, and improves the linkage between the continental high speed network and British rail lines. The construction and operating difficulties of both the Channel Tunnel and the new HSR line provide good lessons in the use and structuring of public private partnership projects. [7][8]

Railteam

In addition to these infrastructure projects, a group of seven railway companies, DB (Germany), SNCF (France), Eurostar (UK, France and Belgium), NS Hispeed (Netherlands), ÖBB (Austria), SBB (Switzerland) and SNCB (Belgium) and two subsidiaries, Thalys and Lyria, have joined together to organize Railteam. Railteam is intended to make travel across the European rail network as seamless and comfortable as possible. Specific benefits include the ability to easily change reservations for connecting trains when arriving trains are delayed, multi-lingual staff, a coordinated ticketing system, and frequent traveller benefits (e.g. use of business lounges for premium customers similar to airline alliances). Railteam hopes to increase high-speed passengers from 15-million annually today to 25-million by 2010. [9]

2.3 A European High Speed Rail Network

The combination of new infrastructure and introduction of a coordinated system strategy (e.g. SNCF and DB operations on the TGV Est and Railteam) are important steps in creating an integrated European high speed rail ***network***. Figure 1 illustrates the existing and planned network.

Figure 1: European High Speed Rail Network. Source [1]

The development of an integrated European HSR network is in contrast to the early focus on national systems. The early focus on national systems led to the development of national technology standards and routes oriented towards national objectives (e.g. France's network focused on Paris and Germany's polycentric network).

According to Vickermann the original high speed lines in France, Germany and Italy were seen largely as a means of overcoming bottlenecks on the national networks. These bottlenecks limited capacity, caused conflicts between types of traffic and increased unreliability. Higher speeds were in many respects an accidental by-product of improved reliability. Furthermore, the difficulties improving existing, often curved and circuitous routes through mountains or along river valleys meant that new construction could be less expensive. [10]

The national focus also led to development of different strategies, with France focusing on building dedicated high speed lines and Germany focusing on a dual approach of improving existing lines and building new lines where capacity was needed. In terms of technology, France focused exclusively on high speed rail, while Germany developed both HSR and MagLev (magnetically levitated trains). [11]

A significant problem with building the HSR network on a link by link basis is that little regard is being paid for the overall network effects. One result is that patronage on international HSR routes has been less than domestic routes. [10]

Today an international HSR network is gradually taking shape. Major network building blocks including the PBKAL (Paris-Brussels-Köln-Amsterdam-London) network and France’s TGV Est have recently been completed. As shown in Figure 1, additional elements including the Lyon-Turin tunnel linking Italy and the Perpignan-Barcelona line linking Spain to the network are under construction.

The first official recognition of a European HSR network took place in the 1990s, when the European Commission designated a high speed rail network as part of the Trans European Network – Transport (TEN-T). The TEN-T network HSR corridors were based on the national networks but extended lines throughout Europe. Unlike the US Interstate Highway system, the majority of funding for TEN-T projects (approximately 90%) is provided by national and local governments. Limited EU funding has meant that the TEN-T networks are developing more slowly than hoped.

In summary, although national HSR networks have been generally successful, it has been difficult to create an integrated European HSR network. One important reason has been institutional barriers created by Europe’s long history of independent national railway systems. These types of institutional problems often surface early in the development of transport networks and indeed for all types of innovation. The important question for high speed rail’s future is: How can institutional barriers to innovation be overcome?

3. INNOVATION AND RAIL TRANSPORT

This research argues that high speed rail is at a major crossroads. It faces two development paths: sustaining innovation, i.e. continued refinement of the existing system, or disruptive innovation, i.e. creating and implementing innovative new services designed to better meet society’s changing transport demands. In other words, will high speed rail remain simply a faster form of traditional rail service or can it be transformed into an attractive and efficient new transport service?

In the short term both paths are acceptable, but the disruptive innovation path provides an opportunity to transform HSR into a “new” form of transport combining the significant advantages of rail with modern travel demand. However, in the long term, if high speed rail does not innovate to better meet modern travel demand, then other products will be developed to meet this demand and will encroach on traditional HSR markets (e.g. increased short-distance air travel). This section outlines ideas from innovation theory to provide a context for identifying high speed rail improvement strategies.

3.1 Development and Application of Technology

A common model for describing development and application of technology is the S-Curve. In the early stages, as the technology is being developed, it is not widely deployed; however, once the technology is proven and shown to be profitable, its deployment follows an exponential growth curve; then, as the technology reaches its practical limits, deployment levels off. Once a technology reaches this flat part of the development curve it is possible to continue improving it by making incremental improvements accompanied by input substitution. However, these improvements have relatively limited benefits in terms of creating new markets and significantly increasing demand. [12]

On the other hand, it is possible to innovate. Innovation consists of developing a new technology to serve the same function or applying an existing technology in a significantly different way, in both cases the objective is to improve system performance and increase market share. Many innovations are technological, for example the airplane was a technical innovation over long-distance trains. One way of thinking of innovation is moving from one S-Curve to another as shown in Figure 2.

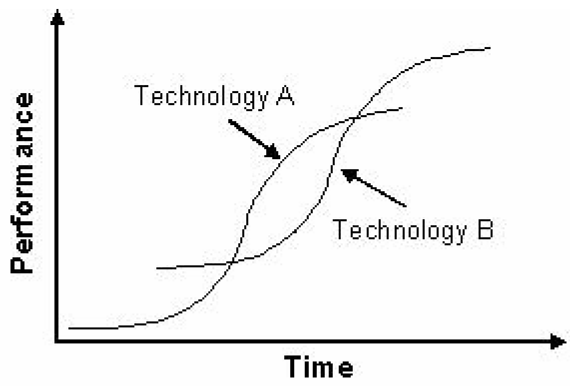

Figure 2: Innovation: Moving from one S-Curve to another. Source [13]

The term "technology" in this description and in Figure 2 is used to include the social systems needed to utilize the specific technology. For railroads, and other complex technological-social systems, the development of institutional and organizational processes was fundamental to the innovation process. Once railway technology and social systems were developed, railroads proliferated rapidly, creating vast networks.

3.2 Innovation Process

There are many theories of innovation. [13] A common thread is the difficulty existing businesses have in developing new products and processes. The economist Joseph Schumpeter believed that creative destruction of old products and processes was needed to encourage innovation and entrepreneurship. Creative destruction is possible in a large established company, but it's much more likely in new companies since they are often more open to ideas for better products and improved production processes. [14]

Christensen extends this idea to sustaining and disruptive innovation. He believes that sustaining innovations are often developed by existing companies while disruptive innovations often come from outside and can lead to the downfall of existing companies. [15]

It is important to understand that disruptive innovation is not a case where the existing technology no longer works or is unattractive, but rather that the new technology provides improved service or an opportunity to do something differently. Often existing companies do not recognize this improvement (following the philosophy: if it's not broke, don't fix it), and therefore new firms are left to implement it. For example, Western Union saw no market for the telephone since there was nothing wrong with the telegraph.

In addition to new technology, disruptive innovation in a complex technological-social system must also include institutional and organizational change. Often, it takes time to fully understand the social aspects of how to best apply a newly developed technology. [16] Information technology is a good example. During the 1990s many companies invested heavily in information technology, but found no increases in productivity. Recent research has shown that business and society needed time to adapt to the new technology. Some have even called for companies to radically re-organize to take full advantage of IT investments. [17]

In the transportation sector Garrison believes that it is fair to say that transportation innovations led to significant advances, but that these advances were conditioned by social environments and markets, and that they took time. Furthermore, the innovations were often resisted by those displaced or otherwise affected. [12]

An anonymous reviewer of this paper asked, is current HSR innovative or destructive of local rail service? This excellent question strikes at the heart of the issue, current HSR is not destructive of local rail service and this is its fundamental problem – rather than fully embracing innovation, in many cases HSR is being planned and operated as a traditional railroad. Only by breaking free of these constraints can HSR reach its full potential.

3.3 Encouraging Innovation

There are many ideas for encouraging innovation. Christensen believes that a big problem facing established companies trying to innovate is that they need to be careful which customers they listen-to; often existing customers only know the direction they are already going in, while new customers can help identify disruptive innovations that lead to real growth. Furthermore many established companies force new ideas to conform to the company's existing business model, rather than to the marketplace. This significantly reduces the number and quality of disruptive innovations.

These problems mean that smaller start-up companies are often better at developing and benefiting from disruptive innovations. Established companies often ignore these small companies, believing that the markets for their new products are not large enough to be attractive. Once they do become attractive it is often too late for the established companies to catch-up. For example, low cost airlines were originally ignored by established airlines, but today low cost airlines serve a substantial share of the market and the legacy carriers are emulating their strategies.

One approach established companies can use to develop disruptive innovations is to create independent business units. These units can develop innovative ideas free from the existing business model constraints thus enabling them to be more flexible and to implement ideas more quickly. [18] A good example in the rail industry is the SNCF’s iDTGV program. The iDTGV applies new service and marketing concepts to traditional TGV service. It is disruptive innovation in the sense of introducing new service ideas and pricing strategies – exactly the type of innovation needed to transform HSR into a new service that meets today’s transport demand.

The methods used by established companies to analyse financial investments are another constraint on innovation. For example, discounted cash flow analysis implicitly assumes that conditions will remain constant if a project (innovation) is not implemented. [16] This is a bad assumption in today’s rapidly changing society. For example, a railway that fails to maintain and improve its infrastructure will soon find it impossible to operate service efficiently.

One approach for preventing investment analyses from sidetracking innovation is discovery-driven planning. This process acknowledges that there are many assumptions at the start of a new venture that must be tested and questioned. Discovery-driven planning consists of drawing up a checklist of all key assumptions, a timetable for proving each one, and preparing a list of threshold economic criteria that must be met, at each stage of the project, if the project is to go forward. [19]

Discovery driven planning focuses on identifying what assumptions must prove true for an innovation to be successful, and then launching a project to test those assumptions. Combining this with Christensen’s approach to customer input, means that some of those assumptions should consider what purpose customers want to accomplish when they use the product. If an innovation makes it through the discovery driven planning process’ economic threshold assumptions and also relates to the customer’s needs, it is likely to be successful. [16] For example, what do customers ***really*** want to accomplish when they use HSR?

In summary, the innovation process is complex, but extremely important for long term success of companies and industries. As outlined in the next section, innovation can be even more difficult for heavily regulated industries such as transportation.

3.4 Government Regulation and Innovation

As this paper emphasizes, railways are a complex technical-social system. Innovation is necessary in both technology and social aspects. An important part of this social system is the role of government.

In its simplest application, Government regulation can prevent the implementation of innovations. A good example is how government regulations have effectively prevented even testing the “Karlsruhe model” of operating light rail vehicles on standard railroads in the USA even though the approach has been proven in Europe.

In addition to specific regulations, government policy also impacts the ability of companies to innovate by impacting revenues. For example, the decline of US public transport can be partly traced to the fact that public transport companies lacked pricing and investment flexibility since they were franchised and controlled by city governments.

On the other hand, regulators have a very important responsibility to ensure that systems are safe; this places them in a real dilemma when it comes to innovation. Trying something new involves risk. Research on the telecommunications industry has suggested that there is a more elaborate, complex, and predictable interplay between regulation and innovation than commonly assumed. The researchers believe that policymakers must comprehend the conditions needed to encourage innovation and respect specific industry dynamics. Two key factors for encouraging innovation are: motivation, in other words incentives, and ability, defined as the capability to obtain resources, craft them into a business model and offer them to customers. [20] The following section describes innovation ideas in the context of the railway industry.

3.5 Innovation in the Rail Sector

Innovation in the rail sector is difficult given the industry's generally conservative business approach and the long-lived nature of its infrastructure, two mutually reinforcing qualities. These two qualities also distinguish railways from other government-regulated infrastructure networks such as telecoms where change can be rapid and the business approach is more flexible.

Ivaldi identifies additional differences including the fact that railways face much greater economies of scale, their investment and operations decisions require much closer co-ordination, this coordination is very complex, and railway services have more substitutes in the lives of consumers than in other network industries. [21] These qualities form the main constraints on railway system innovation.

A recent research study in Austria categorized the barriers to railway system innovation in four general areas: institutional, organizational, socio-cultural and technical. These barriers are summarized in Table 1. [22] The research is particularly interesting as it explicitly recognizes the impacts of cultural and institutional conditions on innovation.

Table 1: Barriers to Innovation in the Railway Sector [22]

Barrier Type	Specific Barriers
Institutional	Monopolistic business model
	Political (internal and external) involvement in making operating decisions
Organizational	Lack of investment capital
	Insufficient professional resources
	Insufficient technical expertise – i.e. reliance on a specific technical path
	Problems caused by European railway re-organization (i.e. vertical competition within companies) that reduce cooperation and increase uncertainty
Socio-cultural	National orientation of railway companies
	Old-fashioned consumer image of railways
Technical	Long innovation cycles
	Misunderstanding of customer needs

In summary, the rail industry presents many barriers to innovation, but, it is also true that rail operators have made huge investments in high speed rail technology development and deployment in the last 40-years, which shows that there is potential for at least technical innovation. The question is can similar innovation take place in the social systems that influence operation of high speed rail service? The following section develops this idea further.

4. POTENTIAL HIGH SPEED RAIL INNOVATION PATHS

High speed rail is a technical innovation – many improvements have been integrated into traditional railway system to create a fast and efficient transport mode. However, it is also true that HSR is often operated in the same manner as traditional rail service, in other words old-style service dressed in new, faster, clothes. This incremental approach has been successful in many markets, but by seeking disruptive innovation on the social side of the social-technological system, it might be possible to develop an integrated HSR network offering attractive and efficient new services ideally suited for today's transport demands.

Many argue that it does not make sense to invest in passenger railways and instead we should focus on improving more modern and efficient modes such as automobiles and airplanes. But, could it be that the efficiency of automobiles and airplanes has more to do with the social systems developed to operate and organize these modes than the technology? If this is true, then developing and implementing social system innovations in the railway industry could help HSR play a fundamental role in a modern transport system.

There are many reasons to encourage such a policy. The steel rail-wheel system is highly efficient. High speed technology is proven and well liked by consumers. There is a huge network of standard railway lines that can feed and support an HSR network. Rail transport reduces energy use and greenhouse gas production.

The rest of this section describes ideas for innovation in high speed rail service. Since HSR technology (e.g. vehicles, train control systems, etc.) is already well developed, these ideas focus on service design, overcoming institutional barriers and encouraging strategic improvement of HSR network. The ideas are designed to move HSR from a path focused on refining the existing system to a disruptive innovation path, i.e. a path that leads to development and implementation of new services designed to better meet the transport demands of a modern society. Clearly, this section only scratches the surface of these topics and much more research and, especially, experimentation will be necessary.

Market Analysis

The first step in identifying a new development path for high speed rail is to identify activities that future HSR systems could enable and the markets they will serve. This means developing a deep understanding of customer needs, starting with the major trends affecting transportation: globalisation, demographic change, the information technology revolution and urbanization.

These four trends are acting together to make regions, i.e. clusters of cities, the centers of economic growth. These regions are fiercely competing for economic growth and development. Two key transport issues that impact regional competition are:

- Regions must have high quality international connections (international airports and high speed rail lines); and,
- Regions must support an intelligent combination of transport modes designed to enhance liveability since globalisation means that international corporations can be located anywhere and will choose locations with high liveability and access. [23]

However, planning and implementing an intelligent combination of transport modes is complicated by the miss-match between "economic" and "planning" regions. Economic regions are how the region actually works together – regardless of institutional borders, while planning regions are how infrastructure decisions are made. This means that projects such as a high speed line between Zurich and Munich, which make excellent sense in terms of the regional economies, are delayed since infrastructure planning is focused on local projects (e.g. the Zurich region within Switzerland).

One interesting trend in regional competition for economic growth from the perspective of high speed rail corporations are increasingly encouraging their employees to use high speed rail rather than flying for short trips as part of their corporate social responsibility program.

In summary, high speed rail will play a growing role in helping to define the competitiveness of regions, the new engines of economic growth. High speed rail planners must understand how HSR systems can be used to stimulate development and enhance regional liveability. This means, among other things, creating attractive local transport systems that are closely integrated with high speed rail and developing land use development patterns that maximize the value of high speed rail investments while increasing regional liveability. Again, this does not necessarily mean developing new technology, but rather focusing on overcoming the institutional barriers that prevent these goals from being accomplished.

Strategic Planning

It will be impossible to serve all markets with HSR service. Therefore investments should be subject to detailed strategic planning using techniques similar to the discovery driven process described above. Railway companies are thinking more strategically, for example, the SNCF believes it's not simply a matter of going faster, decisions on how fast trains must travel on particular lines involve a complex analysis of investment and operating costs as well as customer demand, including explicitly considering the competing modes of automobile and airplanes. [24] Germany has used its HSR experience to identify strategies for improving its network with an overall goal of considering improvements and new products in a comprehensive and coordinated fashion. [25]

The key strategic planning issue from the perspective of creating a new HSR system is to focus on creating an ***integrated international network*** rather than national networks. Encouraging outside companies to participate in operation and development of this international network could help support needed innovation. Outside companies could offer new HSR services or private-public partnerships could build strategic infrastructure projects designed specifically to support the international HSR network. There is much to learn in this area from careful evaluation of existing projects such as the Eurostar service and channel tunnel connection to London. [7] [8]

Independent Business Units

One way existing companies can innovate is to organize independent business units for the purpose of developing and deploying disruptive innovations. An excellent example of this approach in high speed rail is the SNCF's iDTGV service. Essentially, the SNCF formed a separate company to experiment with offering new services to passengers (e.g. quiet zones with restful amenities) and testing new operating strategies (e.g. checking tickets on platforms). The focus is not on new technology (normal TGV trains are used) but rather on operating the system in a different way. The approach transferred ideas from the low cost airline industry to HSR. [26] Results of the iDTGV have been excellent, two thirds of passengers are new business and load factors are 77% compared to about 71% for other TGV service. [3] It is interesting to note that implementing iDTGV service required overcoming institutional barriers as it was initially opposed by the SNCF labor unions.

Railway Operations Information Technology

A great deal of research is being conducted on the use of information technology for improving railway operations. Much of this research is designed to provide operators with tools for prioritizing infrastructure investments, recovering from delays and incidents, and helping develop prices for train paths. [27] The same tools could be used to help plan HSR networks and improve their operation.

The new IT tools are a good example of combining both aspects of the social-technical system. For example, the ability to reschedule trains in real time can both improve service (reduce total delay) and be used to feed information into the customer information systems (so customers know about delays and can decide how to respond). These types of systems, by helping to control the system and providing information to customers, begin to make rail systems better than automobiles – since trains can be exactly controlled for the benefit of travellers, while similar information systems for highways cannot "force" drivers to follow the optimal (from a system standpoint) routes.

Network Operating Strategies

The objective of high speed rail systems is to attract passengers by offering direct fast service, however to increase demand, planners must consider not only direct trips, but trips off the HSR network or requiring changing trains. A good approach for serving these types of trips is the integral timetable used in the Netherlands and Switzerland (Taktfahrplan). In this system trains arrive at node points just before the hour/half-hour, passengers change trains, and trains depart just after the hour. To make these systems work the travel time between nodes must be less than one-hour. This means that infrastructure plans and operating decisions must be made with this goal in mind, the Swiss say "not as fast as possible, but as quick as necessary".

The second part of improving network operations is to insure that good local and regional transport service is provided at the nodes to maximize market area and insure that expensive high speed trains are only used on routes where they generate a profit. The combination of good transfer opportunities and good local transport means more people can be attracted to the HSR system.

Railway Infrastructure Pricing Systems

A critical element in efficiently operating systems is pricing. Pricing gives signals that help people plan and act in the marketplace. Prices reflect the costs of providing services or products and often include some tax (used to increase or reduce demand, e.g. environmental charges).

EU regulations require that rail infrastructure operators adopt prices for using their networks. These prices are set differently throughout Europe and there is wide variation as well as uncertainty in their use. The variation and uncertainty works against encouraging international rail service, because it is hard to determine exact prices. Research has suggested that development of a more consistent methodology could improve this situation. [28] A short term solution developing joint ventures between different operators such as the SNCF has developed with DB on the TGV Est line, and with the SBB on routes to Switzerland.

High Quality Transport Service

High speed rail is expensive to build and operate. Therefore it needs to obtain high levels of revenue if it is to be economically successful. To do this it must offer high quality service.

Airlines define high quality service as frequent and available (meaning that it is always possible to buy a ticket for a flight just before departure), airlines charge high prices for this service. However, it’s not always possible for airlines to fill all the seats on their planes at high prices, therefore they use revenue management to obtain more revenue by selling tickets to price sensitive travellers at a discount (with restrictions). The SNCF is copying these techniques with its TGV service, its average load factor is 71%, and while this is better than the German ICE level (about 50%) it is worse than Air France’s level of 76% in European service. [3]

It is clear that high speed rail operators must develop revenue management programs to increase revenues. However, these schemes must be very carefully designed and implemented. Germany introduced revenue management in 2003, but was forced to drop it amid widespread customer disapproval and falling revenues. [24]

Technology Development and Implementation

There are many different technological improvements that can be made to improve the safety, quality and cost effectiveness of high speed rail service. Two significant problems are the legacy of different national technologies and the absence of a wholesale railway vehicle market. These increase both operating and capital costs as well as create barriers for introducing innovative services.

An important technological innovation effort designed to help revitalize rail service in Europe is development of the European Rail Traffic Management System (ERTMS) and European Train Control System (ETCS). These systems are expected to improve network capacity and reduce operating costs. However, their deployment has lagged. Therefore, in 2005, the European Commission developed a program of identifying rail corridors and developing improvement programs to improve rail service compared to competing modes. In addition to ETCS, these plans consider other improvements designed to improve capacity, operations, efficiency and marketability. The EU has earmarked 500 million Euros for deployment of ETCS projects in the TEN-T rail network between 2007 and 2013. [29] This technology will be critical to creating a true HSR network for Europe and it will be important to monitor its progress.

5. CONCLUSIONS AND RECOMMENDATIONS

This research makes the case that by developing and implementing a series of disruptive innovations high speed rail could be transformed into a mode of transport ideally suited to meeting future transportation demand while helping reduce energy use and environmental pollution.

The key is overcoming institutional barriers to innovation in service design, pricing strategies and integration with other transport networks. HSR technology is already well developed; it must be deployed strategically to compliment these service innovations. Deploying new technology without service innovation will keep HSR on its current path, good in some markets (especially in densely developed areas), but difficult in other markets.

New means of transport will be needed to address changes in society and help people do the things they want to do. High speed rail could play a role in this future transport system, but there is a great challenge in changing the way railway and government institutions operate.

Aggarwala, in an article describing what planners could learn from development of major infrastructure systems in the United States, finds that it is unlikely that the federal government will play the key role in the initial development of high speed rail. Instead federal funding will only be available when HSR benefits have been proven, if HSR does not threaten other programs and if the program includes benefits for the entire country. 30

In the context of this research, Aggarwala's approach makes perfect sense. A state would have a much greater chance of being able to implement the disruptive innovations needed to build a successful HSR network, just as New York took the lead in developing the Erie Canal and California developed the modern freeway network. In fact, California, with its expected high rate of growth, reputation of technological excellence, environmental concerns and the support of elected officials could be an excellent candidate for developing an innovative HSR system.

However, as this research argues, to be successful HSR cannot simply be an improved railroad. It must, in the tradition of other great California innovations, be closely integrated with the social systems needed to enable high speed rail to attractively and efficiently serve modern transport demand. Specifically, the HSR system would need to include land use planning and development, be carefully integrated with multimodal transport systems (including freight), and have the ability to encourage entrepreneurs to create new products and services.

This paper presents policy recommendations for transforming high speed rail into a new system designed to better meet future transport demands. The paper outlines initial ideas and, as such, there is need for more research in almost all the topics covered. However, the key areas for further research include the development of independent business units (e.g. iDTGV), integration of HSR with new spatial development patterns, new railway operating stategies (e.g. Taktfahrplan, and real-time rescheduling), and methods to better finance HSR projects (including revenue management and innovative infrastructure pricing strategies).

REFERENCES

1 http://www.economist.com/printedition/displayStory.cfm?story_id=9441785&fsrc=RSS accessed July 10, 2007.

2 http://www.alstom.com/pr_corp/2007/ accessed July 30, 2007.

3 Briginshaw, David; Pepy Predicts Radical Changes in the HS Market; International Rail Journal, July 2006; pp. 14-15.

4 Faugere, Mireille; TGV, du produit a la marque: 25 ans de Service aus clients; Revue Generale des Chemins de Fer; September 2006; pp. 11-23, (TGV, from product to trademark, 25 years of service to customers).

5 Jaensch, Eberhard; Hochgeschwindigkeitsverkehr in Deutschland – 15 Jahre Erfolg; Eisenbahn Techniche Revue, October 2006, No. 10; pp. 704-712; (High Speed Transport in Germany – 15 Years of Success).

6 Rühl, Aad; Rail News from Europe; Intercity Rail Passenger Systems Update; Number 12, Summer 2007; http://onlinepubs.trb.org/onlinepubs/irps/irps_12.pdf accessed July 27, 2007.

7 Flyvbjerg, B., N. Bruzelius and W. Rothengatter; Megaprojects and Risk, An anatomy of ambition; Cambridge University Press, Cambridge; 2003.)

8 Hall, Sir Peter; High Speed Rail Comes to London; in Access Issue 19, published by University of California Transportation Center, Berkeley, CA, pp. 26-31; Fall 2001; http://www.uctc.net/access/access19.pdf accessed November 14, 2007.

9 http://www.railteam.com/en/ accessed July 31, 2007.

10 Vickermann, Roger; Indirect and wider economic impacts of High-Speed Rail; paper presented at the 4th Annual Conference on Railroad Industry Structure, Competition and Investment, 2006; available at: http://www.eco.uc3m.es/agenda/mad2006/papers.html accessed July 25, 2007.

11 Nieder, Babette; TGV und ICE, im Spannungsfeld von Politik, Verwaltung und Industrie (1968 – 1991) Ein deutsch-franzoessicher Vergleich; Verlag fuer Wissenschaft und Kunst, Herne, 1997; (TGV and ICE, a comparison between the German and French approaches).

12 Garrison, William L.; Historical Transportation Development; Institute of Transportation Studies, UC Berkeley, Research Report; July 2003; available at http://www.its.berkeley.edu/publications/UCB/2003/RR/UCB-ITS-RR-2003-6.pdf accessed July 11, 2007.

13 http://innovationzen.com/blog/2006/08/17/innovation-management-theory-part-4/ accessed July 11, 2007.

14 McCraw, Thomas K.; Prophet of Innovation Joseph Schumpeter and Creative Destruction; Belknap Press; 2007; Q&A with author: http://hbswk.hbs.edu/item/5619.html accessed July 11, 2007.

15 Christensen, Clayton M.; The Innovator's Dilemma : When New Technologies Cause Great Firms to Fail; Harvard Business School Press, 1997.

16 http://www.businessweek.com/innovate/content/jun2007/id20070615_198176_page_3.htm accessed July 11, 2007.

17 http://www.slate.com/id/2167909/nav/navoa/ accessed July 10, 2007.

18 http://innovationzen.com/blog/2006/10/04/disruptive-innovation/ accessed July 11, 2007.

19 http://faculty.msb.edu/homak/HomaHelpSite/WebHelp/Discovery_Driven_Planning.htm accessed July 11, 2007.

20 Anthony, Scott D., Erik A. Roth and Clayton M. Christensen; The Policymaker's Dilemma: The Impact of Government Intervention on Innovation in the Telecommunications Industry; Harvard Business School Working Paper #02-075; 2002. Available at: www.innosight.com/documents/PolicymakersDilemma.pdf accessed July 11, 2007.

21 Ivaldi, Marc and Paul Seabright; The Economics of Passenger Rail Transport: A Survey; IDEI Working Paper, no. 163, 2003; available at: http://idei.fr/vitae.php?i=42 accessed 26 July 2007.

22 Siebt, Claus and Herwig Schoebel; Rail-Net – Innovationshindernisse im Gesamtsystem Bahn; Innovatives System Bahn, Vernetzungsworkshop 2007; Bundesministerium fuer Verkehr, Innovation und Technologie; presentation available at: http://www.bmvit.gv.at/innovation/verkehrstechnologie/isb/workshop/index.html accessed 26 July, 2007.

23 Halbert, Ludovic; Pain, Kathryne; Thierstein, Alain; European Polycentricity and Emerging Mega-City Regions: `One Size Fits All` Policy?; in: Built Environment, Vol.32 (No.2), pp. 205-218; 2006.)

24 Pepy, Guillaume; Heading for very high speed?; Rail & Recherche, January-February-March 2007, No. 42; SNCF, Paris.

25 Breimeier, Rudolf; Planning principles for newly constructed and modernized lines; ZEVrail Glasers Annalen 130, 6-7 June-July, 2006; pp. 250-266.

26 Sauter-Servaes, Thomas and Andrew Nash; Applying Low Cost Airline Pricing Strategies on European Railroads; Transportation Research Record #1995: pp. 1-8; Transportation Research Board, Washington D.C.; 2007.

27 Lüthi, Marco, Giorgio Medeossi, Andrew Nash; Evaluation of an Integrated Real-Time Rescheduling and Train Control System for Heavily Used Areas: Paper presented at the International Seminar on Railway Operations Modelling and Analysis (IAROR) 2007 Conference, Hannover, Germany.

28 Calvo, Francisco Javier, Juan de Ona and Andrew Nash; A Proposed Infrastructure Pricing Methodology for Mixed-Use Rail Networks; Transportation Research Record #1995: pp. 9-16; Transportation Research Board, Washington D.C.; 2007.

29 Vinck, Karel; It's now or never for ERTMS roll-out; Railway Gayette International; May 2007; pp. 275-278.

30 Aggarwala, Rohit T.; The States, New Modes, and Federal Transportation Policy: Lessons from History for High-Speed Rail; Transportation Quarterly, Volume 52, No. 3, Summer 1998; pp. 53-67.