RAIL REINVENTED?

A Brief History of High Speed Ground Transportation

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INTRODUCTION

Despite the decline of passenger rail service for over a half century, the past decade has brought a renewed interest in intercity high speed ground transportation in the United States. Building on successful deployment in France and Japan, preliminary planning is being undertaken to bring high speed rail transportation to America. Though it is clearly descended from conventional rail, in this paper, high speed rail is considered a distinct mode of transportation.

The operating high speed rail (HSR) systems serve high volume, near-by, intercity markets. Examples include the Shinkansen (or bullet train) in Japan or the Train a Grande Vitesse (TGV) in France, which is being extended to a Europe-wide network. Currently ten countries operate trains above a maximum speed of 200 km/hr (JRE, 1994). Proposals in the United States include the a train connecting southern and northern California; the “Texas Triangle” connecting Dallas, Houston, San Antonio, and Austin; in Florida connecting Miami with Orlando; and in the Midwest connecting Chicago and Detroit.

Several technologies lie behind high speed ground transportation (HSGT). The most common form, high speed rail, is most clearly extended from conventional rail, with technological improvements in the train as well as more conducive right-of-way conditions. Some studies, and several prototypes, have evaluated “magnetic levitation” (maglev) technology, which differs greatly from conventional service. To give some definition to what is considered high speed, a test track in Japan has recorded 500 km/hr on a maglev line, compared with maximum speeds of 270 km/hr on more conventional high speed operating lines in Japan, with a maximum of 425 km/hr in 1993 on a test facility with a prototype HSR train. The French HSRs are somewhat faster, a high operating speed of 300 km/hr on TGV operations is achieved in France, with maximum test speeds rising from 280 km/hr in 1981 to 515.3 km/hr in 1990. However, neither the maglev or nor TGV at its highest speeds have been made operational. In either case, extended conventional technology or maglev, as its name implies, HSR is significantly faster than conventional rail service. The service operates on dedicated right-of-way, with track, grades, and curvatures designed considering HSR. Similarly, the engines and trains have also been redesigned.

While its technological advantages over conventional rail are obvious, there are several unresolved questions. *When is it advantageous over other modes?* HSR lacks the point-to-point convenience of the auto and the speed of the airplane on long trips. *When is it worth the cost?* The benefits of new infrastructure in an already well-served area are elusive, and in all cases, HSR requires government subsidy of some form or another, despite assertions of profitability in the French and Japanese cases.

By examining the setting of HSR, perhaps some light can be shed on these questions. The next section analyzes data from France and Japan to establish at least preliminarily, the life-cycle of the mode. This is followed by discussion of the pre-cursor, birthing, growth, and mature phases of high speed rail.

LIFE-CYCLE

The life cycle of a technology can be divided into three stages: birthing, growth, and maturity. While high speed rail is new in the United States, it has been deployed in Japan for about thirty years and in France for almost fifteen years. As these systems are still operating (and growing), it is too early to write the definitive history of HSR. Still, some information can be gleaned by applying methods for analyzing modes to detect which stage each line is in.

Figure 1 displays the ridership on the Japanese Shinkansen (Taniguchi, 1992) as well as the predicted ridership from applying a logistic equation as described in Grubler () and calculated below. Figure 2, shows the observed information for the French TGV-Southeast (Mathieu, 1991) as well as the predicted value from a second logistic estimation.. The parameters of the equations are given in table 1. While as a macroscopic indicator, the logistic approach may be appropriate, clearly the real world is noisier close up. The logistic equation does not predict ridership spikes such as that caused by the 1973 oil shock.

Estimation of S-Curves

	Shinkansen	**TGV - South East**
Parameters		
a - constant	-219.9	-1606.6
b (ß)	0.1111	0.8096
t-statistic (on ß)	12.5	8.7
r-squared	0.87	0.89
N (# Years)	26	11
to (inflection year)	1980	1984
delta-t (10%-90% timespan)	39.6	5.43
K (max. annual ridership)	290,000,000	19,200,000

This analysis suggests that, as one might expect, the scale of the system under analysis determines its growth-span. The larger Shinkansen has a growth period of 40 years, about 7 times longer than the single TGV line analyzed. The larger TGV system may approach the Shinkansen in the length of its deployment period, and the Europe-wide system may exceed it. Despite both systems claiming profitability, the Shinkansen clearly will serve many more people than even a fully deployed French system. Further, it should be expected that the French built their most promising line first, so that other lines may not grow to the same scale, though this is counter-acted by possible network effects, where the expansion of the network increases disproportionately the number of origin-destination combinations which can be served.

PRIOR CONDITIONS

Prior to the introduction of high speed ground transportation systems in Japan and Europe, and currently in those countries as well as the United States, a number of other modes of intercity passenger travel exist, including conventional rail, airplanes, and the automobile. In Europe and Japan, air travel has been artificially constrained by governmental regulation and the limits on competition. Thus the market for high speed rail probably appeared more promising than in a deregulated environment due to these limits on air travel.

There are however constraints on the growth of the highway and air travel systems. Widely cited is congestion, or capacity limits. Airports have limited capacity to serve aircraft in peak times, as do highways. In a priced system, this would result in higher user charges, but in an unpriced system, there are simply queues formed. High speed rail, which has potentially very high capacity on its fixed corridors, offers the promise of relieving congestion on the other systems. In Europe and Japan, with important, though declining, conventional rail services, its extension and adaptation to a higher speed technology was a more obvious choices than in America.

In the United States, congestion/capacity problems are less severe than in Japan and Europe. Moreover, conventional passenger rail has long been a less important mode than the other two. Further, the markets for which rail is best suited, high volume, short distance markets are less common in the United States. For these reasons, high speed rail remains in a birthing or pre-birthing stage here.

The other widely cited complaints against the air and highway modes are their externalities: pollution, noise, accidents, etc. While it cannot be argued that either air or highway modes have internalized their externalities, it also cannot be argued that from a systems perspective high speed rail does not create problems of its own. Access to rail generally requires vehicle trips. These vehicle trips generate pollution of their own, for instance the most severe pollution comes from the so-called “cold start”, or running a car before it is warmed up. Further, it is difficult to establish how much of the demand on high speed rail is diverted from other modes and how much is induced travel. While induced travel may expand the economy, it certainly does not mitigate externalities.

In short, while the conditions have been favorable for the development of HSR in Europe and Japan, they are clearly less so in the United States.

INVENTION AND INNOVATION

Much of the technology behind high speed rail is just improved application of existing technology. By building a new rail infrastructure with 20th century engineering, including elimination of constrictions such as roadway at-grade crossings, frequent stops, a succession of curves and reverse curves, and not sharing the right-of-way with freight or slower passenger trains, higher speeds (250 - 300 km/hr) are maintained. A record speed of 515 km/hr has been run using TGV technology.

The cost of construction is minimized by adopting steeper grades rather than building tunnels and viaducts. Because the lines are dedicated to passengers, grades of 35%, rather than the previous maximum of 10-15% for mixed traffic, are used. Possibly more expensive land is acquired in order to build straighter lines which minimize line construction as well as operating and maintenance costs.

The Japanese (JRE, 1994) continuously have improved all aspects of their system over the years. Major improvements since the first opening in 1964 include the introduction of computerized crew training systems, double-decker cars to expand capacity, the use of regenerative breaks to conserve energy, lowering the weight and increasing strength of cars, the use of electronics in mechanical system management, mechanization of track maintenance, the introduction of tilt trains, the incorporation of aerodynamic considerations in train design.

The French, have introduced new customer service improvements on this principally business oriented service, including additions of telephones, access for the disabled, redecoration, and improved comfort due to new suspension (Schwerr, 1992).. However the TGV is newer, and may have less need or opportunity for innovation than the Shinkansen. Obviously not all of the French improvements have been "pseudo-innovation", there have been minor technical improvements as well as operational reorganizations. But the differing focus of the Japanese and French systems is instructive.

EARLY MARKET

The early markets identified by the French, Japanese, and in the U.S. proposals are to connect pairs of the largest nearby cities. In France this was Paris-Lyon, in Japan Tokyo-Osaka, and in the U.S. the proposals are in high density areas, with the only successful higher (though not high) speed rail service in the north-east corridor.

Market segmentation has principally focused on the business travel market. The French focus on business travelers is reflected in the nature of their rail cars (including the all-important bar-car as noted above). Pleasure travel is a secondary market, though many of the French extensions will connect with vacation beaches on the Atlantic and Mediterranean. In fact, Friday evenings are the peak time for TGV (Metzler, 1992). The system has lowered prices on long distance travel to better compete with air service, and have even turned cities now within an hour of Paris (by TGV) into commuter bedroom communities, increasing its own market while restructuring land use.

BIRTHING

Unlike other modes, whose emergence have at least in part been the result of a forceful entrepreneur, George Stephenson, Peter Cooper, Henry Ford, or Orville and Wilbur Wright come immediately to mind, high speed ground transportation has been a product of planning from the central government in Japan, France, and the United States.

Five years after construction began on the line, on the eve of the Olympic Games in Tokyo, the first Japanese high speed rail line opened in 1964, connecting the capital with Osaka. This Olympic target date clearly reflects mercantilist interests in the promotion of modern Japan to the world. The French high-speed rail, the TGV, was opened in 1981 by SNCF, the French rail agency, also after many years of planning, beginning in 1966 and construction beginning in 1976. The opening ceremonies were a significant event, being reported internationally, but not associated with a major showpiece even such as a World's Fair or Olympic Games.

Depending on how it is defined, high speed ground transportation in the United States today remains in its birthing, or even pre-birthing stage. The United States efforts have been multi-pronged, various states have promoted study and design of high speed rail lines, six corridors have been designated by US DOT for study as high speed rail corridors: (1) Chicago to Milwaukee, St. Louis, Detroit, (2) Miami-Orlando-Tampa, (3) Washington D.C.-Richmond-Raleigh-Charlotte, (4) San Diego-Los Angeles-Sacramento, (5) Eugene-Portland-Seattle-Vancouver, (6) New York-Albany-Buffalo. The Clinton Administration has proposed a High Speed Rail Development Act (1993), again to study the issues involved and provide seed money. Money was set aside in ISTEA (1991) for magnetic levitation development, and proposals for deployment have been made in Orlando and Texas, but there is still not maglev operating in revenue passenger service.

In the area of higher speed (but not quite high speed) rail, money has been set aside for the electrification of AMTRAK's northeast corridor and elimination of at-grade crossings

In terms of its top-down planning, the development of high speed rail in the United States borrows conceptually from the interstate highway system. Typically modes emerge without any significant or central planning at the outset, examples include air travel, highways, or rail. Later central planning is tacked on, as when the government established specific trans-continental routes or began funding airports or the interstate highways. In all likelihood this probably confirms high speed rail's role as successor to conventional rail rather than holding status as a new mode on its own.

Operationally, the systems are largely adapted from conventional rail systems, with similar labor organization and ownership in Japan and France and similar architectures in many other respects.

GROWTH

In 1967, after the Tokaido Shinkansen was deployed, a second line, the Sanyo Shinkansen was begun. The inter-relationship between land development and the high speed rail network was recognized, leading, in 1970, to the enaction in Japan of a law for the construction of a nationwide Shinkansen railway network in order to expand the network. By 1973, the Transport Minister approved construction plans for five additional lines and basic plans for twelve others. But despite the approvals, financial consideration intervened, the cost of the five lines (five trillion yen, or fifty billion dollars at 100 yen to the dollar, a somewhat hopeful exchange rate) combined with the oil shock and recession of the late 1970's and early 1980's result in their delay until 1989. Ironically, high oil prices, which should increase the relative demand for non-oil based transportation such as high speed rail, delayed their construction.

The new Japanese lines are also not "Full Shinkansen", with all of the characteristics of high speed rail. Rather they are mixed, and thus less expensive technology, combining narrow gauge and wider gauge lines on the same structures. New structures allow for eventual upgrade, but existing narrow-gauge structures are kept in places, allowing the bullet train to use them, but not at the higher speeds. As with birthing, the 1998 Winter Olympics in Nagano Japan are a target for the opening of an rail line extension.

If one views high speed rail as an attempt to adapt passenger rail, then its entire existence has been marginal changes to a mature mode. If however, one views it as a new mode, it has only been in its mature phase in Japan for a few years. In France, the mode as a whole is still growing, though specific lines have been deployed and possibly reached equilibrium levels of ridership, with slight growth associated with population.

Within Japan, some of the most significant changes in the mode's growth phase has been the break-up and privatization of the rail system, begun in 1987. The restructuring is hoped to lead to more efficient methods to ensure profitability in the passenger rail sector. Incremental improvements to the high speed rail technology are continuously being undertaken, and the network continues to be expanded. As an example of improvements, the travel time from Tokyo to Shin Osaka (the first route opened), has decreased from 4 hours in 1964, to 2 hours and 30 minutes.

CONCLUSION

Despite a great deal of legislative effort and lobbying by the large engineering interests, it is doubtful that without considerable subsidy high speed rail could be constructed, much less profitable in the United States. The conditions in Europe and Japan during the conception and birthing stages are significantly different than most parts of the United States. Land uses are denser and cities are closer together. Furthermore, constraints on federal spending in the 1990's hinder the development of new infrastructure. A last key distinction is that the regulated transportation sectors in Japan and Europe prevented competition from air travel to the same degree as in the United States when the HSR lines were planned and deployed. Had air travel been deregulated and privatized at the time, the decision to proceed with high speed rail, particularly in Europe, may have been different. As an illustration of this, Southwest Airlines is a major opponent of high speed rail in Texas (Krumm, 1994)

As with all rail modes, there is a significant amount of inflexibility associated with the system design. The high speed networks are limited, and the rails require very specific vehicles. Compared with the greater flexibility afforded the untracked air travel system or the ubiquitous highway system, high speed rail faces serious difficulties.

It will be interesting to observe the progression of the Japanese and European high speed rail systems from growth to maturity, and to compare this with the earlier history of conventional rail. Whether high speed rail is a new story, or simply the final chapter to the history of conventional rail waits to be seen.

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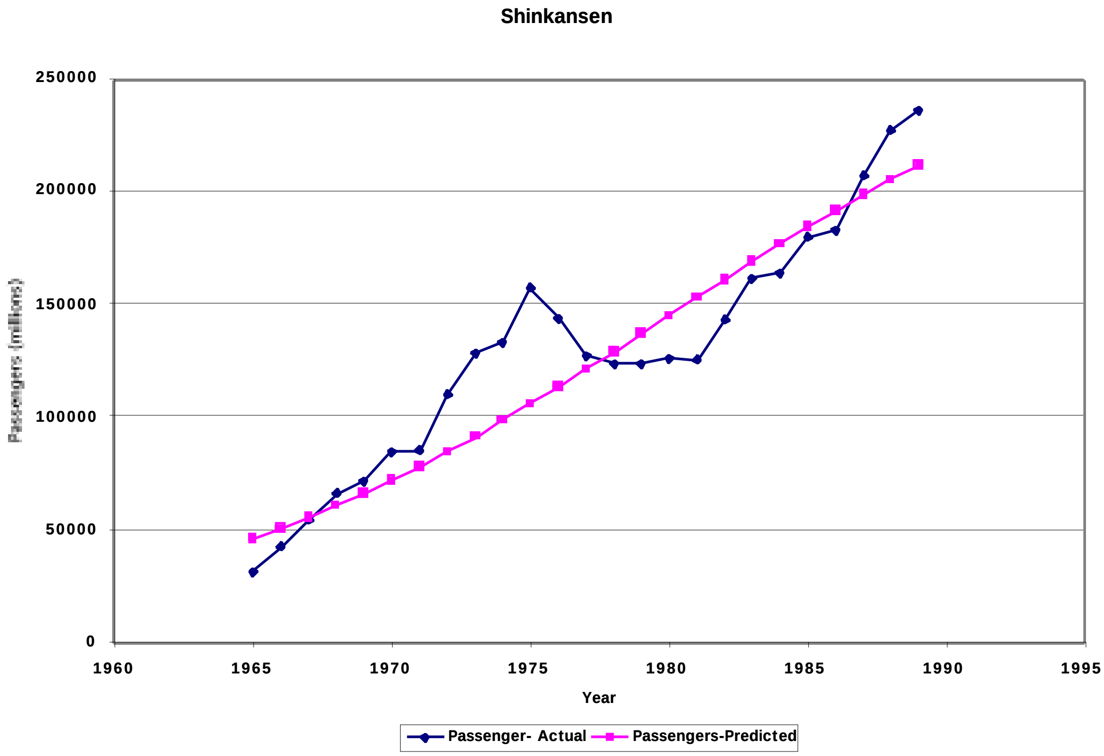
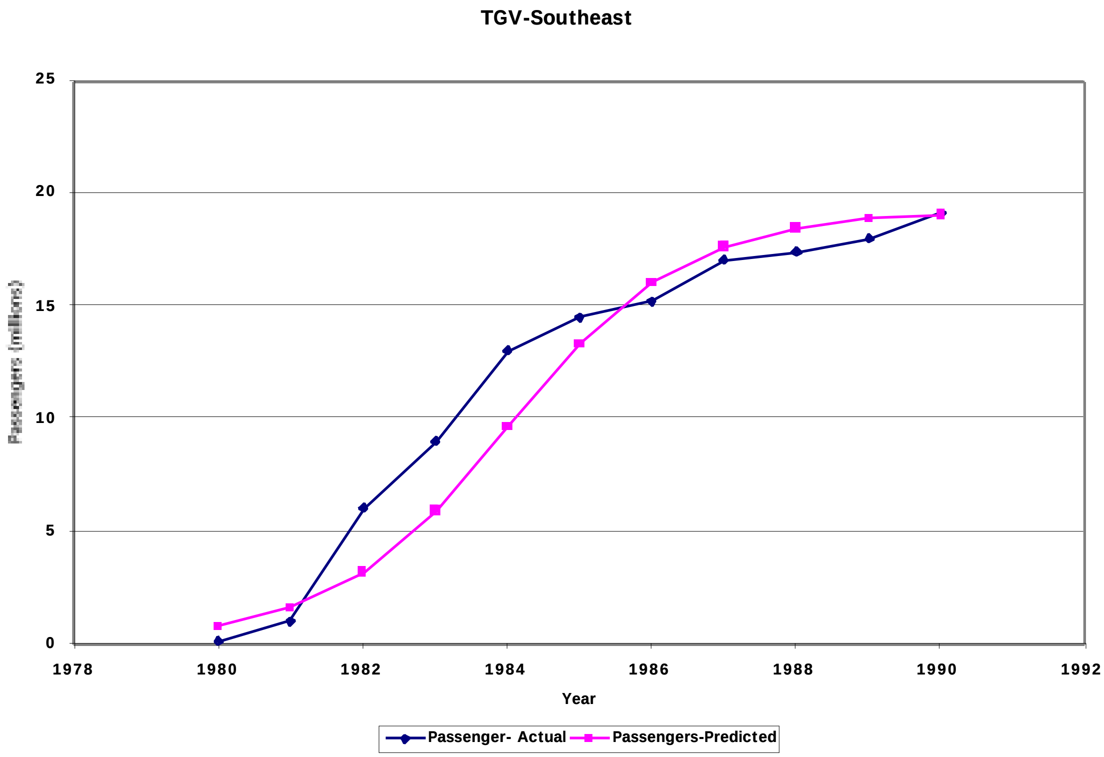

Shinkansen
250000
200000
150000
100000
50000
0
Passengers (millions)
1960
1965
1970
1975
1980
1985
1990
1995
Year
Passenger- Actual
Passengers-Predicted


TGV-Southeast
25
20
15
10
5
0
Passengers (millions)
1978
1980
1982
1984
1986
1988
1990
1992
Year
Passenger- Actual
Passengers-Predicted