BSL Management Consultants of the Lloyd's Register Group

Southern California Logistics Rail Authority

Maglev or High Speed Rail in the Las Vegas to Southern California Corridor

Hamburg, November 2008

BSL Management Consultants GmbH & Co. KG

Lloyd's Register

Content

1. The Background and Aim of This Paper

The Las Vegas to Southern California corridor is a heavily frequented transport link between the fast growing urban areas of Clark County, Nevada, with over 2 million residents, and Southern California, where nearly 60% (almost 23 million) of the states' population of over 38 million people live. While travel demand is projected to grow even further, the transport infrastructure already is increasingly saturated, both in terms of the I-15 highway and the Las Vegas McCarran International Airport as well as all of the Southern California airports.

Given the need to increase transportation capacity, ground based mass transit systems can be an important part of a solution to future transport challenges with a number of economical and ecological advantages.

A 2007 study by the Regional Transportation Commission of Southern Nevada focused on restored intercity passenger services with conventional rail-equipment for existing corridors.

A privately funded high-speed rail (HSR) project, the so-called "*DesertXpress*" (DX), is proposed by DesertXpress Enterprises. It will start in Las Vegas at a proposed interchange point with the Monorail, and run directly towards Victorville, California, mostly parallel to the I-15. Scheduled for opening service in 2013, 5.1 million annual round trips are forecast for trains with a maximum speed of 150 mph, which will result in travel times lower than 1.5 hours over the nearly 200 miles distance. The environmental impact statement (EIS) is nearing completion and preliminary engineering has been completed. All of the project development work, including the EIS, is being privately paid for.

A separate vision is the "*California-Nevada Super-Speed Train*", which also intends to roughly follow the I-15 freeway but with a Magnetic Levitation (Maglev) system and track infrastructure. Travel time between Anaheim and Las Vegas (269 miles) is estimated to be less than 1.5 hours due to speeds of up to 300 mph. This would be the first long-distance application of Transrapid technology. Initially, the Magline Group plans to construct the 35-mile connection between Las Vegas and Primm at the California state line. The Maglev project expects funding partly from tax-payers and partly from private investors. The American Magline Group, working with the California-Nevada Super Speed Train Commission, has received federal government funds for the early planning and promotion of the project. Some $45 million in federal highway trust funds were recently allocated to the Maglev project for planning and environmental study purposes in 2009. Both the DesertXpress and the proposed Maglev system could service the proposed Las Vegas-Ivanpah Valley Airport connection to Las Vegas, although the DX project's EIS is not assuming this will occur.

Both the DX and the Maglev project would improve capacity and service quality in the corridor and could shift at least 25 percent of the automobile traffic off I-15. As a practical matter, both projects are competing for implementation since transport economics will justify one system only.

In view of the fact that the proposed projects would have stations in Victorville, the City of Victorville, California has had extensive experience working with both the DesertXpress and American Magline Group projects extending over many years. For example, Victorville Mayor (now City Councilman) Mike Rothschild served for many years as a member of the California/Nevada Super Speed Train Commission. In addition, the City has cooperated with DesertXpress throughout their project planning and environmental impact process.

Because the proposed project could have a profound impact upon the mobility of its residents and help reinforce the economic vitality of the entire High Desert region, the City, working through the Southern California Logistics Airport Railroad Authority, decided to conduct a feasibility study and comparison of the maglev and DX projects. Having been involved with these issues for some time, it became apparent to the City that only one of the proposed projects is likely to be implemented, making it imperative to consider their viability and likelihood of success. Given that both proposals are based primarily upon technologies developed in Europe, it became clear to the City that it was necessary to seek out a European-based consultant with hands-on factual information about both systems. Thus, the City selected the BSL division of the Lloyd's Register Group, a firm that has advised the European Union and several of its members on high speed transportation issues and policies.

Against that background, this paper aims to support the policy-level discussion by comparing key Maglev and HSR characteristics. It builds on "*lessons learned*" from European and Asian countries with tested real-life experience from operations or advanced planned projects of both systems, which will be related to the situation of the Las Vegas–Southern California corridor. Specifically, the paper will address the following study objectives:

- Case studies examining the Maglev projects planned and/or built in Germany and China including a discussion of Transrapid's worldwide prospects which covers American experience which has been restricted to planning only.
- The system characteristics of Maglev that will make it suitable or unsuitable for the Las Vegas – California corridor including technical aspects of infrastructure and operations.
- Economics including capital costs, O&M costs and assumed revenues, energy consumption, strength of the supply chain for delivery and long-term O&M
- The impact of that cost on other transportation priorities in the corridor.

2. Overview of International Experiences with Maglev

Different technologies apply and exist for Maglev high speed systems. Plans for Nevada-California focus on the Transrapid. Thus this paper will focus on the Transrapid experience as this is the only system that can claim to have a commercial operation and can provide a point of reference. Since 2004 a 19-miles link between Pudong International Airport Shanghai (China) to a suburban railroad station has been in operation with speeds up to 260 mph. An alternative Japanese technology has been in development since the 1990's at a test ring in Yamanashi (Japan). Recent developments have also taken place in Dalian, China.

The use of magnetic forces to lift, move and guide a vehicle over a specially designed guideway can reduce wear and tear on the track infrastructure. Thus, high acceleration and speeds up to 300 mph can be reached. However, numerous attempts to bring the technology into commercial operation failed in recent decades so there is very little real world experience.

The underlying reasons for the repeated failure to produce a commercially viable system are to be found in basic transport economic realities. On a recurring basis understated costs in the early planning are followed by new more realistic estimates. These in turn are then compared to conventional high speed rail in a similar corridor. In the German experience at least, this has always resulted in a finding that additional costs of Maglev can not be justified and can not be recovered from the market.

The German Transrapid experience undoubtedly provides the best commercial reference for the Nevada-California case. Putting China aside, this is the only case in the western world where a major commitment was made to implement a high speed maglev transportation solution. For decades the German Federal Government was the primary sponsor of maglev technology. It was German policy at the highest levels to promote the technology as a showcase from which to launch world wide sales of the Transrapid maglev system. Development was funded with about 1.4 billion Euros of taxpayers' money (approximately $2 billion U.S.). Thus, detailed project plans were prepared that included specific right-of-way decisions and funding agreements. These projects consistently moved forward with great political support until severe miscalculations in project economics became apparent. For many years, significant investment in these projects continued until they were finally abandoned. Meanwhile, competitive rail projects were postponed which resulted in rising costs and delays in achieving the rail service. In the final analysis, this proved to be extremely costly and the decision was made to abandon further consideration of Maglev implementation in favor of rail.

In the following case studies, the relevant facts of the most advanced planned Transrapid-projects worldwide will be outlined:

1. the Hamburg-Berlin route,
2. the so-called "*Metrorapid*" in North Rhine Westphalia,
3. the Munich Airport link (the most recent project).

2.1 Hamburg – Berlin Project

Infrastructure improvement played a big role in the context of German reunification. One symbolic and popular proposal was to create a high speed connection between the Northern metropolis of Hamburg and the new capital city of Berlin through the former Eastern German countryside (180 miles). This corridor would not only link East and West, but it would also connect the two most populated metropolitan areas in Germany.

In 1996, a decision was made at the highest levels of the German government to build a Transrapid Maglev System on this route. Estimated infrastructure costs (CAPEX) of 3.1 billion € were to be provided by the state, while another 1.9 billion € for rolling stock and system equipment were initially to be funded by industry partners. Later on, the investment would be refinanced by user fees of German state railways, the anticipated operator. In the standard German planning process a series of formal steps for major infrastructure investments start with "*demand projections*". Demand for this project was "*stated*" in special legislation so that the formal steps to approve a transportation project could be suppressed. Revenue projections were based on the assumption of 15 million passengers annually.

In the course of the project preparation, both infrastructure costs increased and serious concerns about the demand figures occurred:

- A 1998 study of the German Federal Railway Authority indicated that infrastructure costs would rise to a range of 3.9 -4.6 billion € (about plus 25-45%). Further calculations showed that infrastructure costs would even rise up to 5 billion € and rolling stock/system equipment costs up to 2.4 billion €.
- A revised demand assessment concluded that assumptions about strong economic developments would not materialize. It also questioned the projected suspension of services on the existing parallel rail line. This was hardly realistic in the context of open network access for all rail operators which is required by the rules of the European Union. The assessment concluded that only one third of expected passenger numbers were realistically achievable.

Disillusioned political stakeholders decided in 2000 to stop the project and upgrade the existing railway line to produce high speed rail service. Thus, high speed ICE trains now serve the route every hour with speeds up to 140 mph at less than 100 minutes travel time.

In this context it was nevertheless decided to divert some of the funds foreseen for the Berlin-Hamburg project to another Maglev project in Germany. After studies of five possible routes, two regional lines were selected for further planning. These were the so-called Metrorapid and an airport-link in Munich.

2.2 Metrorapid

A 50 mile Transrapid-link between six neighboring cities within a densely populated, old industrial area of Germany was approved in 2002. Travel time was expected to be reduced by 35% due to a planned maximum speed of more than 180 mph. Since routing was designed primarily along existing rail lines, the Transrapid-link was to be integrated into hubs of the regional rail network.

Expected investment costs (CAPEX) were 3.2 billion €, of which at least 2 billion € were to be publicly funded. The operation was scheduled to start at the Soccer World Cup 2006 in Germany.

In the course of the planning process the projected cost increased by 1.5 billion € (about 45%). Thus, the government of North Rhine Westphalia decided in 2003 to stop the implementation of the project. This came after 54 million € of public funds were spent on the project. Quotation of the prime minister: "*We have to decide against the desirable and for the feasible*".

2.3 Munich Airport Link

The 24 mile-long connection between the main train station and the Munich-airport has been the most promising Maglev project in Germany. Travel time would have been reduced from 40 minutes with current suburban trains to 10 minutes by a Transrapid service running every 10 minutes at 155 mph within the city area and more than 215 mph outside.

Investment costs were estimated at 1.4 billion € in 2002 and raised to 1.8 billion € in 2005. Little private investor interest was found, thus it was decided the project would be almost completely publicly funded. On this basis the project was contracted in 2007.

Preliminary engineering works up to detailed planning were undertaken. The goal was to complete the right-of-way by mid 2008. As the planning went forward, strong concerns arose again over the project's cost projections and commercial viability. There is little question that the project was politically driven, neverthe-less, concern continued to grow that the project's cost framework was unrealistic.

Finally, in early 2008, updated investment cost assessments were delivered that estimated the cost of the project would be 3.4 billion € (+80%). In March 2008 it was decided to drop the project and not to pursue it further. The city of Munich is much in favor of realizing a suburban express train now, which is to be operated basically based on the existing track infrastructure.

2.4 Other Projects World Wide

2.4.1 China

Since no other projects are in an operational stage of implementation at the moment, the Shanghai line remains the only commercial project world-wide to which we can look for a foreseeable period of time.

The "*Shanghai Magnetic Levitation Demonstration*" was the first commercial high-speed maglev line in the world, and it remains the only one in operation. The system and trains were built to the Transrapid standard. Construction began in March 2001, and public service commenced on 1 January 2004. Services run with high reliability, although there was a serious fire on one of the trains on August 2006, reportedly due to a failure of the vehicle battery.

Decisions about an extension via Shanghai Hongqiao International Airport, the Shanghai South Railway Station and the Expo 2010 site towards the city of Hangzhou (110 miles) have been on the planning table for many years, but remain unclear. Officials estimate the cost of the project construction to be about $5 billion US. Media reports on 26 May 2007 said the Shanghai city government announced that the project had been suspended, citing "*radiation concerns*". However, the Shanghai government then denied those reports. In a highly unusual event in China, during January and February 2008, after being turned down for demonstration permits, hundreds of residents demonstrated in downtown Shanghai against the line being built close to their homes. The residents were reportedly concerned with potential health hazards, noise and loss of property value.

The status of the extension is unclear although in August 2008 the Shanghai Daily reported, that the final decision has been made, and that construction of the project would start in 2010. According to German press reports, Chinese stakeholders have struggled to gain direct control of the Transrapid technology, and have repeatedly suggested that they will launch their own initiatives to develop any extension.

In the meantime, 6.000 miles of high performance conventional rail network for speeds between 150 and 190 mph are planned and scheduled for completion within the next 15 years in China. A 75 miles connection between Beijing and Tianjin was put into operation in 2008.

Consistent with their commitment to intercity high speed rail, China already has new versions of the Swedish Regina high speed trains operating at speeds of 125 miles per hour and has ordered a new fleet of 150 mile per hour trains based upon this technology – which is the same technology as proposed for DesertXpress.

2.4.2 USA

Whilst a number of maglev projects were suggested in the US since the 1990s, many of them are not being pursued any longer. Beside the Las Vegas-Primm case, three other projects are still discussed yet for Transrapid maglev use:

- a suggested 54-mile Pittsburgh International Airport-Greensburg line
- a 39-mile connection between Baltimore and Washington
- a 31-mile link between Atlanta and Hartsfield International Airport with extension to Chattanooga.

Further, a maglev link between San Diego and the Imperial Valley Airport was studied.

Experiences from these projects are restricted to planning only. None of the projects reached a level of detail like the above analysed lines in Germany. Thus, cost figures are preliminary and can be expected – based on the German experiences – to be subject of significant changes.

The SAFETEA-LU Technical Corrections Act of 2008 made $90 million in highway trust fund money available for maglev projects. All federal funds are on an 80-20 federal-local match.

Some $45 million was set aside for a competition between the three projects each of the Mississippi, for which the Federal Railroad Administration announced on October 17, 2008 to begin receiving applications.

An additional $45 million was "*earmarked*" for the Las Vegas-Anaheim project. The State of Nevada is the eligible recipient. At the time of publication, no announcement of fund availability has been made.

2.4.3 *Others*

A number of other projects are being promoted world-wide. Currently discussed projects include

- **Great Britain:** A connection between London and Glasgow, 500 miles with 14 intermediate stations, maximum speed 300 mph and 160 minutes trip time,
- **Saudi Arabia:** A link between Bahrain and Qatar and further on a city/airport link between Abu Dhabi and Dubai (United Arab Emirates) with line lengths of 90/110 miles,
- **The Netherlands:** A ring connection in the so-called Randstad conurbation including the city of Amsterdam and Schipol airport, line length 140 miles, travel time 45 minutes, proposed initial section between Amsterdam and Almere (20 miles),
- **Japan:** A long-term plan for a Tokyo-Osaka Maglev link (340 miles), which reduces current travel times of 2,5 hours with Shinkansen high speed trains to about 1h from possibly 2025 on (if the project will be financed).

All these projects are in the conceptual stage. While there are preliminary studies, little valid cost and technical data can be drawn.

Meanwhile, the joint marketing and planning consortium "*Transrapid International*" (TRI), which consisted of Siemens and ThyssenKrupp, has been disbanded by October 2008, since none of the world-wide projects was considered to be in a stage which justifies further provision of these expert capacities.

This is in line with recent news, that federal funding for the German Transrapid test ring will be stopped as early as 2009.

2.5 Conclusions

Germany has essentially closed down its commitment to develop maglev systems, and the Transrapid consortium has disbanded and is reportedly looking to sell the technology in an effort to recover some of its development costs, as no commercial project appears to be reasonably expected.

While China has committed to implementing a high-speed rail network, it appears that there is continuing interest to gain control of the Transrapid technology to implement an extension of the airport line to Hangzhou without German involvement. As a result, recent (as per German press reports in September, 2008) information indicates that the German Transrapid consortium is now attempting to sell its technology to China.

This could be a reasonable approach since the analyzed projects show that, other than often stated, decisions to stop the projects can not be narrowed to a "*conventional-rail ideology*". Compatibility issues to existing networks and concerns about risks, which are imminent to new rail technologies, were undoubtedly factors in these decisions. However, it may well also be the case that stated Maglev benefits as "*higher speed*", "*lower energy consumption*", "*better accessibility*", "*lower noise*" and finally "*lower costs*" simply failed to materialize as the projects were worked out in greater detail and under real-life boundary conditions.

In the final analysis, there are many indicators that decisions to cancel Transrapid projects in Germany were taken as a kind of "*emergency brake*" in order to avoid major risks for tax-payer-money.

3. Maglev/HSR at the Las Vegas-Southern California Corridor

In this chapter, Maglev and HSR characteristics will be related to the specific situation of the Las Vegas - Southern California corridor. German Transrapid technology and Bombardier electric trains from the so-called "*Regina*" series have been proposed for this corridor and will be used in this report.

The German Transrapid projects will be the main source for Maglev data. This is due to the advanced planning levels and public availability of data in the context of planning studies, while figures of the Chinese project are rather undisclosed with few independent, quotable sources. The lack of transparency and reliable statistics in the Chinese commercial system results in little that is of value in planning the commercial aspects of either a maglev system or a high speed rail system in the United States. In addition, the labor costs in China are far less than in the United States, and because the construction of the unique close-tolerance structure upon which the maglev must operate is labor intensive, any quoted cost for construction in China are rather irrelevant.

3.1 Speed and Travel Time

The maximum speed of the Transrapid with up to 300 mph is twice as high as the Regina EMU. In addition, the Maglev propulsion system, which is situated in the guideway, allows for constant high acceleration regardless of train weights or line grades. Thus, a Maglev train can reach 180 mph after about 4 miles of acceleration while the proposed DesertXpress 10-car high speed train needs about 7.7 miles to reach 150 mph.

As a consequence, intermediate stops affect Maglev travel times somewhat less than HSR. Of course, dwell-times at stations reduce the overall effect on total travel-times. This is reflected by the DX/Maglev project characteristics: While DX is envisaged to be a non-stop train between Las Vegas and Victorville, stops of the Maglev tentatively include Barstow and Primm on the same section.

Effectively the Transrapid would reach Anaheim in about the same time which the DesertXpress High Speed Train would need to the 30% closer Victorville. However, the business case for each project (HSR and Maglev) is quite different, so in isolation, such comparisons are not particularly meaningful. However, relative advantages of higher speed for travel times decrease with increasing speed levels of HSR (see figure 1).

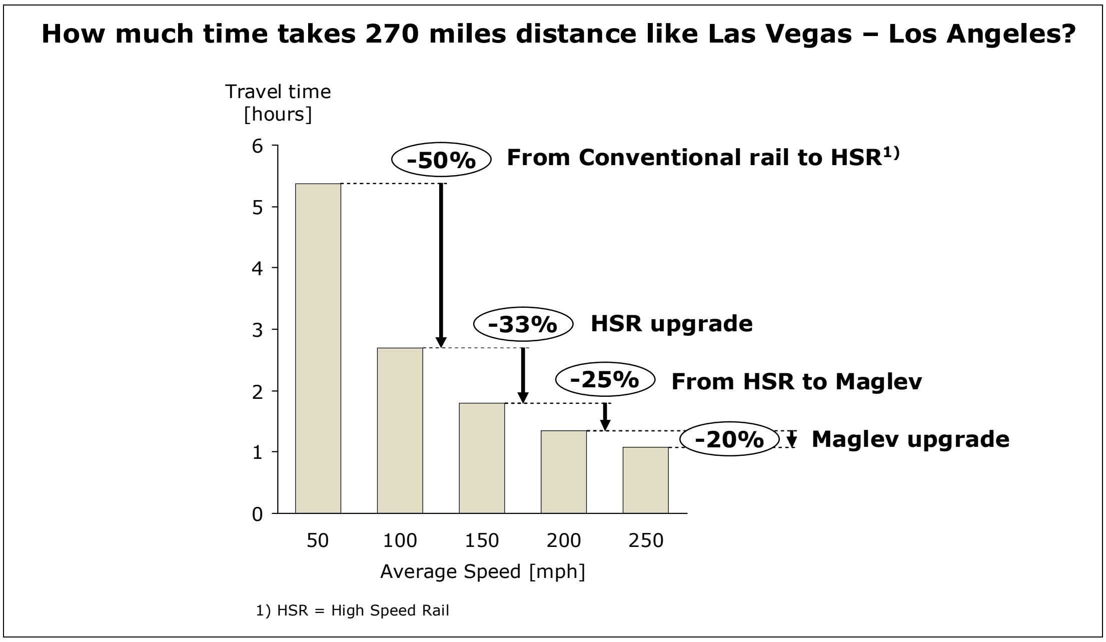


Figure #1: Relative travel time advantages by speed levels

When Maglev technology was initially proposed for the transport markets in the 1980's, its speed level was almost in the middle between aviation and rail passenger services. At that time, conventional rail hardly reached average travel speeds of more than 50 mph (which is still true in the United States today).

Since then, major progress in rail technology has been achieved. High-speed trains can reach operating speeds up to 200 mph on appropriate track infrastructure. The French TGV completes, for instance, the 600 miles run between Lille and Marseille in 280 minutes in daily operation. Thus, the relative advantage of Maglev speed over technological alternatives is much lower today than it was decades before (see figure 2).

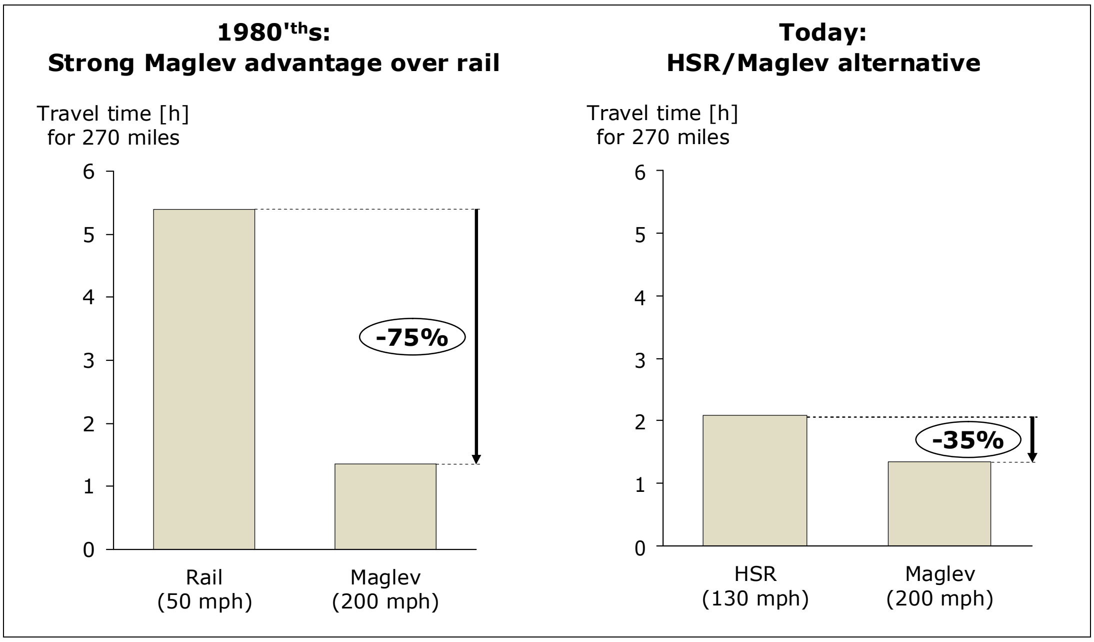


Figure #2: Decreasing relative speed advantage of Maglev

As a practical matter the question becomes whether the residual gap in higher speed is worth the difference in cost. Considering most of these projects require major public funding, perhaps with some private participation, is the market prepared to pay the substantially higher cost to achieve maglev? This question appears to be especially relevant to the Southern California to Las Vegas corridor, where the majority of trips are recreational in nature, hence, where ridership demand may not be particularly sensitive to relatively small differences in travel time. The other major difference in the Nevada-California corridor from the European and Chinese corridors is the DX group intends to privately finance the project. It is not clear what public-private mix is intended for the maglev option.

3.2 Operations

Maglev services must be kept simple and may be highly automated. Turnouts ("*switches*") are complex and expensive structures and are therefore reduced to an absolute minimum, for instance at ends of lines only (see figure 3).

Figure #3: Track layout of Shanghai Airport

This approach limits operational flexibility. In case of technical breakdown, implications for maglev operations may be more severe than for conventional railways. The high speed passenger railroad typically has more possibilities to utilize adjacent tracks to park or repair a faulty train.

This factor constitutes a risk since there is very little experience with long-term operation of regular Maglev services or its robustness at extreme weather conditions such as exist throughout this corridor. This becomes especially significant given the unique climactic and geological conditions of the Mojave Desert. In addition to seismic concerns, there is a very wide temperature variance and windy conditions, with temperatures ranging from below 30 degrees F to well over 110 degrees and peak gusts reaching 90 MPH. In the short run, experiences from the Shanghai lines do prove a fair reliability in the first years of operation (see figure 4). However a considerable amount of maintenance work is necessary, this could almost completely be done during regular service interruptions at night.

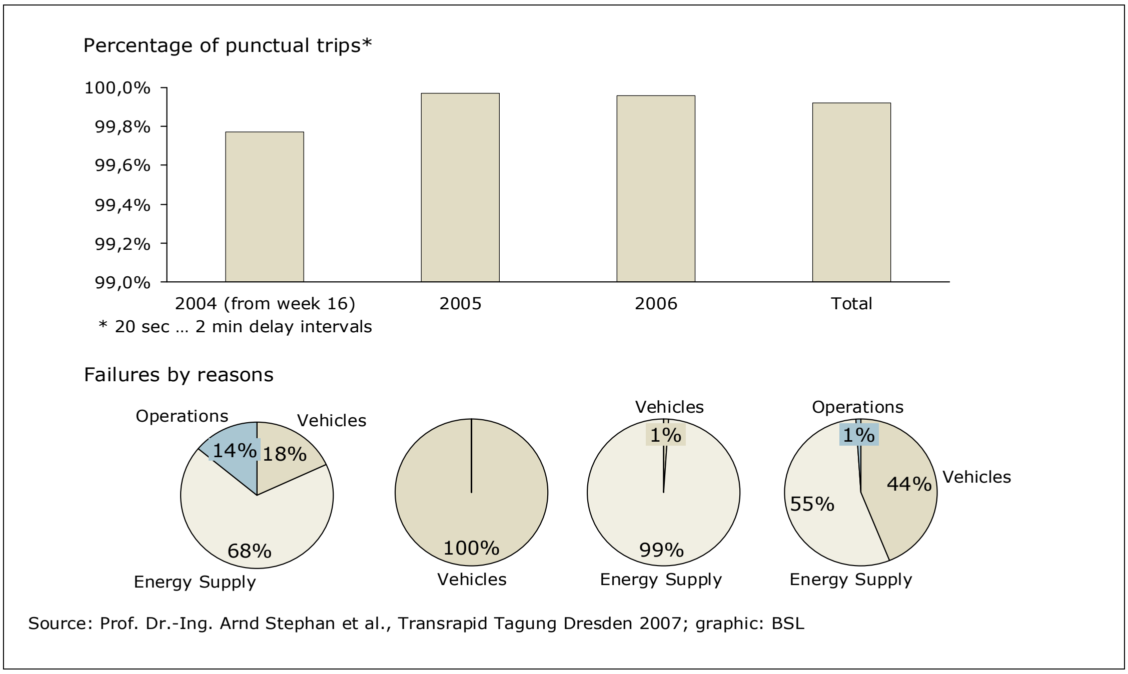


Figure #4: Operational reliability of Shanghai Maglev

Since wages in China and America are not similar, and Chinese data is not available on maintenance experience, the ongoing maintenance is an unknown cost item.

In addition, qualifying to meet safety standards and regulations is a major issue in qualifying a maglev train to go into commercial operation in both the United States and Europe. A major outstanding issue for both DX and Maglev will be the federal qualification, certification and licensing of the equipment and track structure. DX is proposing standard high-speed rail equipment that operates today in Sweden and China. While high-speed rail regulations exist at the US Federal Railroad Administration, they are designed primarily for HSR operations where there is mixed freight and passenger traffic (which currently exists on virtually all US intercity train operations), with at grade highway-rail crossings. Because of weight and strength requirements the Regina train could not be qualified under those regulations. DX will have to seek a waiver or a project-specific rule to allow their equipment to operate in an environment where there are no level at grade crossings and no mixed freight train operation.

We are not aware of any safety regulations, guidelines or approvals that will permit the commercial operation of maglev. While there is established regulatory approval and authority guidelines for operation of conventional high speed railroads, it is not clear that there is a process to qualify an intercity maglev operation. That could well require a new statutory authorization.

3.3 Investment and OPEX

Investment

As reported by the Maglev consortium, investment (CAPEX) of the full 269 miles of Maglev line from Las Vegas to Anaheim is estimated to be at least $10 billion, while the 35 mile Las Vegas -Primm section accounts for about $1.3 billion. This is an average CAPEX of about $37 million per mile for a primarily single-tracked route.

As already noted, there are few thoroughly planned, comparable projects. Shanghai and the proposed Munich and Metrorapid cases are urban lines which required much integration into existing infrastructures and housing. More comparably, the Hamburg -Berlin corridor would have cut through low populated areas with a similar length as the proposed California-Nevada line. Latest investment figures (including rolling stock) for a double-tracked maglev line required an expenditure of 41 million € per mile (equivalent to $60 million per mile U.S.). There has been an attempt to cut back cost by switching to a single-track infrastructure. This has not been worked out in detail but would result in an expenditure of roughly 28 million € ($41 million) per mile. However, the maglev consortium’s estimate of ridership on the proposed project is so high that it almost certainly would require a two "*track*" system throughout.

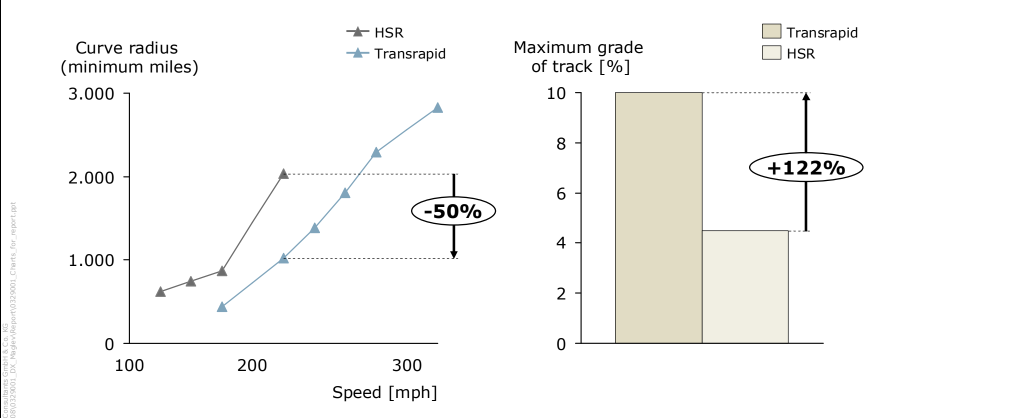
A valid benchmark would require a more detailed evaluation of project characteristics, exchange rates and purchasing power. However, given the facts that investment figures date back 8 years and price levels have risen heavily since then, there are strong indications that investment estimates for the California Maglev are "*at the bottom*" of realistic ranges and the project may result in a similar story of later cost increases as the Hamburg-Berlin case.

There have been recent independent studies of maglev costs for proposed projects in the United States, however, that could give some indication of what the current costs could be:

Proposed line	Length	Capital cost	
	(miles)	(billion)	(million per mile)
San Diego-Imperial Valley Airport (SANDAG 2006)	90-98	$15.2-$18.5	$148-$199
Washington-Baltimore (MTA 2007)	39	$4.3	$112
LosAngeles–Ontario International Airport (SCAG 2006)	56	$5.4	$99

Total cost for the DX high speed double-track system (including vehicles) is estimated at $3-5 billion (equivalent to $15-25 million per mile), which is much less than recent Maglev cost estimates.

This relation is reasonable because Maglev investments are mainly driven by the guideway structure, which often represents much more than half of the total investment. The "*engine*" is effectively incorporated into a very rigid track structure built to unprecedented strict tolerances, which makes the infrastructure exceedingly costly regardless of utilization rates. In part this may be compensated by a greater flexibility in the alignment, since some bridges and tunnels may be avoided due to the Maglev capability to go for higher grades and narrower curves than conventional rail systems at same speed levels (see figure 5).



Source: Schach/Jehle/Naumann, Maglev and HSR – an integrative system comparison (2006), pg. 74,75,81
Values for 200 km/h: ThyssenKrupp tec forum 02/2007
Maximum HSR-grade (4,5%) enhanced according to real DX figures

Figure #5: Typical alignment features for Maglev and high speed rail

However, in most cases these benefits will be reinvested to reach higher speeds with similar curve radii.

About 15-35% of investment costs relate to rolling stock and system equipment, which also contributes to the Maglev cost structure. For instance, Transrapid vehicle cost by passenger capacity is at least 2.5 times higher than for high-speed railcars, even in comparisons based on "*best case*"-assumptions (see figure 6).

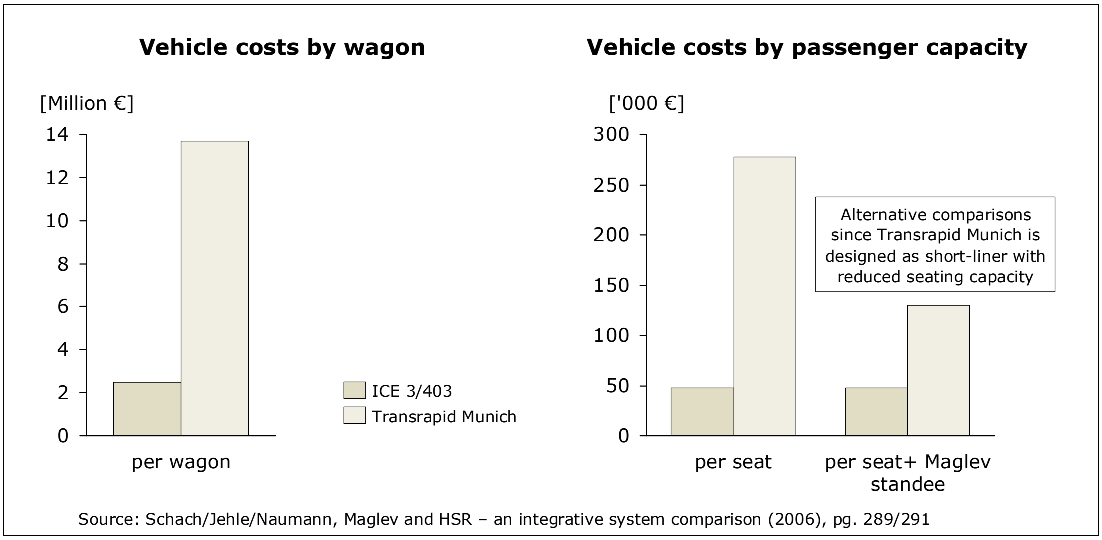


Figure #6: Comparison of rolling stock costs

This leads to a conclusion as formulated in a US-DOT report from September 2005, that, taken from a strictly Federal viewpoint "*intercity systems based on currently available Maglev technologies are expensive*" and "*other contemporary HSGT [High Speed Ground Transportation] technologies [...] typically show higher projected transportation and economic benefits, including highway congestion relief, relative to their costs, and could bring many of the advantages of HSGT to more markets at much less cost*".

Operation and Maintenance

Energy costs account for about a third of total Maglev O&M costs. Energy is needed for magnetic levitation and track guidance (about 1,7 kWh), for vehicle and track equipment and to generate the vehicle movement by magnetic fields.

At speed levels up to about 150 mph, consumption figures are disadvantageous for Maglev compared to conventional rail, since the resistance of the guiding magnetism is higher than the rolling drag and dynamic friction resistance of railways. The contactless Maglev technology pays dividends only at higher speeds.

However, since aerodynamic drag increases exponentially with speed, effective energy consumption of a Maglev which typically runs faster than high-speed railcars is higher. One may discuss whether it is rather fair to compare similar speed levels, but this does not alter the fact that, based on actual speeds, no effective energy-cost saving can be expected.

Other O&M-costs depend on assumptions which are based on little experience. Generally, maintenance of the Maglev track is proposed to be less costly than rail infrastructure because of advantageous whole life-costs of concrete structures. However, experiences from the Shanghai line show that strong magnetic forces apply to the track, the long-term impacts of which are not fully predictable yet.

Medium-term development of maintenance costs will further be influenced by how the technical services and parts markets function. Currently, there is only one supplier of the Transrapid technology and that company reportedly is selling the technology to China, while there are several suppliers of high speed trains that operate on standard gauge trackways.

This will probably not change significantly in the future since highly integrated Maglev guideways and vehicles as well as a lack of any real commercial prospects are barriers for new market entrants into the supply business. This causes risks for the O&M supply chain both in terms of cost and availability.

Furthermore, it is unclear how the maintenance market will develop in case the Transrapid technology actually is sold to China. In that case, there is a likelihood that all parts and supply will come out of China. Certainly, with a limited number of projects, there is a good chance that suppliers will have a kind of monopoly on the market under any circumstance.

O&M costs from recent American studies are provided in the following table.

Proposed line	Length	O&M cost/yr.		O&M / capital cost ratio
	(miles)	(million)	(million per mile)	BSL calculation
San Diego-Imperial Valley Airport (SANDAG 2006)	90-98	$100-$150	$1.1-1.5	0,7-0,8%
Washington-Baltimore (MTA 2007)	39	61,8	$1.6	1,4%

With reference to the considerations above and international experience the expected ratio of O&M cost to capital cost of 0.7-1.3% is clearly unrealistic. Based on international benchmarks, annual maintenance cost alone are often in the range of 1-2% of modern equivalent values (MEV). After some years of operation, renewal expenditure becomes a necessity. Renewal accounts for another 2-5% of MEV on an ongoing basis. Hence, business plans that anticipate revenues to cover costs in the order of 1% MEV will result in substantial losses.

3.4 Revenues and Profitability

Maintenance costs, interest and depreciation rates, as a general principal are about 12% of infrastructure investment costs. This must be earned every year to make a project profitable. Thus, for the investment delta were about $100 million per mile between Maglev and HSR, more than $10 million per mile in additional revenue must be earned by the Maglev compared to HSR.

The cost difference is only justified if the markets are prepared to pay for the additional travel time savings and if demand is strong enough. Revenues depend on the number of passenger trips and the average revenue per passenger kilometer. Both have to be calculated on the basis of individual market conditions of each project. However, some general lessons can be drawn from international experiences.

In the case of the proposed Hamburg-Berlin maglev line in Germany, it was supposed that both airline services would be completely abandoned and rail service quality would be left unchanged, i.e. kept in a poor state. Under these circumstances, high average revenues of 0,135 Euro per passenger kilometer were calculated (equivalent to $0.32 per mile at the price level of the early 1990's). However, the Maglev revenues were still positioned between rail and air modes. The expected revenues were twice that of German rail revenue levels but only a quarter of airfares in the still regulated aviation market of that time.

Current air-fares from LAX to Las Vegas on Southwest Airlines, typically the lowest cost carrier, range from $122 (most discounted fare) to $288 (normal coach fare) for a round trip in economy class, depending upon how far in advance the ticket is purchased. This is equivalent to about $0.45-0.90 per passenger mile. Interestingly enough, this is about the calculated range for the German Maglev line at today's price levels. It will hardly be reached in a more deregulated and competitive transport market. Thus, an assumption of $0.32 average revenue per passenger mile, as taken in a business plan dated from 2001 for a Los Angeles-March Inland Port Maglev links, seems to be more realistic.

Effectively, about 31 million additional passengers would have to be attracted by the Maglev every year in order to annually earn $10 million per mile in additional revenues. Consequently, Maglev proponents have high expectations on ridership: they forecasted more than 42.8 million passengers for the Anaheim-Las Vegas Maglev. This is almost 10 times the projected ridership for the DX line to Victor-ville and would load the guideway with 60 full-length Maglev trains daily in each direction. Given the fact that there will be peak hours when people want to travel, this could reach the capacity levels and saturate the infrastructure. Further, each train would need to be fully loaded with up to 1.000 passengers. In other words, every inhabitant of Nevada and California would be expected to use the Maglev more than once a year. Additionally, this represents more than three times the amount of people that travel to Las Vegas from Southern California per year by all modes.

If these expectations were met, profitability would be assured. However, as already noted, in international cases it often turned out that the planning produced passenger numbers which were highly overestimated in early project stages. This became a key driver for these projects. When these estimates had to be considerably downsized, a whole new detailed planning process was required. In each case in Germany the end result was project cancellation. There is strong evidence that this dynamic might be the case also in this project. Thus, the question of economic viability of the Maglev project is open and should probably be realistically addressed before significant public funds are committed.

For the HSR project DesertXpress calculated a regular round trip fare between Las Vegas and Victorville of about $100 which is equivalent to $0.25 per passenger mile. This seems to be realistic in comparison to air fares.

For comparison, fares for European high speed service are shown in figure 7.

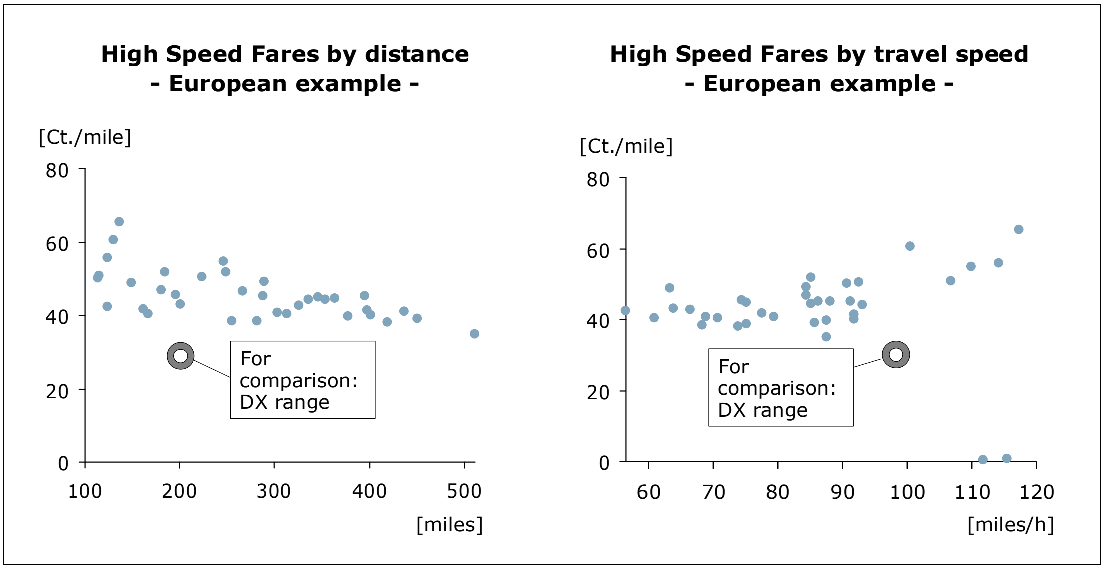


Figure #7: Example for fare level in a high speed system (Germany)

The – at this background - low range of DX fares reflects the market situation in the corridor.

4. Summary

There is a great need for new solutions to the growing traffic congestion in the highly frequented corridor between Los Angeles and Las Vegas. Further, the fact that there is only one highway connecting them and that the airports already are at or near capacity is compelling.

A ground-based public high-speed transport system is with little question a logical part of such a solution. Due to high fixed costs there is clearly only room for one such system. Thus, the proposed Maglev and high speed rail systems are in fact competitive approaches.

Maglev is the fastest available system world-wide. However, commercial implementation is limited to one case world-wide, although the technology has been available for more than a decade. Further, it is reported that the technology may be sold to Chinese stakeholders who would then undertake an extension of the current urban line there. This indicates that the German Transrapid consortium has limited trust in further business opportunities around the globe.

One reason for the failure of Maglev initiatives is due to the fast development of conventional high speed rail technology. Current technology which is in commercial operation, offers a (compared to Maglev) reasonable high speed at a much lower cost. In transport economic terms, in most markets there has simply not been sufficient willingness to pay the additional costs of Maglev compared to cover the additional costs to HSR.

In order to show profitability of Maglev projects, passenger numbers and revenue figures were often much overestimated in international projects while costs were underestimated ("*optimism bias*") as a result of popular support and political momentum. This led to funding decisions and advanced planning activities that were generally quite far along before figures were recalculated and it was determined that the projects were not commercially viable. Disillusioned public officials then had the very difficult job of terminating projects they had long supported. Further, as substantial Maglev planning funds were spent the development of alternative rail projects was delayed.

While it is not the purpose of this paper to analyze the situation in the Las Vegas - Los Angeles corridor in detail, there are many indications that conditions are very similar to those that exist in Germany. Certainly, ridership expectations of the California-Nevada Interstate Maglev Project require scrutiny. While there is also some concern that the ongoing Maglev planning made possible by a new infusion of federal funds ($45 million) could affect the development of the DX project, as a practical matter this may not be the case, as the DX project is being privately financed.

It is the Consultant's opinion that the German Berlin-Hamburg experience and the Nevada-California corridor are comparable for purposes of general comparison. It is the Consultant's recommendation that concerns about realities of the Maglev project should be discussed and appraised in a short timeframe before substantial public funding is further committed.

While the DX project appears to be independent of other events, if the German experience is any guide, a conventional HSR solution to the current transportation problems of the corridor could be blocked or postponed if it appears there is a serious commitment to a Maglev solution.

Based on our worldwide experience, and the discussion topics presented in this paper, it is the consultant's opinion that when compared to Maglev, the high speed rail DesertXpress project is clearly the most practical and viable alternative for the corridor.

About the author

BSL Management Consultants GmbH & Co KG is the leading German strategy consultancy in the rail transport sector, with a strong international orientation and global consultancy experience. Since 1991, the company provides a broad range of strategic and management consulting services for operators, owners, government and industry bodies, associations, and suppliers.

The BSL staff consists of around 60 employees. BSL's highly skilled consultants are qualified in business & economics, engineering, science, transport & urban planning and IT. In 2006, the company expanded its expertise internationally by joining Lloyd's Register.

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