SwissRapide Express, A Maglev High-Speed Line for Switzerland

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ABSTRACT: With the aim to meet the transport needs of Switzerland in the coming decades, as well as providing a commercial showcase line for the promotion of European Maglev technology worldwide, SRE GmbH has launched the ***SwissRapide Express*** project. The 135 km high-speed line linking Bern, Zurich and Zurich International Airport is to be built using Maglev technology, with line speeds of over 500 km/h. The start of commercial operations of the ***SwissRapide Express*** is planned for the end of 2017 with building costs estimated at between 4.7 and 5.7 billion €. To be managed, built and operated by SRE GmbH, the success of the ***SwissRapide Express*** will rely on the support among companies, organisations and financial institutes in the project consortium as well as close co-operation with federal, cantonal and civic governments.

1 INTRODUCTION

A new project, the ***SwissRapide Express***, has been started by SRE GmbH in Switzerland to connect Bern, Zurich City and the Zurich Airport with a high-speed line based on Maglev technology.

This paper presents an overview of the ***SwissRapide Express*** project, its objectives, time frame, milestones, project costs, opportunities and challenges, as well as potential technical collaborations and financing models. Comparisons are made with the Shanghai Transrapid, the first commercial operating Maglev system.

2 THE MARKET

Today, an average of about 15,000 passengers per day travel on the Intercity train line linking Zurich and Bern. Particularly in peak times, the railway line has already reached the limits of its capacity. By 2015, an increase in demand of up to 30% is expected. Presently though, there are no projects planned in Switzerland to address this increased demand in transport capacity.

In addition, the Bern–Zurich freeway is also severely congested during rush hours. Investments to alleviate this problem through additional roadways would cost billions of Swiss Francs and are not likely to find acceptance in the Swiss political system. The AlpTransit Gotthard project, a pair of new 57 km high-speed technologically advanced railway tunnels at grade through the Alps, achieved much of its acceptance because of the pressure it would relieve on the Swiss roadway system.

Another important market factor is that new transport services drive new transport needs. For example, the number of passengers on Zurich S-Bahn lines has grown at an average of almost 3% per year since the introduction of services in 1992. The total growth in the number of passengers on certain lines has *exceeded 300%* since 1992. One of the main reasons for this is that the Greater Zurich area has become increasingly popular for new and expanding companies, in no small part due to to its excellent public transportation system. Outlying cities and towns have boomed as well because of the improved accessibility to the Zurich job markets, some increasing their population by more than 100% in the last 10 years.

Added to this, there has also been a marked increase in the demand for faster and more reliable service for people living in the Bern area and commuting to work in Zurich and vice versa. For this reason rush hour trains between Zurich and Bern (06.30 to 09.00 hours) are normally full to the very last seat, some passengers with 1st Class tickets even needing to stand for the trip.

How are these demands in transport capacity in Switzerland to be met?

3 THE PROJECT

Inspired by the high speed of Magnetic Levitation railway system, its attractiveness for passengers, its

low environmental impact as well as further advantages of the Maglev technology, SRE GmbH has initiated a visionary project for Switzerland. The ***SwissRapide Express***, a new high-speed Maglev line linking Bern and Zurich with an extension to the Zurich international airport, provides an innovative solution to the future transport needs of Switzerland.

The present planning of the line foresees a route that largely follows the motorway between Zurich and Bern. The ***SwissRapide Express*** station in both Zurich and Bern are to be integrated into the existing main train stations in those two cities, to allow a quick transfer of passengers to other modi of pubic transportation.

It is also planned that the line should be completely above ground, thus significantly reducing building costs as well making the trip more attractive for passengers.

In co-operation with partner organisations and sponsoring companies within the ***SwissRapide Express*** project consortium, planning has begun to make this vision become reality. At the same time, it is the aim of the project that the Bern–Zurich Maglev line shall serve as the European showcase line for the promotion of the construction and operation of Magnet Levitation Railway technology in Europe and around the world. Being at the hub of the ***SwissRapide Express*** development, SRE GmbH is ideally situated as the catalyst for the co-ordination of all the technologies necessary to implement this new evolution in public transport.

4 THE TECHNOLOGY

To describe the Maglev technology available today, we have visited and evaluated the only commercially operated Maglev railway line in the world, the Shanghai Maglev Transrapid (SMT) airport link and would like to use their success to compare this with the ***SwissRapide Express*** project.

Shanghai is China's largest city, with a population of 18 million, or two and a half times that of the entire country of Switzerland.

When the new Pudong International Airport was opened it was evident that being stuck on a freeway in a taxi to get into the city was not viable, nor a good image of the vitality of the city. For this reason, a Maglev line based on the German Transrapid technology was proposed, linking the airport to the nearest metro station at Longyang Road. Longyang Road is not in downtown Shanghai, but it is 30 km closer and only a taxi or metro ride away from the centre.

The Shanghai Maglev Transrapid (SMT) makes use of the high vehicle speeds of the Transrapid system, it has been tested to 505 km/h but uses 430 km/h as its cruising speed. The ***SwissRapide Express*** project foresees regular line speeds of up to 550 km/h, truly a challenge for the technology.

One of the most impressive feats of the SMT project is that the line was constructed in just a 24 month period, almost unimaginable for projects of this nature in Europe or the US. For the construction of the ***SwissRapide Express*** line, this construction time cannot be assumed, but it is an indication of what could be possible with support from the public and a close co-operation between various levels of government as well as the companies and organisations supporting the project.

The SMT program began with a feasibility study in 2000. The contract between the German industrial consortium of Siemens, ThyssenKrupp, Transrapid International and the Chinese organisation was signed in January 2001. The first trip on the new line was on December 31, 2002. Commercial service began in January 2004 and final acceptance was concluded in April, 2004, truly an amazing feat of engineering.

The original budget for the project was 10.0299 billion yuan (¥) Remnibi (RMB - official money). Published accounts have disagreed with this, but the official final approved statement indicated the total cost of the Shanghai Transrapid line as 9.943 billion yuan RMB, or € 970 million (US$ 1.198 billion), or a per-km price of 330¥, or € 32.3 million (US$ 39.759 million).

The SMT was built based on German Transrapid technology and the experience from the test-line in Emsland, though the Chinese also made significant contributions to the engineering of the project.

The German portion encompassed the Electronic and Magnetic system consisting of four parts:

1) Vehicles (ThyssenKrupp)

2) Power and Propulsion System (Siemens)

3) Operations and Control, Signalling (OCS) (Siemens)

4) Guideway component (ThyssenKrupp)

The Chinese portion of the budget encompassed guideway, civil, and domestic purchase. This included the pylons, girders, and track (exclusive of the propulsion system). For the maglev system to operate, the trackway had a geometric tolerance of $\pm$ 4 mm.

The pylons are spaced at 25 metres, with a tolerance of $\pm$0.8 mm, and weighing 170 tonnes. Since the ground near Shanghai is soft, with a very high

water table, this required development of a laser-guided calibration and adjustment system for the trackway. This, in the opinion of key SMT executives, was the key to operational success.

There are four areas of concern for the continued alignment of the guideway to the very high standards required for this system, all of which will also be significant factors for the building of the line in Switzerland:

- Vehicle loading
- Temperature induced geometry changes
- Wind loading
- Subsidence

The SMT solution was to make the roadbed dynamic, with adjustable bearings in the pylons capable of movement in three dimensions. Every morning a slow run test vehicle is dispatched to confirm the integrity of the system.

For the high running speeds needed for ***Swiss-Rapide Express*** project, alignments systems of this kind will be crucial, even though the guideway will be built largely on stone and is thus inherently stable.

There was minimum local input as to site acquisition. The SMT line runs parallel to the airport road, which has a 25-metre greenway on each side. SMT extended the greenway to 50 metres in some areas to place the guideway. They also used existing public lands where possible. This form of land use and land acquisition together with existing roadways will also serve as a good model for Switzerland.

Apparently, no government subsidies were granted for the building of the line. It is the policy of the Chinese government to supply capital funding but projects subsequently must be self-sufficient. Interestingly, the income in 2005 exceeded operating costs, including maintenance.

The ticket cost is 50¥ one-way, 80¥ for a one-day return, or 40¥ one way with an airline ticket. 40¥ is the equivalent of € 10 (US$ 8.00), which is directly competitive with the price of the equivalent taxi.

During our visit, the operations were excellent, efficient and transparent. Today, the operational reliability of the system is 99.92%. This compares to an operational reliability of Swiss Federals Railways (SBB) of about 94.7%, which is the highest in Europe and second only to Japan worldwide.

A gratifying surprise was that the SMT stressed the importance of the ecological benefits of his system, including minimal site impact, low pollution and low noise, all factors also crucial in Switzerland.

During discussions held with SMT officials, they indicated the possibility of co-operation or collaboration with SRE GmbH within the context of ***Swiss-Rapide Express*** project. It was felt that SMT could share their technology and experience in five areas:

I) Experience and technology of concrete hybrid guideway system: SMT have 8 or 9 patents now arising from their experience, and felt that the construction and site conditions would be substantially better in Switzerland. Also, the Maglev system allows for a higher gradient, with 9° to 10° inclines possible, an important factor in Swiss topology!

II) Proprietary equipment: Through necessity, SMT developed specific systems to compensate for unstable subsidence on which the guideway was built: a special bearing for the dynamic roadway, and according to the officials, this was a Chinese development.

III) Knowledge of overall system: The overall design of the Shanghai system is German. However with the announced and anticipated additional lines, with a probable extension to Hongshu, a major manufacturing centre 175 km away it is anticipated that system operation knowledge will undoubtedly be concentrated in China.

IV) The new Chinese projects would involve spanning the Huangpu River, which is the site of the world's third longest suspension bridge. Similar topographical challenges may also need to be met in Switzerland.

V) Commercial operation experience: SMT have the only commercial operation in the world and report to be carrying about 12,000 passengers a day.

5 THE OPPORTUNITIES

The key to the success of any project lies in addressing the needs of the stakeholders who are financing the project as well as the needs of the customers who will use the system once it is completed.

In this spirit, one of the major opportunities of the ***SwissRapide Express*** project is that it addresses the ever-growing need for fast and reliable transport between two of the most important cities in Switzerland.

But where do other opportunities for this Maglev project exist?

Given the "green and clean" nature of Switzerland, it is clear that the environment impact of a project of this size is a major issue among voters and politicians in the country. Environmental impact studies carried out by Transrapid International GmbH and other organisations, as well as the ease of integration of Maglev technology into the existing landscape prove that the system is one of the most ecologically friendly transport systems today.

Furthermore, the fact that practically the entire Maglev line between Zurich and Bern is planned "sur terre" and given the minimal land needs if the track is built elevated means that the construction costs for the line can be significantly reduced compared to underground concepts as well as in comparison to the classical intercity railway line.

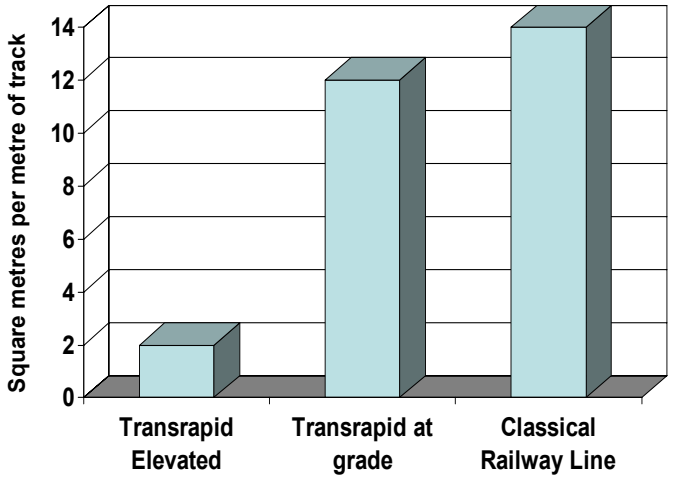

Figure 1: Land Use for the Transrapid System Compared to Conventional Railway

The above ground concept of the ***SwissRapide Express*** project also means that passengers can truly experience both the high-speed of the Maglev technology as well as the enjoyment of the Swiss landscape during their trip to Zurich or Bern. This advantage is not to be underestimated since it is a key factor for the long-term acceptance and use of the line by the general public.

Another important benefit of Maglev technology is its low operating costs. Although exact figures still need to be calculated within the context of the ***SwissRapide Express*** project Business Case, it is clear that only a minimum number of staff is needed for train operation since the system is 100% automated. It is important that competent sales staff be present at all times at each of the three nodes to assist passengers but this will not be a significant cost factor.

Maintenance costs of the line are also expected to be low, particularly in the first 20 years of operation, before the first guideway elements need to be replaced. In this time, the costs of maintenance are estimate at approximately 10% of the maintenance costs of the conventional Zurich-Bern railway line. For the Transrapid, total maintenance costs are estimated to be 65% lower than those of a conventional ICE high-speed line.

An on-going theme in Switzerland in the past years is the need and desire for more innovation from persons and companies within the country. There is a growing feeling that the desire and the ability of Swiss companies to provide innovative solutions and products are being lost. The ***SwissRapide Express*** project can be seen as one of the most innovative and attractive projects in Switzerland in the last 50 years:

- Speeds of over 500 km/h
- The innovative "riding on air" concept of Maglev technology
- Fully automated transport technology
- First-time Swiss (perhaps European?) application of Maglev technology
- Integration into existing landscape with very low ecological impact
- Quiet operation for both passengers and the local environment

With this, a new era in transportation opens, a future landmark for the country. Experience has already shown that this factor is a key for obtaining the financial, marketing and technical support needed for the project from sponsors and partner organisations.

The building and operation of the line will also drive innovation in Maglev projects, and companies involved in the project can establish themselves as centres of competence for Maglev technology worldwide.

Related to this is also the fact that once the ***SwissRapide Express*** line is in operation, it is expected to become a major tourist attraction for visitors to Switzerland.

In addition, the close integration of the ***SwissRapide Express*** into the multi-modal Swiss public transport system will be a major benefit for travellers within the country.

The implementation the ***SwissRapide Express*** line will also push forward new technologies in this field and build a basis in Europe in related businesses for export around the world.

6 THE CHALLENGES

The major challenges of the ***SwissRapide Express*** project are not technical in nature. It is obvious from the Shanghai experience that the technology to build and operate a financially viable Maglev system is mature. The real challenges as with any project of this kind are political in nature.

The key factors for obtaining public and political support for the Swiss project are:

- Public recognition that the organisation(s) financing and running the project are professional and committed to the implementation of the line
- Developing a clear and inspiring vision of the project that is creatively and attractively communicated
- Ensuring that all information given to the different levels of government is well timed and in tune with information communicated to the general public through the media
- Close co-ordination and work together with major media providers within the country

Of course, the second major challenge facing any project of this nature is the financing of the endeavour. The keys to this are:

- Getting acceptance of the project as described above
- Developing a financing model that is publicly and politically accepted
- A strong marketing and corporate image concept

Another major challenge will be to acquire the land needed for realisation of the Maglev line. In order to keep the cost of acquirement down, this will also require changes to the land acquirement laws in Switzerland to allow construction of the support pylons on the right-of-way without needing full acquisition of the land from its present owners. Local, cantonal and federal governments control much of the access to land needed, which is why close co-operation with these organisations is crucial.

Getting "back-room" support from the major banks and companies within Switzerland will also be a key since these organisations have a major influence on the business politics within the country.

One final challenge that must be addressed early in the project however, is technical in nature: the Proof of Safety for the system. The effort needed for this should not be underestimated. Industry and government organisations must work closely together to guaranty that ***SwissRapide Express*** and the Maglev technology are given official System Acceptance and operating licences on schedule by the Swiss government.

7 THE MILESTONES

The following are the key project and planning activities for the construction of the ***SwissRapide Express*** line.

Activity	**Completion**
Marketing Plan	January 2007
Consolidation Project Consortium	December 2007
Concept Study	December 2008
Marketing & Public Relations	Ongoing
Completion of the Business Case	December 2008
Approval of Planning Documents	March 2011
Approval of Construction Plans	December 2013
Completion of Land Acquisition	December 2013
Start of Construction	January 2014
Start of Operational Testing	November 2016
Start of Commercial Operation	December 2017

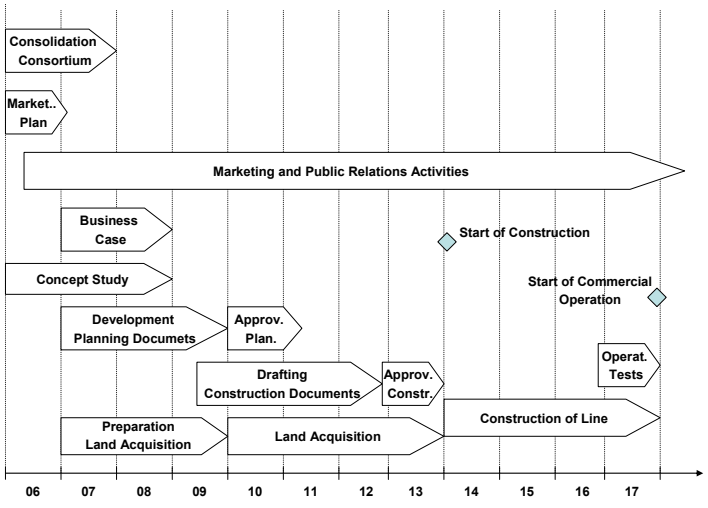

Figure 2: Road Map for the ***SwissRapide Express***

8 THE COSTS

As mentioned, the per-kilometre costs of the Shanghai Airport Link were about 32.3 million € or approximately 52 million Swiss Francs (CHF). These costs include the concrete guideway, electronic guide and propulsion systems, vehicles as well as terminal stations.

In Figure 3 a comparison is made between the building costs per kilometre for the Shanghai International Airport line as well as cost estimates for the Hamburg-Berlin, Metrorapid (Nordrhein-Westfalen, Germany), Munich Airport, Baltimore-Washington and Shanghai-Hangzhu projects. In all cases, this includes costs for vehicles and terminal stations.

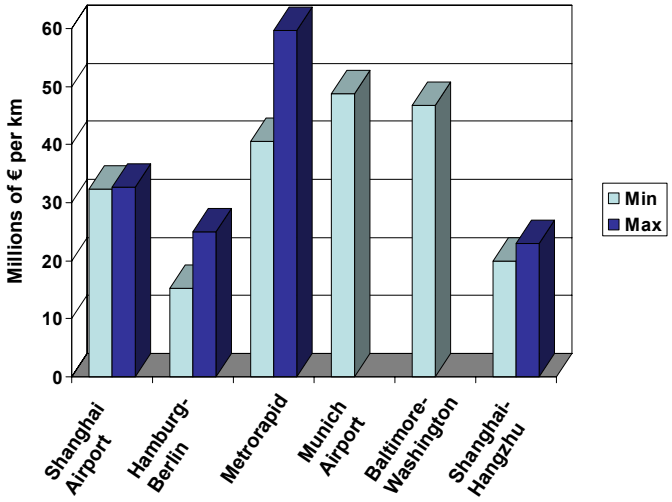

Figure 3: Comparison of Estimated Building Costs per Kilometre

For the ***SwissRapide Express*** construction costs, including vehicles, terminal stations and a maintenance centre, are estimated at between 35 and 42 million € per kilometre. With a line length of 135 km between Zurich Airport, Zurich and Bern, the costs for the construction of the ***SwissRapide Express*** are expected to be between € 4.7 and 5.7 billion.

A yet unknown cost factor for the ***SwissRapide Express*** project will be the efforts and investments needed for land acquisition. Again, this will depend largely on the land acquisition laws in force as well as the willingness of various levels of government to make the land needed for the construction of the line available. The unique low environmental impact characteristic of Maglev right-of-ways may actually prove advantageous in this case when compared with conventional steel-wheel lines with overhead power grids.

9 THE FINANCING

For the construction of the ***SwissRapide Express*** line, various financing models are possible.

I) Solely private sector financing through a construction and investment consortium

II) Public / Private Partnership (PPP) financing

III) Mixed model with both public and private sector financing similar to that of AlpTransit Gotthard AG

The optimal financial model for the project will need to be developed among the consortium partners and negotiated both with private investment organisations as well as the various levels of government involved in the project in Switzerland.

10 THE STATUS

The start-up phase is one of the most challenging for any project but also one of the most interesting; the work on the ***SwissRapide Express*** project is just that. Presently, the following activities are taking place:

- Acceptance of new sponsors and partner organisation for the Project Consortium
- Development of the Concept Study to form a basis for marketing and planning documents. The study sets down the What, When, Who, Why and How of the ***SwissRapide Express*** project and is the basis of discussion with government authorities.
- Development of a detailed Strategic Marketing Plan for the project
- Development of marketing tools and materials
- Development of the Business Plan for the ***SwissRapide Express*** project, including the Project Consortium and the business aspects for SRE GmbH
- Development of a Project Business Case, including detailed construction and operation costs estimates, financial models, pay-back schemes, etc.
- Development of the formal, detailed project planning documents
- Start of the Preliminary Planning documentation for the Federal Department of Transport and Energy as well as cantonal and civic governments

11 THE INNOVATION

Although the Shanghai commercial line as well as the Transrapid test line in Emsland are in operation, further development of the Maglev technology will likely be needed for the realisation of the ***Swiss-Rapide Express*** project in Switzerland:

IV) **Reduction in the costs of construction** for the infrastructure / track

V) Ensure **high reliability** of services. According to official reports, the Pudong Airport link has an operational reliability of 99.92%. Can this reliability be maintained or improved for longer, more complex lines?

VI) **High capacity at nodes**: What is needed for train leaving a node every 5 minutes? Every 3 minutes?

VII) **Reduce line headways** to about 2 to 3 minutes: What are today's limiting factors and what needs to be done to reduce these headways?

It is important to note that these factors are also likely to be a key for the acceptance and implementation of Maglev technology worldwide.

Furthermore, while there is a single shining example of a commercial Maglev system, there is no single supplier of practical Maglev technology. A viable commercial operating system will be composed of suppliers from various companies and countries. New developments in control systems and construction will arise, requiring flexibility in creating innovative partnerships. An example of this might be a technical and marketing collaboration between Transrapid International, the SMT guideway technology and the Swiss concrete industry.

12 THE CONCLUSION

The start of the ***SwissRapide Express*** project marks a major milestone in the legacy of passenger transportation in Switzerland and for Europe.

As with any Maglev project of this nature there are many challenges that yet must be faced and many hurdles to cross. However, we believe the future belongs to the Maglev technology and that the ***SwissRapide Express*** project is an innovative, exciting answer to the future transport needs in the country.

Gauged on the positive response to the project to date, the ***SwissRapide Express*** and the companies involved are expected to quickly gain a high profile in the media as well as in the public eye both in Switzerland and worldwide. We invite you to join us.

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