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Management and Decision-making in projects with strong technological rupture

Case of High Speed Ground Transportation Systems

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Topic 2.2: Marketing, Political and Financial aspects

Maglev technologies are at an historical turn, with the first commercial implementation of the Transrapid in China. This article examines what are the causes of market barriers encountered by such disruptive technologies and what are the future challenges. It underlines that behind technological rupture the real challenge stands in the management of systemic networks between manufacturers and operators.

Synopses

As for other large infrastructures, innovation in High-Speed Ground Transportation Systems (HSGT) projects is complex to manage, involving industries, operators, institutions and politicians. The structure of public/private investments and the long life of such projects (much longer than many industrial ones) require from decision-makers a good understanding of the management of complex systems. This necessitates a good technology assessment to identify technological lock-ins, performances and benefits. But only assessing projects wouldn't be enough. The ability to introduce changes (in products and processes) is a determinant of the successful development of such projects.

The role of industries, operators and institutions are examined in the implementation of innovative transportation networks and in the diffusion of innovations. Depending on the national context, experiences have been different among countries. Sometimes innovative projects were successful. Other times they failed, with millions of dollars wasted. Decision-making is a hard task, especially when it concerns R&D investments in projects that imply strong technological rupture, when the assessment of risks and uncertainties is not easy. Also, decision-making unfolds in design, construction and operation phases. Therefore, the importance of integrating structural/organizational factors into the analysis seems to be necessary to understand the kinds of public-private partnerships, which will be needed for a sustainable and innovative development of transportation infrastructures.

Keywords: High-speed Transportation system, Innovation, Public-private partnership.

1. Introduction & Methodology

This analysis strives to illuminate innovation processes and their impact on risks and uncertainties.Case studies concerning Europe, U.S.A. and Japan aimed at highlighting critical links among innovation, technology and policy. As will be elaborated, the configurations of public/private partnerships for innovation development and implementation are shaped by project assessment and risk sharing concerns. Rupture or incrementalism creates risks and uncertainties and has major implications for managing change in organizations and institutions.
This research project was done within the French PREDIT Program (1998-2000) focusing on European case studies (Prof. F.L. Perret, G. de Tiliere *ITEP/EPFL Lausanne*, Prof. D. Foray et al. *IMRI / Paris-Dauphine* and Prof. P. Llerna et al. *BETA / Strasbourg*. This project is now continuing founded by the Swiss National Found of Research through an exchange Program at UC-Berkeley focusing on US and Japanese cases (2000-2002).

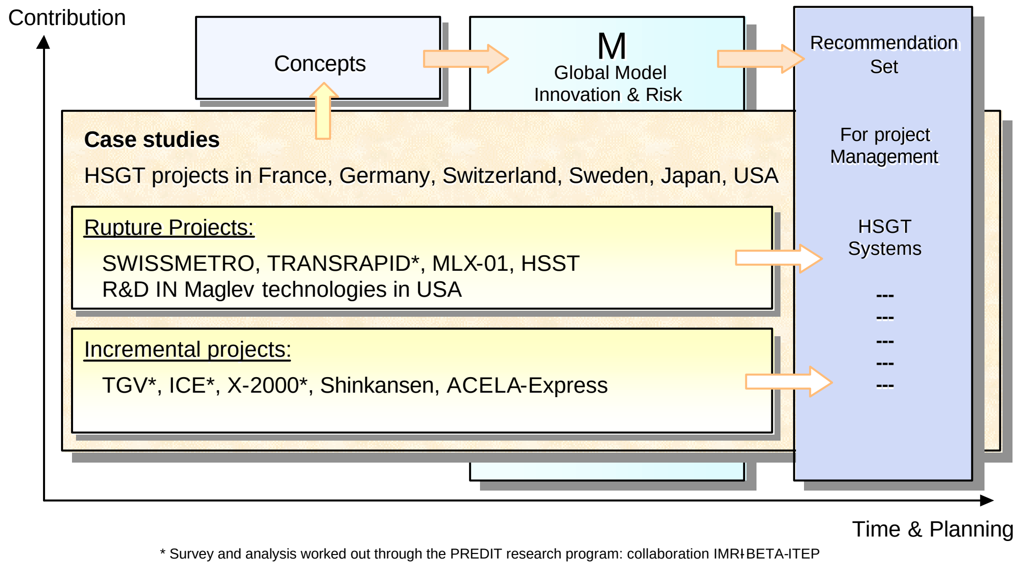

Figure 1: Case studies were used to develop concepts, models and make recommendations.

In this paper, we only look at technological innovations and the respective roles of corporate actors. User needs are assumed to be met, as much as possible, through the interactive role of operators and institutions. But, apprehending innovation is more complex than that and needs further discussion of its real impact on services (see Garrison 2000).

2. Innovation phases

In the 1960's the development of the aerospace industry and the increasing impact of technologies through large R&D programs induced a period where decision-making was strongly technology driven. As the development of the economy was strongly related to the development of technologies and infrastructures[1], a new interest in applying new technologies began, and produced a large spectrum of options that have been studied through national R&D programs. This period (1960-1989) produced some interesting innovative and complex systems - the Concorde, Ariane, Superphoenix, the Transrapid or the MLX-01 among the most emblematic ones. Those new technological developments were also strongly supported by institutions, which saw in them the opportunity to improve the performances and the competitiveness of the related sectors (Bell 1998).

[1] Idea that the Economy development was strongly dependent on the application of new technologies in infrastructure projects (role of innovation as a growth engine).

2.1 Exploration Phase: Learning through diversity

In the HSGT industry, the emergence of new rupture concepts flourished with the development of the air-cushion technologies[2], maglev technologies[3] and turbo-jet propulsion applications. Some of these technologies mixed concepts: combination of air-cushion and turbo-jet-propulsion for the Aerotrain. Idem for the Grumman concept involving maglev propulsion after the cruse speed has been reached. But some innovations were more adapted to existing constraints of the network such as the concept developed by Garret (USA): turbine-driven alternator coupled with a linear induction motor, with the vehicle using ordinary railroad tracks.

Those radical innovations were developed by newcomers in the transportation market. Politicians and institutions were supporting these alternatives as an incentive for the improvement of ground transportation systems. One of the most interesting case is the example of the aerospace industry in the USA which provided the majority of contractors under the HSGT Act (1965-1974). The HSGT Office (HSGTO), created for this federal program, was very interested in attracting aerospace contractors in the ground transportation market. As those contractors proved their ability to manage innovation in complex aerospace systems, they saw an opportunity for a profitable technological transfer. But as it will be developed further, the structure of this market and the organizational and institutional characteristics resulted in some failures.

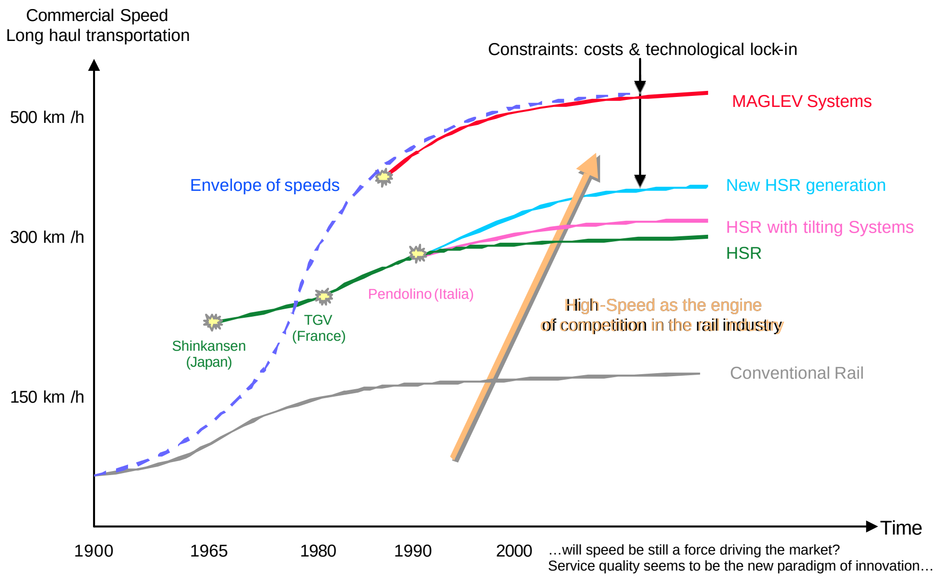

Figure 2: S-curves and product life cycle / technological envelopes and velocities

2.2 Tension between transition & rupture: the innovation dilemma

In many national R&D programs, a large spectrum of technology was assessed and this exploration phase was characterized by a tension between transition and rupture. Rupture is also associated here with the non-compatibility with rail infrastructures. The rupture is usually thought of as breaking presumed technological lock-in in a current system to respond to a

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[2] French Aerotrain developed by Bertin Co. (1963-1974) supported with 12 Million 1968 US$ by the French government. The British Tracked Hovercraft Development Ltd. also received a 5 Million 1968 US$ from the British government for a prototype demonstration. In the USA R&D on this concept was conducted by General Electric and Grumman Co., but no full scale demonstration project was build (Yaffee 1968).

[3] New interest in maglev R&D in 1962 in Germany with the Transrapid concept, 1962 in Japan (JNR) and 1963 in the USA at the Brookhaven National Lab. Full scale demonstration projects were build only in Japan and Germany for High-Speed maglev systems.

future market adaptation or a special market niche. In contrast, incrementalism development allows a improvement of performance without fundamental break in the learning curve. An innovation linked to a technological rupture implies in the early stage of the development (prototype) a decrease of the product performance due to the lack of experience concerning both product and processes (Figure 3). This handicap could be overfilled through a “learning by doing” strategy during the development and the operating phase (learning by using).

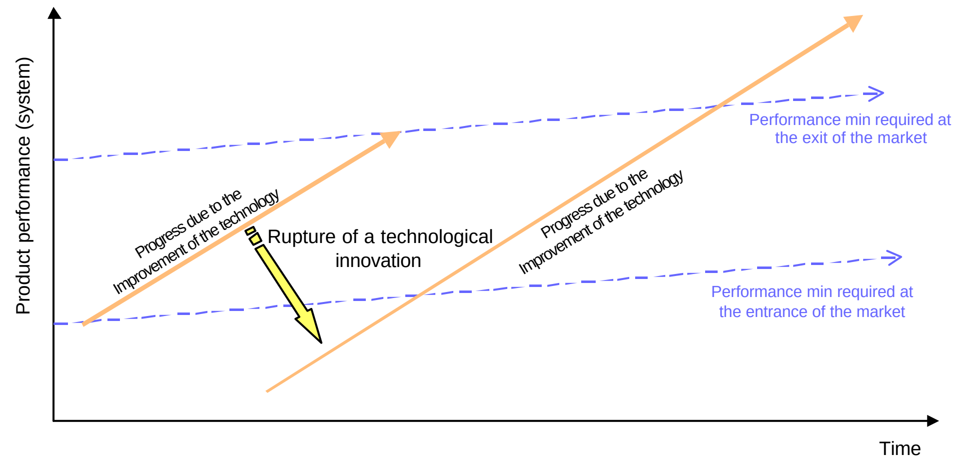

Figure 3: Notion of technological rupture. A rupture may decrease performance during a transition period.

In most countries where HSGT systems where developed, R&D programs were done for both incremental and radical innovations. High speed rail (HSR) solutions were more incremental whereas maglev concepts or Track Air-cushion technologies were more radical. They involved higher commercial speed (rupture in the supply) and non-compatibility with the existing rail network.

R&D-based development of high-speed wheel-rail technologies was a priority for many rail operators / industries involved in this market. The Shinkansen technology and the emergence of new alternatives (rupture) was an incentive to enhance the performances of the current rail systems in many countries. Japan chose to develop two options in parallel: the Shinkansen, and maglev systems for the longer term (The maglev options was preserved until now).

The same dilemma arose in Germany with the Transrapid maglev technology. In the USA, Japan and Europe the dilemma between transition and rupture was set up around the notion of performance / compatibility and alternatives were tested until the mid 70’s.

The concept of evolution / compatibility versus revolution / performance is the basis of discussions on innovation. Different models of innovations[4] were shaped depending on the industry’s position in this market, its type of organization and the institutional context.

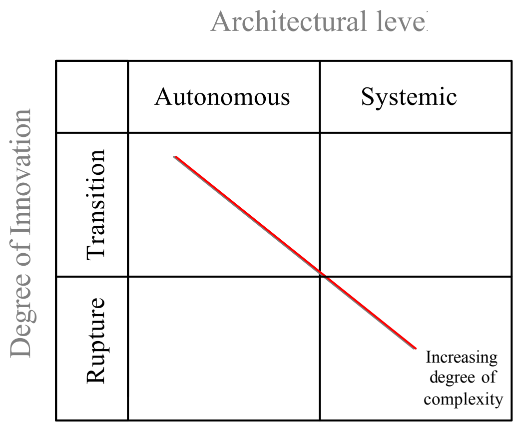

Figure 4: Innovations categories

The different kind of innovations that could be produced could be classified as shown in Figure 4: The degree of innovation could be graded from transition / incremental to rupture / radical.

[4] Innovation models: push (technology driven), pull (market driven) and interactive (see also Trott 1998).

But complexity in engineering systems also emerges at the architectural level. An innovation might be located at a component, subsystem or system level. The innovation could be defined as autonomous or systemic (architectural[5]). This relates the innovation's interdependences in the system. In an architectural or systemic innovation, a large part of the system needs to be modified, adapted. This new configuration could require some autonomous innovations to be implemented in order to allow the new recombination.

2.3 Selection Phase: Learning through the standardization of the dominant concept

After a decade of investigation in new HSGT concepts and interesting evolutionary developments, a large part of those alternative options were abandoned in the mid 70's: the French Aerotrain in 1974 and all US technologies, excepted the metroliner and the turbotrain. Institutions ended this extensive R&D phase by focusing on wheel/rail technologies, working with current operators. Only rail options were implemented, and only two maglev technologies were still maintained as an option in Japan and Germany.

This selection phase is the way to concentrate resources on a technology and learn more rapidly through an early adoption of the system for operation (learning by using). The main difficulty is the timing of those phases and of the selection process for both industry and institutions. An early adoption could result in a failure if the technology was not sufficiently developed for an accurate assessment. One example is the Japanese maglev system (MLX-01) for which a test track was built in 1991. Full costs of development until now are about 1.5 billion US$, but the operation's costs of the cryogenic cooling system seem too high for eventual commercial implementation (technological lock-in in term of cost-efficiency).

Since the 80's, the dominant concept of HSR has held. After the dominant concept selection, competition was based on incremental innovations along this path (technological system as a dominant design). If institutions are mainly involved in the selection of system infrastructure concepts, their role is also very important for technological choices of components (through the definition of safety standards etc). Within this framework, industries are innovating on a technological path, which is partially defined. In the 90's, options were focused on the development of tilting technologies and double deck cars. Innovations were mainly oriented on cost efficiency, materials life-cycle, comfort etc.

Since the implementation of HSR networks in Europe, rail industries have competed through different standards[6]. Coevolution or cohabitation of standards for such infrastructure could be analyzed through the notion of national markets. The harmonization of the European rail market started in 1990 affect the innovation processes. Operators and institutions have to reposition themselves and therefore the industry sees its environment changing (restructuring of the structure of decision-making processes).

An interesting tool for decision-making analysis is option choice theory, which could help in understanding the selection process of new technologies. This analysis has to be done by the private industry for its definition of R&D strategy and also by institutions, which have to support or evaluate emerging technologies for future implementation (attribution of concessions, public participation in infrastructure investments etc.). This assessment takes into account economical and financial criteria, but other critical factors have to be considered to explain the real decision-making process in both industry (suppliers and operators) and institutions.

[5] Henderson & Clark 1990.

[6] Standards concern Infrastructure, Energy, Rolling stocks, Maintenance and Inspection/control.

3. The Notion of Paradigm

Paradigms play an important role in the emergence of innovations (Dosi 1982). Complex systems such as infrastructure projects require strong relations between "building blocks"[7]: industry, operators, infrastructure owners and institutions. Introducing changes involves new paradigms in those organizations which strengthen cohesion in epistemic communities considered broadly. The more systemic and disruptive is the innovation, the more critical is this notion of paradigm and its diffusion among such communities.

Concerning HSGT systems, two main paradigms could be underlined. The first concerns the definition of performance and the second is related to the notion of technological lock-in. What is performance? Obviously the success of the shinkansen in Japan rapidly spread over among developed countries as a "techno-economic paradigm" (Freeman & Perez 1988). It first introduced speed as the main criteria for system performance in the development of innovations. Therefore, the apparition of alternative technologies such as maglev systems was based on the paradigm of anomaly by presumption. Based on the idea that rail technologies wouldn't be able to reach 300 km/h as commercial speed, a large spectrum of technologies was explored through R&D programs supported by public agencies. But two developments occurred in spite of technological lock-in: the contact wheel/rail was still effective for very high-speed as the energy transfer through catenaries[8].

Paradigms affect organizations and therefore institutions. Two attitudes could be observed: the first one defines performance as strongly associated to compatibility (transition path) and risk aversion. This was the condition imposed by French institutions (Finance ministry) for the TGV development: engineers of the French operator (SNCF) had to argue there was no innovation in this system to convince institutions[9]. Compatibility and transition was therefore the main criteria for the assessment of HSGT systems: beginning with the incremental HSR development in the UK (1975) and the abandon of the French Aerotrain in 1974. The success of the TGV operated since 1981 opened a new area for the development of national HSR networks.

The new paradigm of the 80's until the mid 90's was therefore setting the new standards in the international market with a competition based on "national HSR systems". But the European harmonization concerning the rail sector started in 1989. It brought a new paradigm with the development of the trans-European networks (TEN): compatibility began to be a critical factor in the mid 90's (technologies / interoperability) and now politicians are pushing for more collaboration between European industries.

One interesting case concerns the German strategy with the preservation of two technological options: the Transrapid (maglev system) and the ICE. In fact, each technology was supported by a separate institution with its own paradigm. The Transrapid was supported by the Department of Science and Research, whereas the ICE was supported by the Transportation Department. The Transrapid was developed assuming that winning new market share against TGV would best through a new generation of technology (anomaly by presumption). This same argument prevailed also for the development of the Japanese maglev system (MLX-01) and for the NMI[10] program in the USA. But both Japanese and German maglev technologies did not find a market niche until recently. In January 2001, China signed a contract with Transrapid international for a 30 km maglev project between Shanghai and its airport. Obviously China wants to be a technological show-case and this decision shows how strong paradigms could influence decision making processes. In the extreme inverse, the failure of

[7] Interview with W. Garrison, ITS Berkeley 03.2001.
[8] Interview with J.C. Raoul, R&D manager ALSTOM; meeting PREDIT Paris 12.2000.
[9] Presentation M. Cornil, R&D manager SNCF, meeting PREDIT Paris 12.2000.
[10] National Maglev Initiative (1990-1993) to assess the opportunity for the US industry to develop maglev technologies.

the introduction of new technologies could set the paradigm that innovation leads into trouble. This has been the case in California, with the technical problems of the BART and the MUNI (Boeing-Vertol) at the end of the 70's. As promoters claimed that their systems were innovative, their technical problems set this paradigm among politicians, institutions and planners for at least two decades

4. The technical and organizational path dependency

The diffusion of a paradigm required for the success of innovation is also dependant to the current context of industries or organizations. Two kinds of path dependencies may be described: technological and organizational.

4.1 Technological path dependency

Based on the theory of increasing outcomes, industries and operators try to benefit from scale effects in their strategies. Therefore, technological choices and innovations are conditioned by existing boundaries set by lead-users (operators) or the industry itself (infratechnology[11] and competences).

For HSGT systems, the first path dependency concerns the network compatibility. As operators play a crucial role in the adoption of innovations as lead-users, interoperability remains as the determinant factor of success. It has led to the failure of non-rail HSGT technologies (entry barriers, see Figure 5). After the success of dedicated high-speed networks, the development of tilting technologies has increased, maximizing the use of existing railways, which have not been designed for high-speed. Scale effects concerning operation and maintenance are critical factors for operators in the assessment of new technologies.

Concerning the Industry, the size of this market is not favorable for new entrants as the critical threshold is around 50 rail cars per year for a proven technology, and economies of scale decrease costs by 20% for 200 units (Klein 1994). Behind scale economies stands the concept of infratechnology (Foray 2000). This shapes R&D activities and determines the definition of the innovation boundaries. This constitutes a main criterion in the decision-making process within the industry, along with the definition of the lead-users needs (operators).

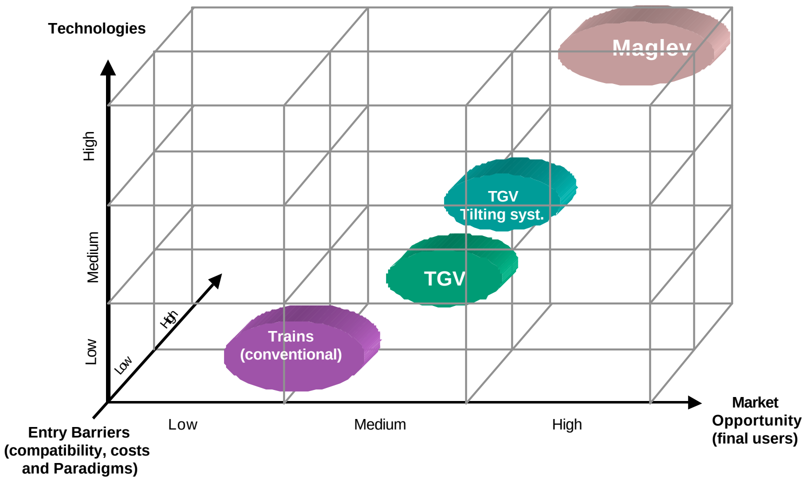

Figure 5: Entry barriers are formed by compatibility, costs and technological paradigms

[11] Infratechnology: technologies and tools, which are required for the R&D processes associated with the technological option (instrumental basis).

4.2 Organizational path dependency

Case studies underline this pattern in the industry and for operators, but also for institutions. This often becomes obvious when we look at the way organizations manage changes. In the USA, it is underlined by two interesting cases concerning aerospace contractors entering in new markets: Boeing-Vertol (Light Rail Vehicles) and Grumman (for buses). Both organizations entering in the ground transportation market faced big difficulties concerning product reliability. But usually behind technological failures are organizational failures. Innovation and organization are two paradoxical phenomena (Alter 1998). This example illustrates the problem of knowledge and experience acquisition (learning curve). As the tacit knowledge is "sticky" (Von Hippel 1994), introducing radical changes is not easy, especially in big organizations.

The role of Institutions in the assessment of new technologies is critical for infrastructure projects. New technologies and innovations imply an improvement of assessment procedures or tools: radical innovations couldn't be evaluated with the criteria previously used. If innovation points to a technological rupture or a rupture in the market, then it has to be assessed with an adapted and accurate methodology. Such examples show that organizational path dependencies are sometimes very strong in institutions. One interesting example of dependence concerns the assessment of the SWISSMETRO project: this underground high-speed maglev system has been assessed through the classical rail concession procedures. Even if the outcomes of this procedure would remain unchanged due to the actual context, it underlines the importance of accurate assessment procedures (de Tilière 2002).

Both technical and organizational path dependency influence decision-making or cognitive processes. But the distinction is useful as an innovation could be technologically or organizationally based.
Innovation in HSGT systems thus deals with technical and organizational boundaries. Compatibility with current infrastructure or not, network effects etc. Once a choice is done, then a very long relationship between the industry and the operator occurs,[12] introducing future path dependencies. Choices are therefore locking other future paths. But lock-in could be attributed to increasing returns (Gifford 1996), combining economies of scale achieved by industries, and economy of scope achieved by networks (Braeutigam 1999).

5. Notion of Risk and uncertainties

Innovative HSGT systems have to face two difficulties. The first is finessing technological lock-in, the second is evaluating the market demand. Looking at strong technological innovations such as the Japanese MLX-01 or the German Transrapid, those projects were highly risky (problem of irreversibility), costing respectively at least 1.5 and 1 billion US$. The demand forecasts and the relative advantage of such new systems or technologies are very difficult to assess, especially if the innovation induces a strong rupture in the market. Schnaars (1989) mentions the "over-evaluation of technological wonder" in some transportation projects, which underlines the difficulties of forecasting.
An interesting example of forecasting difficulty is the differences between the Boeing and Airbus strategies concerning Superjumbos: it is mainly because their respective demand forecasts were strongly divergent.[13] The same uncertainties are encountered for HSGT

[12] For example the choice of a system (Shinkansen / TGV) in Korea or Taiwan implies a choice for the long term: this conditions maintenance contracts for few decades (introducing both technological and organizational path dependency).

[13] Superjumbo (500-1000 seats): Boeing forecasted 320 units for the 747 and Airbus 1200 for the A380; with a profitability threshold around 500 units.

ridership forecasts, especially when a new type of services is provided (first TGV line between Paris and Lyon, Swissmetro market analysis etc.)

In fact, one of the main risks for radical innovative systems, ex-post, was the decrease of the relative advantage of the technology (see Figure 6). The critical factor for maglev technologies was mainly the problem of adoption by operators (lead-users). The risk of implementing a disruptive system in a period driven by reorganizations, with the European harmonization process in the rail sector, was definitely not the right period.

One interesting approach is to analyze the performance shaping factors (Williams 1988, Bea 2001) in the management of innovative projects. This approach will be used for the next step of the research at UC-Berkeley and EPFL-Lausanne. The objective is to complete the global approach of risk analysis by identifying the critical factors in the management of innovative projects in the transportation industry.

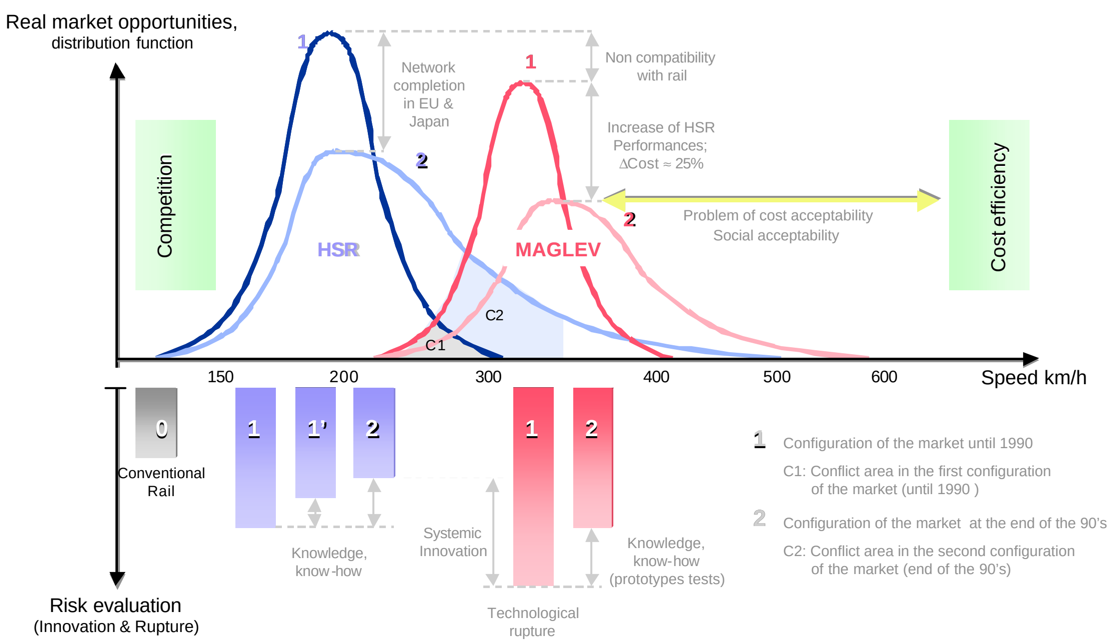

Figure 6: Improvements in existing technology could change the opportunity for new technology.

Those factors will underline the critical steps and tasks of innovation project towards risk. As shown in maglev projects, first or early adoption of a technology is associated with risks concerning problem solving. Testing and upgrading the product as it was done in Japan and Germany for maglev Systems through full-scale prototypes early in the development phase could be very risky if the project is not commercialized[14]. But it was a strategy for competing to the leadership, to win market shares and set the future standards. This risk-taker strategy didn't paid until now due to the change of paradigm and the fast completion of HSR networks. Therefore, upgrading an existing technology through operation of a new generation of trainsets seems to be the better way to benefit from economies of scale and also from the experience of lead-users that are operators.

In large infrastructure projects, innovations require a very good methodology for risk assessment. Innovation could imply a rupture associated with the product, processes (organizations) or the market. Therefore, the phase of identification becomes crucial to assess

[14] Case of full-scale demonstration projects not implemented: French Aerotrain (1974), Japanese MLX-01 (1998) and German Transrapid (1984) until the first contract in China (01.2001).

the impacts of the rupture for all the project stages (R&D, construction and operation) in order to reduce descriptive uncertainties. Uncertainties on measures could be treated with an extended probabilistic analysis of the net project value (NPV). This analysis has to be made for each main actor: industry, operator and public at large, in order to identify their strategies.
Finally the success of innovations in transportation infrastructure projects is closely related to a good definition of roles between the private and the public sector. A special risk profile is associated to each type of innovation. Depending on the ability of the private sector to carry the risks, the public sector has to secure some of their components according to the objectives of the transportation policy.

6. The link between transportation policy and innovation

As it was worked out in case studies, the private sector rarely carried alone a radical systemic HSGT innovation without the support of the public sector. One of the main components of risk remains political. The case of HSR projects failure in California and Texas in the 90's (Lynch 1998, Thompson 1999) underlines that critical link: the political and institutional framework is a critical point. Looking at innovation development in the past decades the link between transportation policy and innovation is very important and influences the paradigms that drive changes.

6.1 Looking for new alternatives, from technical performances to sustainability

The role of public institutions is very important to support the elaboration and the assessment of alternatives or solutions for future transportation needs. This role must be a support for the private sector when this last one can't afford it alone and if the NPV for the public at large is sufficient. This role has been critical for the HSGT programs during the 60's and 70's in UK, France, Germany, Canada, USA etc. Such R&D programs have supported improvement of existing technologies or alternatives in order to provide sufficient elements to meet the requirement for assessment and decision-making.
In that sense the role of public policy is to define the boundaries and the framework of alternatives within which the industry has to innovate. This underlines the importance of the role of institutions and the influence of their attitude towards innovation and changes (Gaudin 1978).

6.2 Development and diffusion of a technology: the competition for setting new standards

After the selection of one option or more (as in Japan or Germany supporting both HSR and maglev alternatives), the public sector could also support the industry for the development of the technology aligned with the goals[15] of transportation policy. The support could also be the securing of the network development or improvement. To guaranty a sufficient deployment of the innovation could make R&D investments for both private and public profitable (scale effects, case of HSR networks in France, Japan, Germany etc.).
Such deployments of networks increased the maturity of HSR technologies at a national level and allow private consortia to export their technologies. Even for exportation the public and private sectors are working closely, especially when government have supported strongly the development of a national technology. Therefore, governments support exportation to maximize network deployments based on their technology and try to set their standards abroad. This is the case for the Shinkansen technology concerning the Taiwan contract, where a 50% discount on the system was done[16], in competition with the European consortium leaded by Alstom and Siemens. The same strategy was used by the German government for

[15] Case of the US-FRA supporting 50% of the development costs of a HSR gas-turbine locomotive with Bombardier to extend the HSR network on non electrified areas (Source: US-DOT 12.2000).
[16] Interview with M. Takabayashi, Osaka University, 02.2001.

the contract with Transrapid international for the Shanghai contract, providing 300 million US$ for the implementation of the project[17].
Subsidizing the exportation or the development of a technology to maximize scale economies for the industry could be a strategy to maximize the profitability of initial investments or reduce losses. Once again, this underlines the importance of long term path dependency associated with those technological choices for both private and public sectors.

6.3 Influencing the market structure (Operators and industries)

The structure of markets including operators and industries has a strong impact on the kind of innovations that are implemented. Therefore, the link between transportation policy and the market structure is crucial.
The European transportation sector began its harmonization and liberalization process with the keywords: interoperability and Trans European Networks.

First changes have first concerned operators: separation between infrastructure and operation, and a progressive vertical disintegration. Financing HSR in Europe evolved during the past decade from a purely public sector enterprise, to one with an increasing level of support and long term commitment from the private sector (Lynch 1998). While the role of the public sector remains important in HSR infrastructures, private sector responsibilities are becoming more and well defined. The decision in 1989, concerning the development and improvement of the Trans European Network was very important. It contributed to redefining the roles of public and private sectors in a cooperative way to co-finance such investments[18].

Concerning the industry, those changes are coming from an increasing pressure from politicians who push for more cooperation between European manufacturers. This new area of increasing co-development or “coopetition” between European firms is seen as strengthening collaboration in costly R&D programs. The purpose is to decrease high investments needed for developing new technologies that were before supported mainly at a national level. Behind this trend stand the increasing pressure for standardization (interoperability), also related to economies of scale for both operators and industries. How will it influence the innovation processes and the governance modes of such projects?

Another interesting case concerning the influence of transportation policy on the industrial market structure is the HSGTA[19] (1965-75) and the NMI[20] (1990-93) program in the USA (de Tiliere 2001). The US-DOT favored the entrance of aerospace industries in the ground transportation market (rail and maglev) to boost innovation capabilities of this sector. But through the implementation of the Urban Mass Transit Administration (UMTA) Act which investments where too much unstable, all the US railcar manufacturers left the market before 1981. Preoccupied by the increasing role of HSGT in the transportation policies, the NMI was launched to look for future generations of technologies. The focus on maglev systems was based on the interest of US military contractors. Indeed, facing the same difficulties as other HSR projects in the USA, added to the non-compatibility of magelv systems with infrastructures, the NMI hasn’t been followed up. Finally a tilting technology has been implemented in the North-East Corridor and start its operations in November 2000. Indeed, the US-DOT had selected two projects among seven candidates for maglev implementation.

[17] Signed in Shanghai in January 2001, the 30km line will be put into operation in 2003. Earlier in 2000, The German government has offered to pay DM1bn for a 100km maglev test track in China in an effort to get China to choose Gernany's Transrapid maglev for the new high-speed railway linking Beijing and Shanghai.

[18] At the European level, the result was the creation of the European the Cohesion Fund established in the Maastricht summit and the Investment Fund.

[19] HSGTA: High Speed Ground Transportation Act.

[20] NMI: National Maglev Initiative.

But both are leaded by consortia based on the Transrapid technology. An incentive of 900 million US$ should be attributed by the US-DOT to the finalist at the end of the year 2001 if no cancellation occurs.

7. The links between Organizations, Institutions, and Innovation

7.1 Effects of vertical integration or centralization on infrastructure networks configurations

Looking at the experience of different countries that have developed HSGT technologies, the link between the organizational and institutional context and the type of innovation it has produced is obvious. In France the quasi-vertical integration between institutions and SNCF, and between SNCF and Alstom had produced the TGV network (HSR dedicated networks). The same kind of context has produced the Shinkansen in Japan, which was the first in the world. The strong cohesion of politicians, institutions, operators and industries had resulted in more radical options of infrastructure networks. The case of HSR projects in the USA or in Sweden, where the institutional framework was less centralized, led to more incremental solutions (Metroliner, Acela Express and X-2000) that maximize the use of existing infrastructures.

7.2 The role of lead-users in the adoption or development of Innovation

With the impact on network structure, innovation in vehicle technologies is suggestive regarding organizational and institutional contexts. The role of lead-users seems to be the dominant criteria in the selection of technologies (path dependency). Maglev systems didn't find a niche in HSGT markets. The most interesting case is the co-evolution in Germany of the ICE and the Transrapid technologies. Each one was in fact supported by a different institution: the ICE by the Federal Ministry of Transportation and the Transrapid by the Federal Ministry of Research and Technology. The main problem of such technology is the adoption by the "national operator" even though they usually are part of the administration board of those projects. Swissmetro is facing the same problem for its future with the CFF. One fact is that operators are still very close to institutions in decision making processes. That makes new entrance of a completely new technology difficult (reluctance of non incremental innovation adoption).

7.3 Changes of the context: social acceptability and organizational complexity

Since the 90's the golden age of new high-speed rail projects has ended. In this period of Concorde, Superphoenix and TGV, HSR projects were designed and build much easily with a strong cohesion of politics, institutions, operators and industries. The belief in a certain type of progress also allowed escaping from the social debate (60's, 70's). But social acceptability became a major issue since that time, added to an increasing complexity of technological and industrial policy structures with the deregulation of the transportation sector[21]. For operators this induces for the long term a separation of infrastructure and operation, and an opening of national markets. Therefore, the restructuring of the main European rail operators make them more concentrated in keeping their market shares than in launching new high technological projects with the industry.

Concerning the industry, the increase of co-development[22] and mergers[23] is now the trend for rail-car manufacturers. Politicians are also pushing for an increasing collaboration of

[21] Those last changes introduced in Europe concerning the deregulation of the rail transportation sector was embodied in the Directive 91/440/EEC: management independence of railway undertakings, separation of infrastructure management and transport operations, reduction of debt, establishment of access rights.

[22] Co-development: Alstom and Bombardier for the US Acela-Express (1997-2000), Siemens and Adtranz for the ICE, Alstom-Siemens for the Taiwanese submission (2000) and for the AVG, Talgo and Adtranz for the EMU with passive tilting technology (proposition for the Madrid Barcelona line, 1999).

European rail-car industries, probably influenced by the example of Airbus (cooperation between Alstom and Siemens).
This context implies that the paradigm of race for high-speed and the tension between radical and incrementalism concerning systemic innovation now let place to more autonomous innovations in components. This new paradigm is more customer-oriented, focusing on service quality (comfort, security etc.). Therefore, the completion of the Trans European Network has few places for radical systemic innovations such as maglev systems, and market niches may become too small to provide sufficient economies of scale.

7.4 Consequences on Public-Private partnership models

Innovations produced by an institutional and organizational system strongly depend on its decision-making structure and processes. Because of joint involvment, accurate models of public-private partnership are extremely important to establish a long-term development of such infrastructure systems. Financing of HSR in Europe has been supported, until the last decade, by the public sector through direct commitments of governments or public national enterprises. Since the 90's the evolution of the transportation framework lead to an increasing role of the long-term commitment from the private sector. Indeed the role of national companies and the public sector will still remain the basis for such transportation and land-use projects due to the predominance of their external benefits.
Both public and private sectors have to complement each others limited resources. Their roles and responsibilities are becoming more crisply defined. Each project has a financing plan made to measure, based on risk sharing strategies between the public sector (national and local levels) and the private sector according to the benefits of the projects.
Two types of models describe the actual trend of public-private partnership (Lynch 1998): The first one is the constitution of a private company whose shares are held by the government. This configuration allows the company to borrow capital at very competitive rates with the government backing. The second model is a company established with mixed private and public ownership. This last model often used in France allows use of complementary competencies. Efficient management of the private sector could be developed with an efficient management of the government policy regarding to land-use, right-of-way, or environmental concerns. This solution provides an integrated management team, but this underlines the importance of cooperation and coordination between the private and the public sectors (to manage change).

7.5 Coordination as a critical point

Managing complex projects and moreover those bringing strong uncertainties related to innovation requires a strong coordination of actors. Therefore, the importance of the cohesion of those organizations and institutions leads to the notion of shared paradigms or convergence of interests. Strategies of organizations and institutions are also driven by national or European economies, by changes in the market structure or changes in political priorities[24]. Thus some phases are more propitious for their engagement in a partnership to develop such infrastructure projects. This implies to better understand which components influence those "cycles" to bring together the public and private wills. The roles of institutions are therefore critical to defining frameworks of partnership and managing interfaces. This role underlines the central position of institutions regarding to systemic innovations in HSGT technologies.

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[23] Mergers: Siemens Rail division merger with Bombardier announced as a pressure on DBAG for the purchase of another 50 ICE3 trains in 1999. Bombardier and Adtranz (August 2000), Alstom swallowed 51% of FIAT rail division in June 2000.

[24] Case of the Transalpine crisis concerning freight transportation with the accident of the Mont-Blanc Tunnel in 1998. The disturbances in the road network leaded to the approval of the new rail tunnel project between France and Italy late 2000.

8. Conclusion: Private-Public partnership for innovative HSGT Infrastructures

High Speed Ground Transportation Systems are thought of as providing more external benefits for the public at large than a sufficient intrinsic profitability to be privately build and operate. Due to the importance of its effects on land-use, it has been since decades operated through national companies. Until the 90's, with the deregulation of the transportation sector, its institutional and organizational framework is in mutation. The opening of national markets implies a separation of infrastructure and operation activities, and a progressive introduction of privatization in operations. Therefore, decision-making processes are evolving, reshaped by all those changes. They are becoming perhaps more complex than in the past due to the current trend of vertical disintegration. Innovation processes are thus in evolution, accompanied the redefinition of the public-private partnership.

Successful innovations require a prospective role of institutions open to innovative solutions proposed by industries. But their role at the national or European level is also to look forward to support new alternative and give some incentives to the industry to explore those ones (through a pertinent definition of R&D programs and an accurate assessment of their outputs).

Radical innovations in infrastructures have been supported by institutions and the public sector. When other alternatives were explored in the 60's and 70's, R&D programs were established and funded by institutions, in relation with the industry (HSR dedicated lines, R&D in maglev or Aircushion tracks). Since the emergence of HSR standards has spread, research is concentrated in improvement of systems components and cost efficiency. Due to land-use implications, the role of institutions is critical for successful innovation and project implementation. For this reason and due to the share of infrastructure costs in such projects, all networks Infrastructure companies will be still largely publicly owned.

Concerning equipments and operations, the role of the private sector will increase. Also the role of institutions will still be very important, setting the framework of innovation (regulation, standards of safety etc). Incentives for both products (equipment and vehicles) and services (operation) will be done through the progressive opening of national markets. Concerning the structure of the market, current restructuring will probably leads to more mergers or cooperation. Finally, those arrangements will influence both market and decision-making structures. Those changes should therefore influence innovation processes: from the industry because of the current reconfiguration of the equipment market, and from operators (lead-users) because of the deep transformation of the European rail sector.

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