CAN INFORMATION TECHNOLOGY HELP RAIL PLAY A GREATER ROLE IN PREVENTING CLIMATE CHANGE?

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ABSTRACT
Increasing rail's passenger and freight transport market share would reduce energy use thereby reducing pollution and climate change. Unfortunately, many railroads have capacity constraints and are institutionally skeptical of introducing new products, operating strategies and technologies that could help them better meet the needs of today's passenger and freight customers, ultimately helping railways increase market share. One solution to these problems is clever implementation of new information technology (IT) strategies. IT can help in several ways. First, IT can help maximize the utilization of existing capacity. Second, IT can be used to help improve service quality by providing improved reliability and information to passengers. Finally, IT can help identify and prioritize infrastructure investments and institutional changes needed to improve rail service. Importantly, IT-based applications can help communicate the need for change to public and private decision makers. However, ultimate success will not come by simply adding IT to existing systems, but rather by using IT to re-invent the railroad to provide new products and services oriented towards today's customers. The paper outlines how IT can be used to improve railway capacity and quality.

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1. INTRODUCTION

A former president of the UIC once said, “The railway will be the 21st Century’s preferred mode of transport – if it can survive the 20th Century.” [1] On the other hand, the renaissance of railways has often been predicted to be just around the corner.

Railways, like other transport systems, began life as the mode of choice. Since they moved goods and people more efficiently than the competition, railway networks grew rapidly throughout the industrialized world. Railways were economically successful and the industry developed into a complex socio-technical system. But, following World War II, newer technologies replaced railways by providing more attractive products; airplanes are faster, automobiles and trucks provide more choice in routing and scheduling. Railways have been relegated to niche transport markets, important niches, but niches none the less.

Today, many argue that railways could play a very important role in helping to reduce energy consumption, improve the environment and reduce climate change. This is true, but it won’t be easy. Potential customers value the independence provided by automobiles and trucks. In the short run higher fuel prices will attract more customers to rail, but attracting customers in the long run means offering truly improved services. Rail’s competitors are working hard on new fuels and technologies to power airplanes, cars and trucks well into the future. Railways have a window of opportunity to revitalize their operations and services – to create a system fit for the 21st Century – but they need to break free from the past and embrace more modern institutional and technological ideas. Only then can railways seize a larger share of the market and effectively help reduce energy use and climate change.

The goal of this paper is to describe how adopting new information technology (IT) strategies could help increase rail’s share of the transport market by introducing change to social systems and technology. The paper argues that innovative use of IT applications could help ensure that rail really does become the preferred mode of transport in the 21st Century.

2. A CUSTOMER-ORIENTED BUSINESS?

Railways are complex socio-technical systems. The term socio-technical system highlights the fact that, while many people focus on technology when considering how an industry operates, in fact, social and institutional influences also play a key role. For example social influences help explain a technology’s lifecycle from adoption to replacement (and, the technology lifecycle helps explain the industry’s lifecycle). [2]

This paper’s thesis is that social and institutional issues – in addition to technology itself – will play a critical role in determining whether IT can help increase rail’s share of the transport market (i.e. supporting a railway industry that contributes substantially to reducing energy use, pollution and climate change).

Customers are part of the social side of a socio-technical system. In fact they are the most important part of the business. Here, it can be argued, is where the railroad industry’s problems begin; the railway industry’s customer image (who the customer is and what the customer needs) was developed in the early days of railways and has not changed much since. The customer image is moving many people or lots of freight between particular points (defined more by the railway than by the customer).

To be fair, this customer definition is pretty closely matched to the railroad’s technology, rail technology is most efficient in these markets. Before alternatives to the railroad (automobiles, trucks) were developed people who (and goods that) were not moving between points on a railway line had no option other than arranging their own transport to and from the railway. Railroads never developed effective socio-technical systems for efficiently feeding people and goods into their network. But, the problem is even deeper – railroads developed an institutional mind-set that they did not even want to carry these people and goods because they interfere with the main business of moving many people or lots of freight between particular points.

It's interesting to compare how railroads in the USA and Europe evolved. One reason US railroads focused on freight is because people started spreading out earlier and because freight was being moved much longer distances than in Europe. In contrast, European railroads focused on passengers because people remained concentrated in cities longer and most freight traveled only a short distance (trade barriers kept most freight internal). Both systems made rational business decisions based on the technology and social systems of the time, but both are stuck today when they want to increase service to other markets.

3. A MESSAGE FROM THE RAILROADS

On the other hand, railways are doing pretty well. Freight railways in the US and many parts of the world move a huge amount of freight efficiently and are profitable. European railways move huge numbers of people, and a growing amount of freight, and are slowly becoming profitable. So, is it really possible that railways could attract a greater share of the transport market and thereby reduce energy use and climate change?

In Europe, despite strong policy to shift traffic to rail, rail's share has not been keeping pace with growth. Goods transport in the European Union by road is over 3 times greater than for rail (in t-km) and truck transport has been growing at an annual rate of 3.5% per year versus 1.1% for rail. The passenger mode split (passenger-km) for rail fell from 6.6% to 6.1% between 1995 and 2005 (air travel's share increased from 6.3% to 8.6%). In the United States rail has done much better for freight transport. In 2005 rail carried over 34% more freight (in terms of t-km) than trucks and its mode share has been growing faster than road-based freight. In terms of passengers, while there has been growth, the base is so low that the mode share has remained approximately 0.3% between 1990 and 2004. [3]

Railroads recognize that they could carry a larger share of the transport market, but counter with a long list of problems preventing them from doing so. Most of these problems are social and institutional rather than technological. They include:

- Lack of capital, railways are highly capital intensive and economic returns are limited;
- Out of date regulations, while there has been institutional reform (e.g. deregulation in the USA, EU rail packages in Europe), there are still many constraints on what services railway companies can provide and how they can provide them;
- Social responsibilities, often relics from the past (e.g. full employment policies in European countries, requirements to provide uneconomic services); and
- Business strategies developed in an age where rail transport had a monopoly on transport of goods and/or people.

One or more of these macro-level problems are at the root of the specific problems railroads have in implementing operating changes or offering new products that could increase their market share. For example, US railways often argue that they cannot add passenger service to routes because there is too little capacity (due to a lack of capital, tax law, etc.) and/or liability issues (regulations).

The lack of capital problem is a good example of the need for social and institutional change. Among the reasons railways cannot raise sufficient capital for investments are government policies that limit their rate of return, production inefficiencies and the lack of an economic framework that fully accounts for external costs of transport (i.e. if the full cost of externalities generated by automobile and truck traffic were charged to users, there would be more incentive to use modes that generate fewer externalities such as rail).

These socio-technical problems must be addressed if railways are to increase their market share. An excellent example of addressing these problems is California's Capital Corridor service. By working together an innovative public agency and a cooperative railway have been able to significantly increase passenger service with benefits accruing to both sides. [4]

In addition to local governments working with individual railways on specific projects other changes will be needed at the federal and international levels. Higher level governments must update regulations based on new technologies and social needs, but government also needs to “encourage” railroads to develop business strategies more appropriate for today’s needs. As outlined in the following section, a key strategy should be increased use of information technology and adoption of social systems needed to take full advantage of IT.

4. INFORMATION TECHNOLOGY IN THE RAILWAY INDUSTRY

The role of information technology in the railway planning and operations is growing rapidly. The combination of more powerful and less expensive computers, distributed computing systems, improved communications technologies and application of new simulation and operations research techniques to the railway sector has brought significant benefits, [5] [6]

There are three main types of IT applications that could be used to increase railway market share: railway scheduling, railway operations and railway simulation. Often specific applications combine aspects of all three. Many applications could also be used to implement operating strategies and services that could change the railway industry’s socio-technical system, in other words helping railways fundamentally change the way they do business and thus increase their role in helping to reduce energy use and climate change.

The major focus of IT applications is in the development and analysis of railway timetables (schedules). As shown in Figure 1, this makes sense since the timetable forms a link between the market (e.g. pricing system, services and products offered – i.e. the social aspect of the system) and the system (the infrastructure, rolling stock and signaling/operations – i.e. the technical aspect of the system). [7]

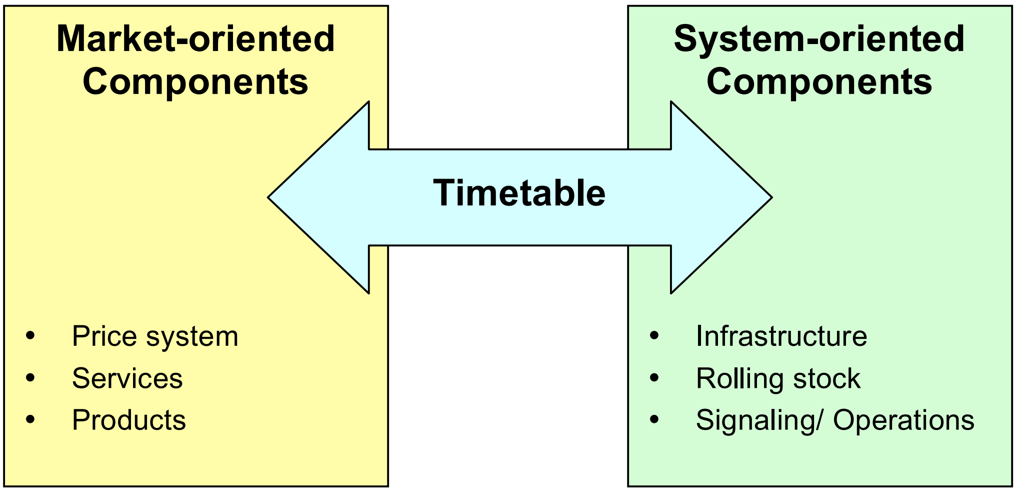

Figure 1: Railway timetable as the link between market and system components [7].

The rest of this section describes five key rail IT issues. First, the relationship between growing demand, capacity and service quality. Next, the three main methods for using IT to improve rail capacity and quality. Finally, an example of how IT can help train operators improve service by identifying and addressing infrastructure and institutional bottlenecks.

4.1 Growing Demand = Capacity Constraints and Quality Problems

Railways are enjoying strong growth in demand and forecasts are that this growth will continue. Three trends are supporting this growth: passenger and freight rail transport is more energy efficient, rail is more climate-friendly and global trade continues to increase.

The strong and continuing growth is causing capacity and quality problems on railways throughout the world. Two examples from Europe are:

- Year 2015 traffic forecasts for Switzerland's Rail 2000 program have already been surpassed; parts of the rail network are systematically overloaded, resulting in regular customer complaints.
- Rail freight transport in the North Sea hinterland cannot provide high quality and timely service for the steep increase in containers. This caused a serious transport crisis in 2007. [8]

The capacity of a rail network is the maximum amount of traffic that can use the network. Railway capacity depends on many variables such as infrastructure quality, type of operations and scheduling assumptions. Railway service quality can be defined in terms of four key factors: punctuality, reliability, comfort/security and price. There is a clear relationship between capacity and quality on all types of networks. As demand increases quality decreases, first slowly, then when a certain demand is reached quality decreases sharply. Figure 2 illustrates this relationship schematically showing how delay increases with increasing demand. The green line illustrates how improvements can increase quality (in this case: reduce delay).

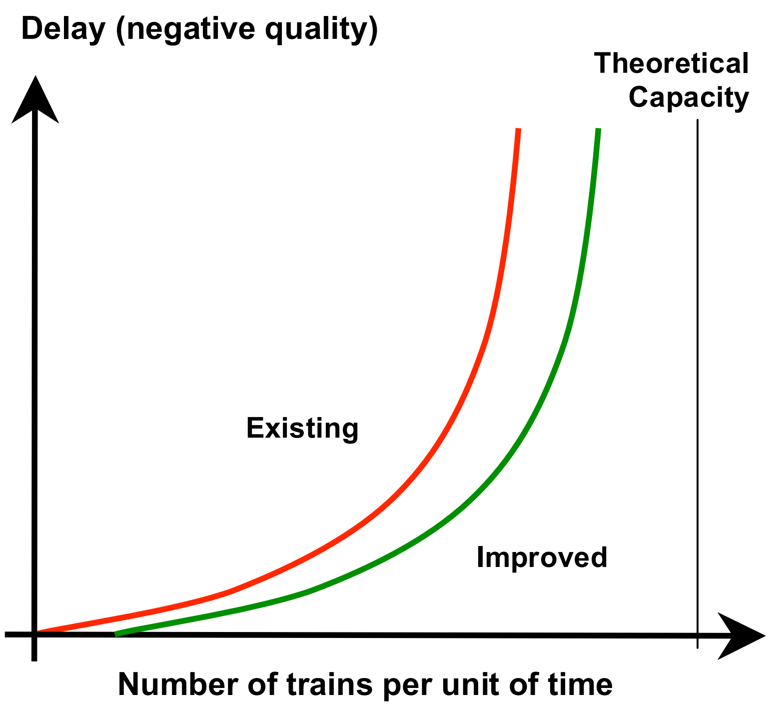

Figure 2: Relationship between delay and number of trains operated.

Railways are in an especially difficult position because not only is demand growing, but customers expect high quality service and want service further improved in the future. Two specific examples are:

- Improved Information – People are accustomed to using IT systems in their automobiles to provide guidance (navigation) and detailed real time state of the system information (e.g. traffic congestion, route recommendations) to help make travel easier and more efficient. They expect public transport to offer the same types of information and services.
- Just-in-Time Production – Today many freight flows are part of JIT production systems that require absolute reliability. Trucking firms continue to enhance their IT systems to meet these requirements. Rail freight has not kept pace with these innovations and rail's already significant competitive disadvantage in this area threatens to worsen.

It's interesting to note that poor quality rail service in the past resulted only in lost customers (which had only a long-term impact on revenues). However, the EU's third railway package provides for the systematic introduction of penalties for delays. This means that the delays will impact railway revenues in the short term. It will be interesting to see how railways react to this new regulation.

Railways understand that they must increase capacity and quality. The traditional approach for increasing railway capacity and quality is to build and improve infrastructure. However, railway infrastructure is very expensive and requires a long lead time to plan and build. Furthermore many improvements are needed in urban areas where it is difficult to obtain land and expensive (as well as controversial) to build. Finally, as highly capital intensive businesses, it is very difficult for railways to economically justify large new projects in terms of return on investment. Therefore railway companies are very cautious about their capital planning.

Improved IT applications can help address the problems of limited capacity and reduced service quality in three main ways: first, improved scheduling can help railways increase the amount of service that can be operated on a given infrastructure; second, improved operations and dispatching can help ensure that these denser schedules can be operated at a high level of quality; and, third, comprehensive railway simulation can help railways identify and prioritize capacity and quality improvement projects. The following sections outline these three applications in more detail.

4.2 IT and Schedule Optimization

One key to improving passenger and freight rail transport quality and capacity without making significant infrastructure investments is to develop IT applications that create stable and robust schedules. Stability and robustness can be defined as follows:

> ***Stability*** is the ability of the system to recover quickly from service disruptions or delays;
>
> ***Robustness*** is the ability of the system to function well despite disturbances and failures. [9]

There are numerous techniques that can be used to create stable and robust railway schedules. Several IT applications have been developed to help planners evaluate how implementing these techniques can increase service quality and capacity and create schedules based on these techniques. Seven of these techniques are outlined below.

Use stable and simple service concepts.

A good approach for creating robust schedules is to use simply structured line concepts with a high degree of systematization. These concepts usually result in schedules that minimize the number of direct point-to-point relationships. The ultimate examples are the national systematic timetables used in The Netherlands and Switzerland. [10] In both cases trains operate at regular intervals at the same relative times throughout the day (e.g. 5 minutes after the hour and half-hour all day long) and timed connections at main stations provide fast transfers and shortened journey times for most passengers.

It is important to note that introducing these types of schedules can be difficult because, while they improve service quality on a system wide basis, they can result in reduced service quality for specific services (i.e. replacement of infrequent direct train service with frequent service that requires a transfer). This can generate political opposition.

Similar simplified freight train scheduling concepts have also been developed. [11] Note that these concepts must be very carefully planned so that they do not interfere with just-in-time production demands or other logistical processes.

Create optimized train connection relationships.

When developing simplified service concepts such as the integrated systematic timetable, it is important to make certain that the connections take place at stations with efficient passenger transfer facilities and that rolling stock has sufficient door capacity (i.e. the rail vehicles have high capacity boarding/ alighting). Similarly, freight facilities must have sufficient handling equipment and marshalling tracks to efficiently break-up and make-up trains. This is an area where an iterative planning process using advanced IT-based schedule development applications and train simulation applications really can make a difference in rail system performance.

Construct conflict-free train paths.

This well known scheduling technique becomes even more important as demand for rail service increases and excess capacity is reduced. On the other hand, IT schedule development applications make it much easier to develop conflict-free schedules.

Construct realistic train paths.

Realistic schedules are based on the concept that there will always be operational problems that create delays. Therefore planners should focus on creating robust schedules that minimize the impact of these problems. This is done by introducing buffer times into the schedule; but increasing buffer times reduces capacity.

In order to increase robustness and minimize the impact on capacity, buffer times must be added carefully. This means adding buffer times where and when they will not other wise impact capacity. For example, don’t add buffer times in areas with capacity constraints; instead add them in locations where there is excess capacity. This is the approach being taken by the Swiss Federal Railways in their Puls90 program. [9] [12]

Resource Planning

As more trains are operated resource planning becomes more complex. Resource planning should be done to minimize the risk of delays caused by rolling stock and/or staff not being available at the right place and at the right time (e.g. staff transfers between trains with very short connecting time). IT applications can play a key role in developing rolling stock and staff plans.

Staff planning is also an area where railway social and institutional regulations interfere with efficient operations. The crews are changed at the border on many international trains; while there may be good reasons for changing the train driver, there are seldom good reasons for changing the conductors – especially for relative short trips in the second country. These crew changes simply provide another opportunity for a delay without providing any real benefit. They should be eliminated whenever possible (as they have been on some Switzerland to Germany international trains).

Real Time Slot Access

A key problem faced by railway freight operators is the difficulty in obtaining access to rail routes on short notice. This is important because freight operators cannot plan years in advance for their demand if they are to compete successfully with truck operators. Today it is difficult for infrastructure operators to evaluate the impact of adding a train to a congested route during peak periods and even more difficult to develop ideas for shifting scheduled trains to enable the additional train to be added. However, by combining the schedule optimization recommendations presented in this section with the operations optimization recommendations presented below (e.g. real time rescheduling), improved IT systems could enable infrastructure operators to say “yes” more often when freight operators request a specific slot. Interestingly, when combined with innovative slot pricing strategies (described next) slot access could become more market oriented leading to more efficient investment and operating strategies.

Slot Pricing Strategies

The efficient operation of networks requires that capacity be allocated based on the market. The market for railway capacity is unquestionably very complex and, similar to many other networks, there has been great resistance towards the implementation of market-based pricing (including in the USA before deregulation). Railways provide important social services, but these services should be paid for; the system used on the Capital Corridor (trading slots for specified infrastructure improvements) is a good example. There has also been much research in Europe regarding different strategies for setting slot prices. [13]

An interesting concept is using IT to help set slot prices. For example, a slot with a high priority might cost more than a slot with low priority. This would mean that, if there was a delay on the system, the train with low priority would be more delayed than the train with high priority. Such a system could even be transformed into a real-time auction-based train prioritization system. An advanced IT dispatching system would be needed to operate this type of system. [14]

This type of market-based priority system would have the very significant advantage of enabling customers for whom delays matter to pay more to minimize their delays, which could make rail more attractive for just-in-time freight and express passenger trains.

4.3 IT and Operations Optimization

The second main area where IT can be used to improve railway capacity and service quality is in helping optimize operations, in other words actually implementing the optimized schedule. It should be recognized that there is a very close relationship between scheduling and operations – if the operation is very precisely controlled, then the buffer times included in the schedule can be reduced. This is the key to increasing railway capacity.

There are three key aspects of rail operations optimization: improved dispatching systems, improved train control systems and improved customer information systems. They are outlined below.

Improved Dispatching Systems

Dispatching systems are a key instrument for ensuring railway system punctuality and reliability. The current state-of-the-art requires that dispatching systems:

- monitor the network operating situation;
- automatically identify deviations from targeted performance; and,
- detect train conflicts.

The next step in improving dispatching systems will be to add tools that can help dispatchers resolve local conflicts. The main challenges in developing these tools include:

- Forecasting of disturbances including both how disturbances propagate through the network and the detection of follow-on conflicts;
- Determining the optimal network-wide conflict resolution solution; and,
- Including additional factors to minimizing overall system delay (e.g. energy use, train priority) in the criteria used to determine optimum operations. [15]

There are three main issues involved in developing advanced dispatching systems: complexity, data acquisition and human factors.

Complexity – Developing a dispatching system that can determine a network wide optimized dispatching solution is extremely demanding due to the great complexity of the problem. However, several improved dispatching applications are currently under development.

Most of these applications break-down the network into sub-areas and develop localized solutions. For example, the SBB's Puls90 program breaks the railway network into districts based on whether they are operating at capacity or not and develops optimized dispatching strategies for each district. Figure 3 illustrates how this type of system could work; condensation zones are districts that are operating at capacity and compensation zones are districts with extra capacity. As shown in Figure 3, there are a variety of different time-space paths that trains can follow in the compensation zones before reaching the condensation zone. The goal is to have trains enter the condensation zone at their optimal speed so that they can follow the optimal trajectory through the condensation zone. [9]

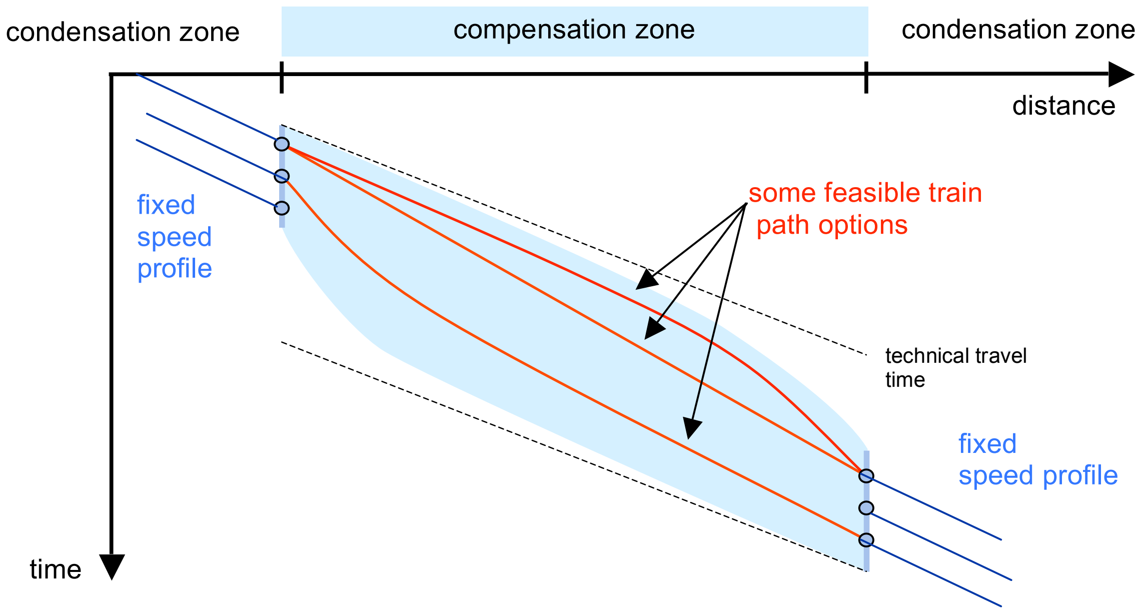

Figure 3: SBB's Puls90 concept for improved train dispatching. [16]

Data Acquisition – Another significant problem in developing advanced dispatching systems is data acquisition and evaluation. While railways are overflowing with data, the key problem is having the right data in the right place at the right time – so that it can be used to help inform dispatching decisions. For example, the compartmentalized nature of railway organizations means that sometimes data coming from a particular infrastructure element is not available in real time for use by the operations department. The new European Train Control System (ETCS) will help address this problem by providing more data, but may lead to information overload.

It will also be important to evaluate both the quality of the dispatching instructions and how precisely these instructions were implemented to evaluate the quality of railway performance. Unfortunately, the conventional measures used to evaluate dispatching instructions (i.e. delay) are much too general and too lumpy.

Therefore, it's critical for railroads to develop a data roadmap as part of the improved dispatching plan. This roadmap must involve all railroad departments and focus on efficiently obtaining only the most relevant data for improved dispatching, but also for improving the schedule planning process. The railway performance data can be used to complete targeted analyses of key weaknesses in production processes. This will provide the information needed for reprogramming of schedules and make the planning and production process a self-learning system.

Human Factors – The role humans play in the dispatching process is changing. Today people are the ultimate decision-makers. While this will remain true with the more advanced dispatching systems, the relationship will change with automation taking on more responsibilities. However, it's important to remember that automated systems react to problems while experienced users anticipate problems, in other words people will always be needed, but decision support tools could help them do their job better.

An important social system issue is the need to recognize the differences between members of the "T-rex generation, Pac-Man generation and iPod generation" in the development of new systems and training programs. The training programs for the Loetschberg Basis Tunnel control system, which were developed in a close partnership between the operators and IT system developers, provides a good example. [17]

Another human factor is whether social and institutional resistance to staffing reductions made possible by the more automated dispatching systems will delay their development and implementation. There are models for successfully introducing these types of technology improvements and it is important that railway management use these models rather than attempting to simply introduce the new systems. If new train dispatching systems are to be successfully introduced, they will require that staff consider them positively and participate in their introduction as allies. Otherwise, the benefits of new technology will not materialize.

Improved Train Control Systems

Train drivers provide train control. New IT systems combined with interfaces in the cab could enable drivers to more precisely control trains, thus increasing capacity and improving service quality. Two key elements necessary to improve train control are:

- Higher timetable temporal and geographical resolution (schedules defined in term of seconds and meters rather than minutes and kilometers); and,
- A requirement that trains always follow their schedule: either the old schedule or a new one.

Research in Switzerland has shown that train drivers can follow detailed schedules (i.e. speed – time – location) provided that the schedules are realistic (i.e. achievable) and that they receive the information in sufficient time. [9]

It's important to realize that in order to successfully increase capacity and quality, other railway operations actors (e.g. dispatchers, infrastructure operators) also need more precise information and to increase their temporal and geographic resolution. Given the need to work with many different people performing many different activities, it is clear that implementing improved train control systems is not only a great technical, but also a great cultural and social challenge!

Improved Customer Information Systems

Improved IT can play a prominent role in providing higher quality information to all railway customers. Indeed, railway competitors have made customer information a cornerstone in their businesses. Two examples are the tracking systems for express packages and GPS navigation systems. These technologies help customers improve their planning and operate more efficiently.

One example of an improved customer information system would be to send messages to passengers about delayed trains. In contrast to similar systems used by airlines, these systems could suggest changes to itineraries that would help customers minimize their delays. By linking these systems to real time dispatching systems, other trains could, for example, add an unscheduled stop to enable delayed passengers to transfer to a different train. By providing all this information electronically, though a coordinated system of handheld devices, public address systems (on-board, station based) and interactive signs, transfers could be made smoothly and efficiently.

Furthermore, one of the main problems with delays is the uncertainty created by the lack of information. If the dispatching system can provide accurate information about the delay duration and alternative possibilities, then passengers can use this information to re-plan their activities. The frustration comes from the loss of control created by the lack of information.

4.4 Railway Simulation

The third main area where IT can be used to improve railway capacity and service quality is using railway simulation to help identify and prioritize capital investment and system improvement programs. A good simulation program enables users to compare alternative sets of changes to infrastructure, rolling stock, schedules and operating strategies. This makes it easier to answer complex questions and set priorities.

Simulation was one of the earliest applications for computer technology in railways. [18] Over the years these simulation applications have been refined and improved by adding new features and making the programs easier to use and integrate with existing databases. For example, an interesting refinement directly related to reducing energy use has been the addition of electrical power network analysis to railway simulation applications. Programs are also now able to model very complex situations (e.g. Paris RER network [19]).

Railway simulation is especially important because, while improved IT can help improve railway capacity and quality, it is only a part of the solution. Significant investments in infrastructure and rolling stock will be needed to substantially improve capacity and quality. Railway simulation is therefore a critical tool in the analysis of these investments, but railway simulation must also be able to incorporate the types of benefits improved IT can provide to the system.

4.5 An Example: Why IT is Critical to the Future of Railways

An interesting example of how IT can help railway companies understand and plan for the future is a study evaluating the future of Thalys operations. Thalys operates high-speed passenger trains between Paris – Brussels – Cologne – Amsterdam. Thalys ridership has grown significantly (up over 28% in the last four years) and passenger demand continues to increase. [20]

Thalys operates its trains on tracks owned by other railways (creating problems similar to those faced by Amtrak and US commuter rail agencies). The tracks are shared by a variety of different high-speed rolling stock as well as other passenger trains and freight trains (all operating with different acceleration rates, maximum speeds and braking characteristics). Speed limits vary by track segment between dedicated high-speed lines to conventional track. Infrastructure operators have uncoordinated maintenance and improvement programs.

Dispatching regulations and schedules – sometimes designed to minimize the delay on national trains (since otherwise operators might need to pay penalties) and to provide national trains with regular schedules impact the speed of international trains and/or their ability to operate efficiently. In this complex and rapidly changing environment, the infrastructure operators want the train operators to bid for train slots five years in advance. This makes it extremely difficult to meet changing demand or to schedule a freight train to meet a customer's specific need.

The only way to operate such a complex a system is through the use of powerful IT systems. These systems can identify physical and institutional bottlenecks and evaluate approaches for eliminating them. Infrastructure bottlenecks are clear, they include low speed track, capacity constraints, stations with limited platform constraints and particular shared-track situations – but deciding how to remove them is very complex. Institutional bottlenecks are more complex; addressing them requires development of more consistent slot allocation systems and prioritization schemes as well as more rational (i.e. coordinated) development of national train schedules.

Thalys used the Viriato software application to better understand the specific infrastructure and institutional bottlenecks they were facing. As shown in Figure 4, Viriato develops a visual timetable that schematically shows both train routing and schedule on the same diagram. [7] The analysis results were used by Thalys both to help plan their own operations, but also to provide specific data that could be used to recommend institutional and operational changes at the infrastructure companies, other train operating companies and with government agencies.

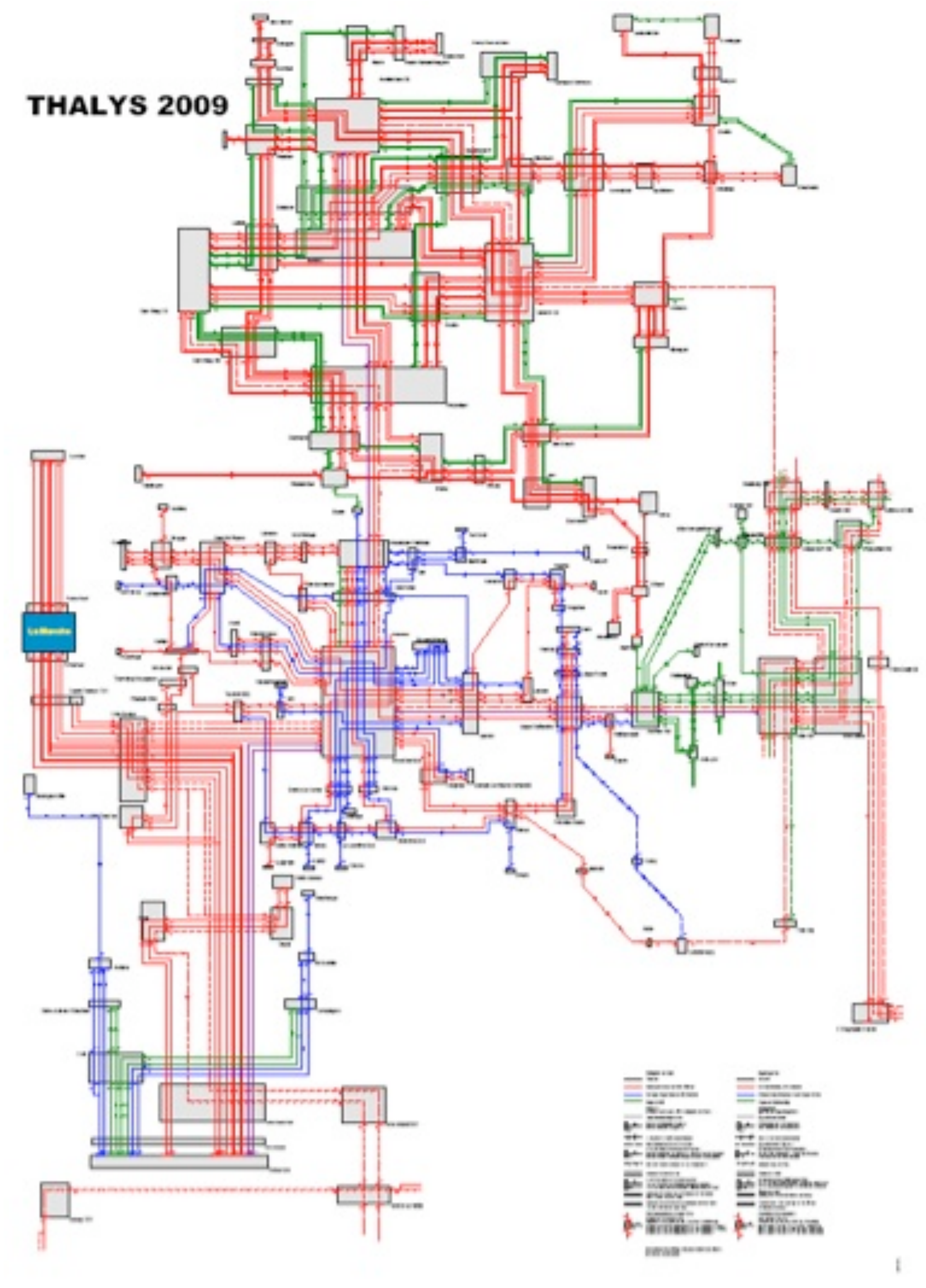

Figure 4: Visual timetable for Thalys developed using Viriato scheduling software. [20]

5. Conclusions and Recommendations for Future Research

Railways are a critical element in passenger and freight transport systems. They provide very energy efficient service and consequently generate less pollution and climate change impact than other modes of transport. While railways carry a substantial share of freight and passengers, they could play a greater role and thereby help reduce climate change. Adopting specific technologies and ideas from information technology could help increase rail's market share.

Advanced planning and information systems are already increasing railway system capacity and quality. These benefits will increase as systems are further developed and implemented. However, it is critical to think carefully about how these new technologies are applied if railways are to fully reach their potential for increasing passenger and freight traffic. Railroads must use IT not only to improve their planning and scheduling, but also to introduce new products and services that IT makes possible. IT must be fully integrated into the railway socio-technical system; it must be used to demonstrate the need for institutional change at the government and business levels.

In other words, while planning processes and tools must be improved if there is to be a significant improvement in railway service, interoperability is not simply a question of technology, but also a question of social institutions, planning strategy and service planning.

The paper highlights many current issues involved with application if IT systems in railways and points out opportunities that would be fruitful for more research. A key area for future research is on how IT strategies could be used to help encourage the types of social and institutional changes that will be needed if rail transport is to successfully increase its role in providing passenger and freight transport service.

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