LEARNING FROM SWISS TRANSPORT POLICY

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INDEX

0.1. INTRODUCTION

This dissertation is born of the desire to broaden horizons and the underlying need to improve day by day, the transportation knowledge. It aims to draw some lessons that certainly have been, are, and will be a source of inspiration for engineers worldwide. On behalf of all of them: "thank Switzerland for your particular approach."

Throughout the following pages, the author seeks to make an accurate description of the reality of railway passenger transport's policy in Switzerland, in recent decades. The starting point is an objective analysis of society and the needs thereof; base of contextualization. Later, we proceed to a description of the actions carried out in recent years in the railway sector, with particular emphasis on the revolutionary project RAIL 2000. Then, from the point of view of "learning" of the study, it has been intended to draw lessons that enable conceptual capture the essence of the measures taken and their possible application in other systems such as Railway Medium Distances in Catalonia. Finally, given that are the decisions of today's leaders, which will make the future's reality, it has been considered essential to know the views of the major current personalities in the transport milieu. Therefore, individual interviews have been conducted with different personalities of the moment, thanks to which we let the reader know the perspective of the main involved institutions. Consequently, we collect the assessments of:

- Mr. Iñaki Barron, as Head of Passenger Transport Section at the UIC (the institution that includes owners and operators of railways around the world)
- Mr. Keir Fitch, as the representative of the European Transport Commission
- Mr. Michel Béguelin active member of the Swiss transport policy, as the representative of the Swiss people in both Houses by the Transport Committee, CFF's Railway General Secretary and spokesman for the Swiss Delegation of Transport in the European Union.
- Mr. Ulrich Weidmann, as distinguished transport networks' planner and expert professor at the Federal Polytechnic School in Zurich (ETHZ), while active representative of CFF.

0.2. OBJECTIVES

The main objective is to learn from Swiss transport policy applied to passenger rail nationwide transport. In this sense, following pages are to:

- To understand the reality of Swiss transport policy.
- To analyze the most important aspects of railway's policy, especially the project Rail 2000, from which it is necessary to extract the key points that have allowed its success.
- To consolidate the learned knowledge finding its application in Catalonia's transport policy for medium-distance rail network.

0.3. ACKNOWLEDGEMENTS

I would like to thank everyone who in one way or another has contributed to making this work:

Of course, Professor Andrés López Pita, for the honor of being my mentor in this great experience.

Very especially, I would like to pay tribute to Professor Panagiotis Tzieropoulos and his entire wonderful laboratory, LITEP, from the EPFL. Not only for the great training and support they have provided me but for his amazing human qualities.

The illustrious Mr. Keir Fitch, Deputy Head of the European Transport Commission, and the honourable Iñaki Barron, Director of Passenger Transport section at the UIC, for their invaluable contribution to my study. Undoubtedly, Professor Ulrich Weidmann and Mr Michel Béguelin, whose nuances contributed to my understanding of Swiss transport policy, and for their incomparable kindness. It is admirable to verify how personalities from this caliber do not hesitate to meet future generations making them partakers of his great knowledge and experience.

Finally I would like to make a special mention to my family, Paqui and Miguel, for the education they have given me and unconditional support during all these years.

1. VENI

"*Plus rapide, plus frequent, plus direct et plus confortable*."

1.1. COUNTRY'S CONTEXTUALISATION

To carry on a transport policy study is necessary to frame it in context, since transport is closely related to economic and social development. In this sense, it is vital to comprehend the influential determinants, because in no case it will be understood a national transport policy if it is abstracted from the action of general domestic and foreign policy.

1.1.1. INTERNATIONAL DETERMINANTS.

Switzerland is a Central Europe's country with approximately 7.9 million people and 41,290 Km^2 that stretches along a very uneven terrain, with an important mountain component. Located in the heart of the Old Continent, it borders on many countries: at North, on Germany; on Italy at South; on Austria and Liechtenstein at East; and at West it borders on France (*Figure 1*). This particular location gives the country a great strategic role, as far as some of major transport corridors cross its domain. A clear example is the case of freight transport by the Rotterdam-Genoa axis of TEN-T project, linking the ports of the North Sea with the Mediterranean Sea via Italy (*Figure 2*).

Figure 1: International determinants' map.

Source : http://www.switzerlandtraveldiscount.info/map%20switzerland.bmp

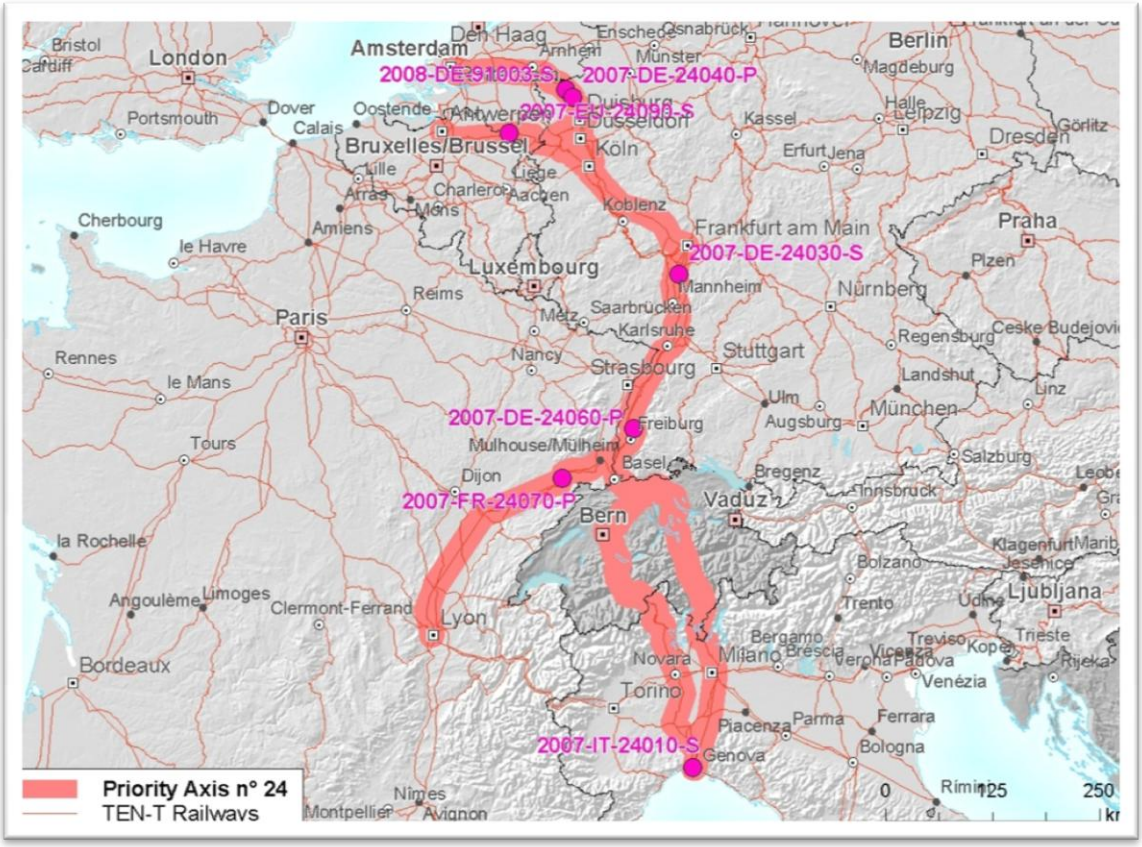


Figure 2: Project 24 of TEN-T.

Source:http://tentea.ec.europa.eu/en/ten-t_projects/30_priority_projects/priority_project_24/

1.1.2. GEOGRAPHICAL DETERMINANTS

In terms of Geography, as it is shown in *Figure 3*, Switzerland has a varied landscape, resulting in the division into three major areas of the country: the Alps, the Plateau and the Jura.

The Alps cover 60% of the total land area and they have always characterized Switzerland's identity. The numerous mountain passes in Swiss Alps, with their perpetual snow, represent important lines of communication and they have been the subject of majestic works of civil engineering through its world-renowned drilled tunnels; at the same time, they are reference ecosystems worldwide.

The economic life is concentrated in the Plateau, which constitutes 30% of the area and where they live two-thirds of the total population. Geographically, the Plateau extends from Geneva to Constance's Lake.

Finally we have the Jura, which occupies 10% of the total area in Switzerland and who borders on the northwest Plateau's side. With an average altitude of 700 meters is characterized by valleys, high plateaus and ridges.

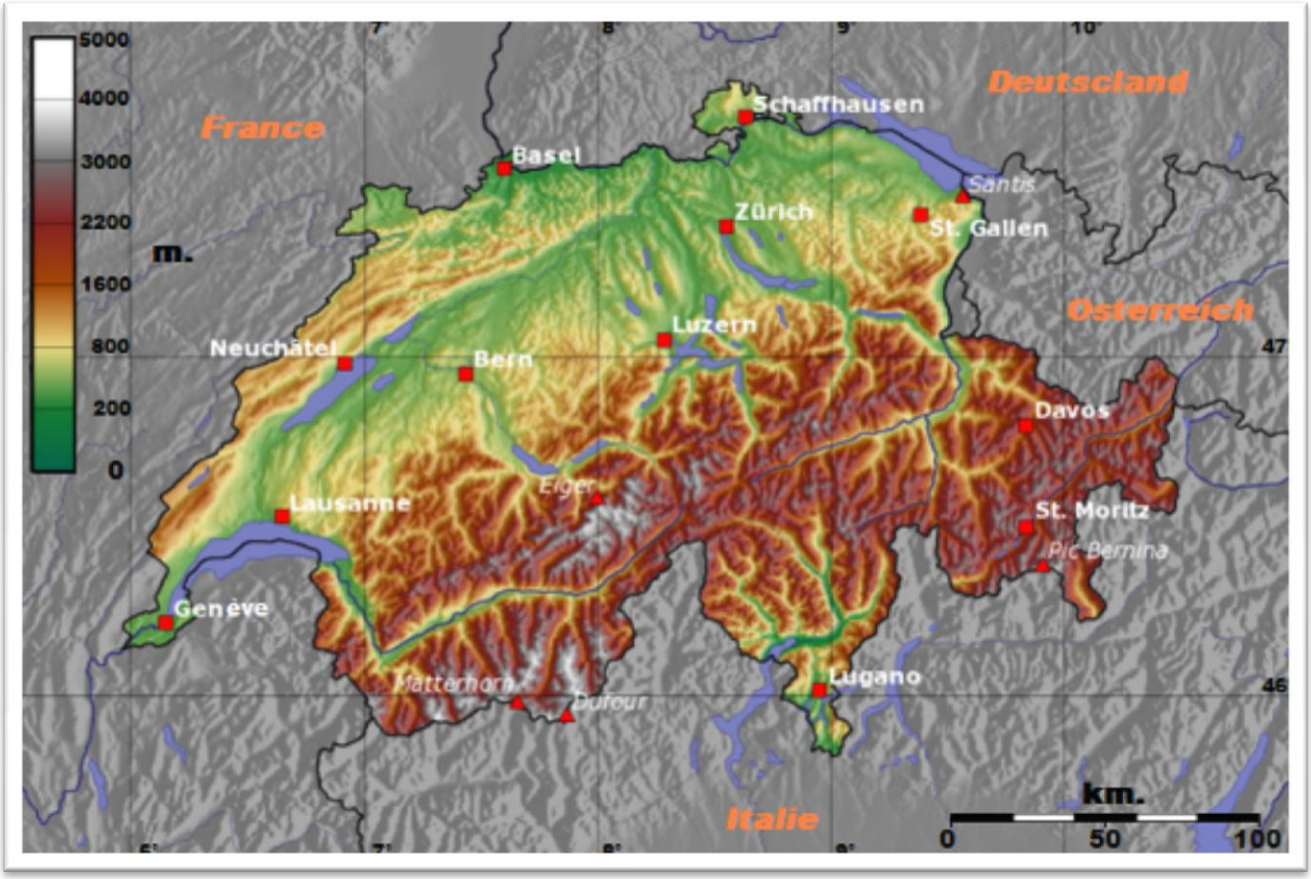


Figure 3: Geographical determinants' map

Source: http://fr.wikipedia.org/wiki/Suisse

1.1.3. POLITICAL DETERMINANTS

Switzerland is defined as a Confederation of 26 cantons, with Bern as administrative capital. Governed by the unique worldwide direct democracy system, the country combines a federal state organization with popular rights which give the people (sovereign) supreme political power. People's rights are exercised using three different instruments: Popular Initiative, Optional Referendum and Mandatory Referendum.

Switzerland is not a member of the EU or the European Economic Area, as its incorporation into the EEA was rejected by the people through a Mandatory Referendum on December 6, 1992; and in 2001 they refused the possibility of new negotiations to be part of EU. However, there is a set of bilateral agreements between the EU and Switzerland to strengthen political relations and it belongs to the Schengen Area since 2005. Thus, we conclude that the Swiss Confederation has its own and independent legislation, even though it is true that development in recent years has shown some flashes of influence from the EU.

Undoubtedly, all of these factors (direct democracy and not being a EU membership but with close links to them) are the starting points for understanding the development of transport policy of the Swiss people.

1.1.4. SOCIOECONOMIC DETERMINANTS.

Regarding to its GDP per capita (seventh placed worldwide) Switzerland is one of the world's richest countries which translates into a high quality of life and exacting requirement levels on issues such as health, education or transport infrastructure. 50% of its GDP comes from financial business, in fact, Switzerland houses a third of wealth in private hands worldwide. Largely, this is due to a strongly neutral tendency in terms of international country's policy (the last conflict in Swiss Region dates back to 1815, before the World Wars).

The financial centers are located in six major urban areas with more than half a million inhabitants: Zurich, Basel, Geneva, Lausanne, Lugano and Bern because they are responsible for 84% of the country's economic output. Consequently, it appears that both demographically and economically, Switzerland is a country with a strong regional balance. This factor is crucial to understand the strategic importance of intercity transport, predominantly concentrated on the E-W corridor.

Figure 4 states the demographic country's configuration in most important agglomerations and according to the two corridors.

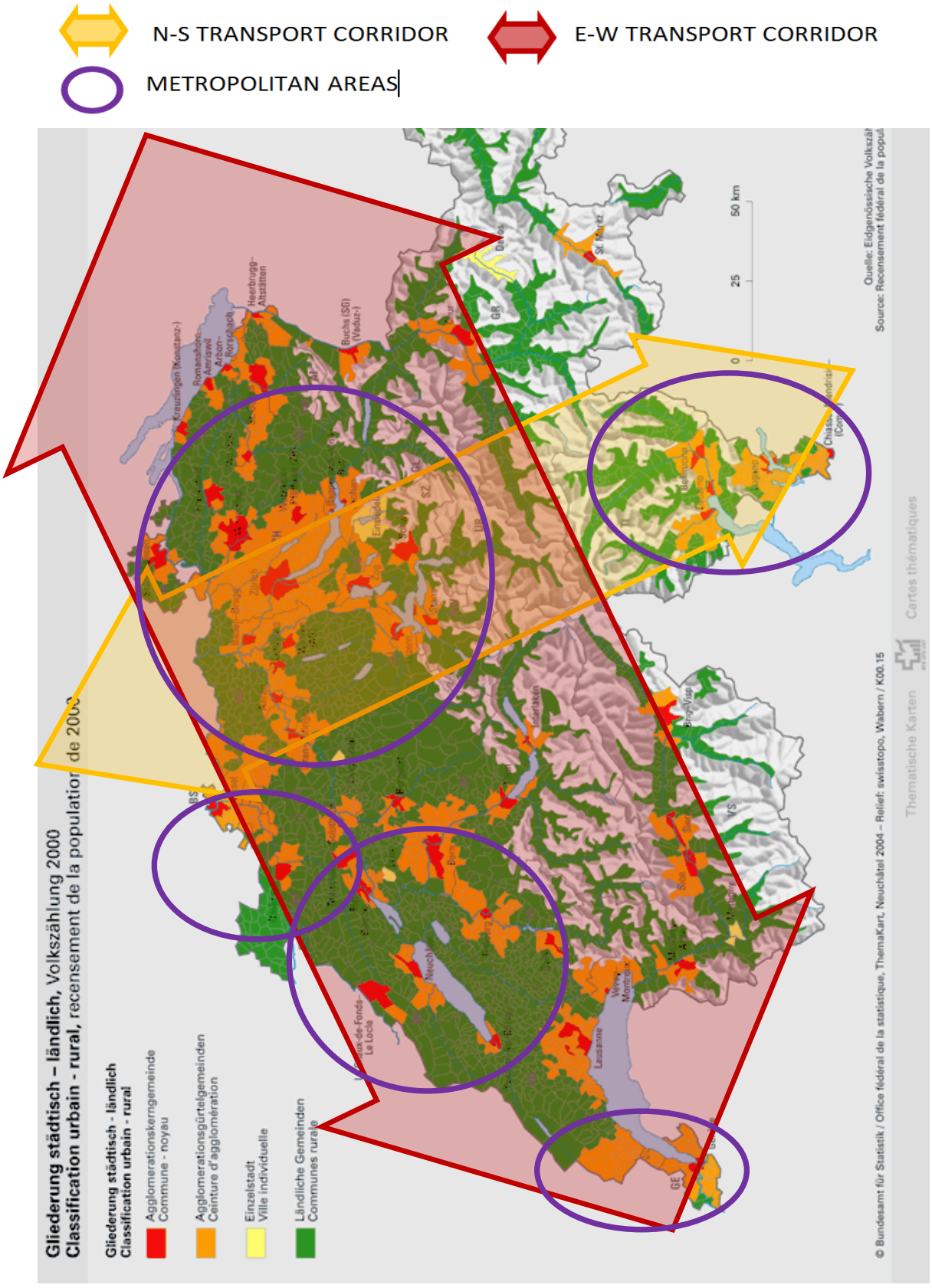


Figure 4: Map of demographic country's configuration

Source: » Recensement fédéral de la population 2000 », Office fédéral de la statistique, Neuchâtel 2004.

Among the main virtues of Swiss society it is highlighted: efficiency, capacity for negotiation and respect for minorities. This last point emerges from the in-depth country's composition: an aggregate of many cultures and ethnicities that makes Switzerland a multicultural and multilingual country. Proofs of this are 4 official languages and the coexistence of three great religions.

The cultural and linguistic diversity is due to the geographic international location, since it is situated at the crossroads of Francophone, Germanic and Italian cultural spaces. The 64% of the population speaks German, with a tremendous variety of dialects, 20% French, 6% Italian and only 0.5% speaks Romansh (a language derived from Latin). However, most of people speak, at least 2 of the 4 official languages (*Figure 5*).

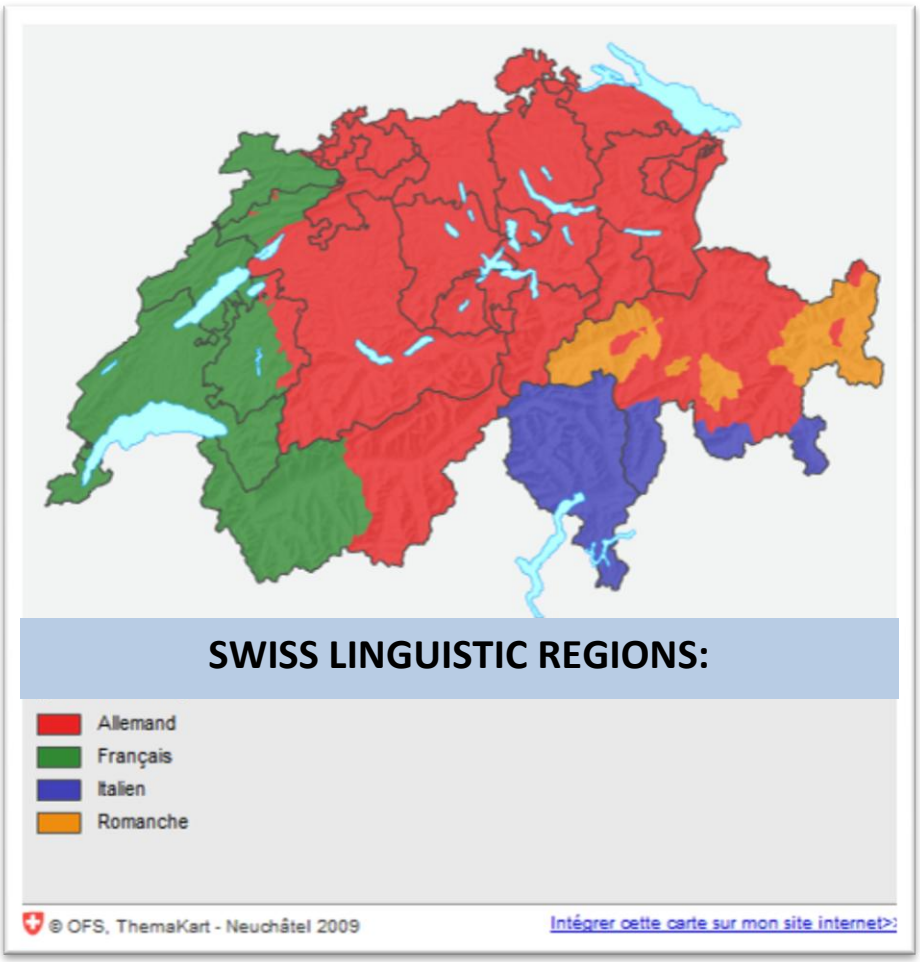


Figure 5

Source: Office Fédéral Statistique Suisse.

As far as religion is concerned, Switzerland has no official state religion, although 42% of people are Catholic Christians and 36% Protestants (approximately). For more information see *Figure 6.*

Immigration plays an important role in Switzerland for having 1.5 million foreign residents (one of the world's highest rates).

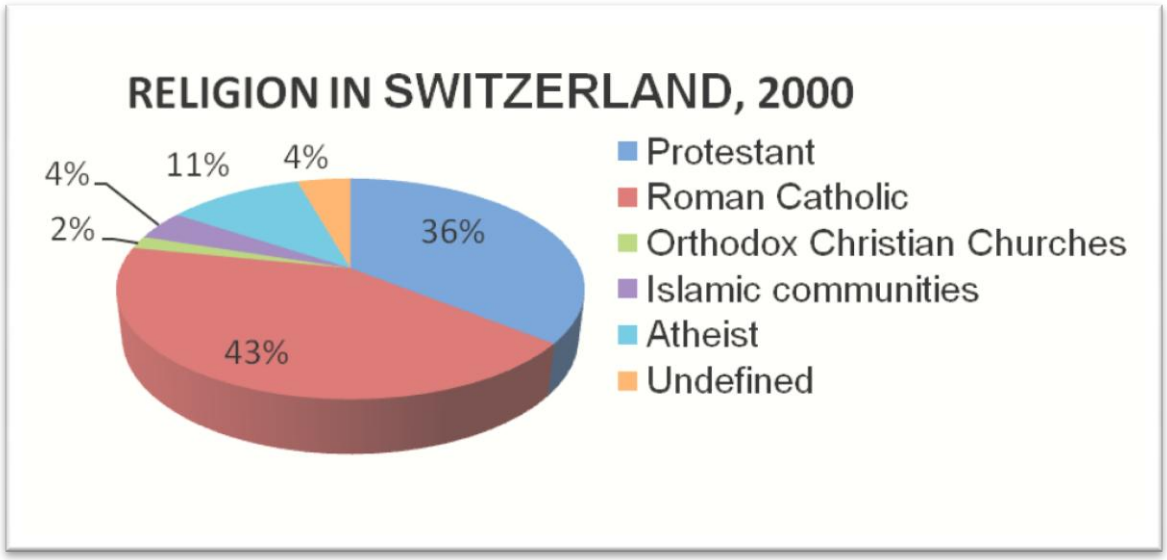


Figure 6:

Source: « Office Fédéral Statistique Suisse » and personal compilation

1.2. NATIONWIDE MOBILITY'S CONTEXTUALISATION.

Swiss citizens' mobility is characterized as one of the largest in the world. Serve as data reference that in 2000, according to the "Office fédéral de la statistique," Swiss people travelled 125.000 million km between Switzerland and abroad. (Swiss population in 2000: 7.2 million. 125.000/7.2=17.361 km per person per year). *Table 1* exposes more details:

Average amount of travel per person per day

	excl. foreign travel	with foreign travel
Distance (in km)	37	48
Travelling time (in min.)	85	89
No. of journeys	3.6	3.6

Table 1: Swiss average amount of travel per person per day in 2000

Source: « Office Fédéral Statistique Suisse »

This total is broken down, according to ages, as shown in *Table 2*.

Distance/day and travelling time

Age	km/day	min./day
6 to 17	23	79
18–25	52	96
26–65	42	89
66 and more	21	66

Table 2: Swiss distance per day and travelling time in 2000

Source: « Office Fédéral Statistique Suisse »

As noted above, the population between 18 and 65 (69.9% of total) covers the order of twice the km travelled by citizens from 6 to 17 years old (14.1%) and over 65 (16%)

In terms of motivations (*Figure 7*), it is especially remarkable the importance of Leisure travels, responsible for 40% of journeys and 44% of travelled distances (16.3 km per person per day). This increasing importance of leisure is a distinctive feature of societies with high purchasing power, which has become more important along with the development of living standards recorded in the western world after the Second World War. In turn, it is also a sign of an aging population; good example is the high number of km that are made for leisure, Monday through Friday (12, 3 km per person, as shown in *Table 3*)

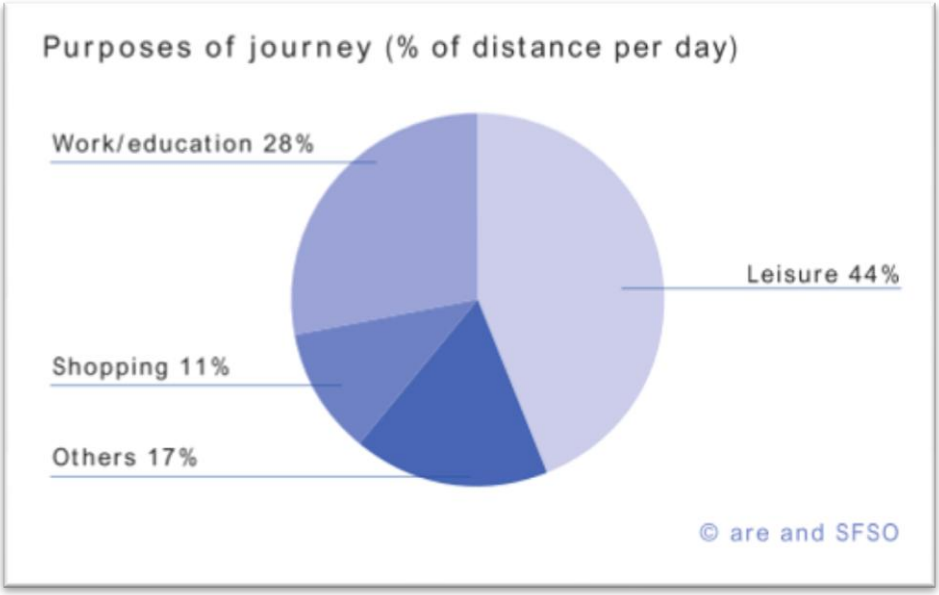


Figure 7: Purposes of journey in 2000

Source: « Office Fédéral Statistique Suisse »

DAILY DISTANCE PER PERSON (in Km)				
	MON.-FRIDAY	SATURDAY	SUNDAY	ALL
Work	11.6	2.1	1.4	8.8
Education	2.1	0.8	0.0	1.6
Shopping	4.0	7.3	1.2	4.0
Leisure	12.3	24.9	27.8	16.3
Caring Services	1.6	2.1	1.8	1.7
Professional services	3.8	1.3	0.3	3.0
Unknown	1.2	2.2	4.0	1.7
TOTAL	36.5	40.7	36.6	37.1

Base: 29 407 people older than 6.

Table 3

Source: Are and SFSO

Obviously, most forced trips are made from Monday to Friday, as well as professional services. Purchases are concentrated essentially on Saturday.

Within the compulsory mobility (*Tables 4* and *5*), commuting trips had a relative importance in 2000 (28% of distances). Beneath are the data by region and gender, respectively.

DISTRIBUTION OF TRAVEL DISTANCES TO GET TO WORK (in %)				
DISTANCE	DOWNTOWN	AGGLOMERATIONS	COUNTRYSIDE	**SWITZERLAND**
< 1.0 Km	22.8	18.0	25.4	**22.3**
1.1< 5.0 Km	37.6	28.5	26.4	**31.3**
5.1<10.0 Km	16.7	21.3	16.6	**18.0**
10.1<20.0 Km	11.7	17.2	16	**14.6**
>20.0Km	11.2	15.1	15.6	**13.8**
Total	100	100	100	**100**
Length average of trips (km)	9.3	11.7	11.7	**10.7**

Base: 21,450 travels for work performed from Monday to Friday by active people

Table 4

Source: are and OFS , « Microrecensement 2000 sur le comportement de la population en matière de transports ».

DATA ON TRAVEL TO GET TO WORK (from Monday to Friday)			
	WOMEN	MEN	TOTAL
Number of trips per day	1.6	2.2	1.9
Trip's length (Km)	8.6	12.0	10.7
Trip's time (min.)	19.8	22.2	21.3
Number of steps per trip	1.5	1.4	1.4
% of all trips	40	49	45
% of the daily distance	39	46	44
% of daily time average	36	43	40

Table 5

Source: are and OFS , « Microrecensement 2000 sur le comportement de la population en matière de transports ».

Notable is the incidence of these in interregional level (13.8% "> 20Km") that shows the high mobility of the population nationally (37 km per person per day) as well as the already mentioned above territory's "regional balance", as a set of metropolitan regions with

comparable socio-economic opportunities. *Table 6* describes the number of commuting trips between major agglomerations recorded for 2000.

COMMUTING TRIPS BETWEEN THE MAJOR CONURBATIONS						
ARRIVALS / DEPARTS	**LAUSANNE**	**GENÈVE**	**ZURICH**	**BERN**	**BASEL**	**LUGANO**
LAUSANE		8.066	272	464	91	21
GENÈVE	5.886		285	213	26	18
ZURICH	109	114		1.078	91	127
BERN	183	158	1.607		480	25
BASEL	39	49	4.144	1.031		22
LUGANO	15	12	168	28	51	

Table 6

Source: are and OFS , « Microrecensement 2000 sur le comportement de la population en matière de transports » and personal compilation.

Approximately 50% of these long commuting trips were already made by rail in 2000, according to "Transports Microrecensement 2000"

The results are also a reflection of the three major cultural areas composition: Francophone (green cells), German speaker (pink cells) and Italian speaker (Lugano).

In terms of modal split (*Table 7*), the car was running as the primary mean of quotidian transport being used for 69,5 % of daily distances and for the 41,6% of travels; followed far behind by public transport with just 17.7% of distances. This is not attributable to long journeys, since 34% of them (by car) did not exceed 3km and were made with an average occupancy of 1.6 persons.

Key figures on the modal split (in %)

	Distance travelled per day	Time spent travelling	No. of stages
Walking/cycling	7.2	39.8	46.1
Motorized private transport	69.5	43.6	41.6
Public transport	17.7	11.4	10.3
Other	5.6	5.2	2.0

© are and SFSO

Table 7

Source: are and OFS , « Microrecensement 2000 sur le comportement de la population en matière de transports ».

From these data, we conclude that mobility patterns prevailing at the time did not denote truly sustainable behaviours; however, they already reflected a substantial improvement with respect to data from a decade earlier, as a consequence of the influence of the gradual implementation of project RAIL2000's measures.

1.2.1. INFRASTRUCTURE AND RAILWAY EXPLOITATION MARKET'S CONTEXTUALISATION

Swiss Public Transport Network is widespread through its territory by involving multiple means and companies: trolley lines, bus lines, metro lines, railways net, ... and routes operated by shipping companies. We verity this fact in Table 8, where the lengths of the different public transport networks are specified. As a consequence of this, the Real Network and the Virtual Network are very similar; and a clear example is found in over two thirds of the population has a station within 5 minutes walk from home, and only 5% is more than 1km far away from the network. In this sense, we can categorize the connectivity and ubiquity as very good. More details about Public Transport Networks lengths are given in *Table 8*.

CFF	**3.000 Km**
Private railway companies	2.000 Km
Mountain railways	1.000 Km
Urban Transport	1.500 Km
Postal Bus Service	8.500 Km
Bus companies	5.000 Km
Shipping lines	1.000 Km
PUBLIC TRANSPORT NETWORK	**22.000 Km**

Table 8: Lengths of public transport networks in 2004

Source: "Plus d'entrain pour la Suisse, l'histoire de Rail 2000"

The most significant basic infrastructures are the national road network and rail network (airport infrastructure to a lesser extent).

The national road network is one of the densest in the world, and it is characterized by a large number of tunnels. At its completion, it will have a total of 1893Km held by the Confederation, mainly dated back from the 80s because it was built very quickly as a result of the great car's boom (it was planned in 1956, and only 15 years later, it had the 52% operating at full capacity and the 14% in construction). Approximately 75% of national highways have separated carriageways with 4 lanes.

A particular importance has its international relevance, which is primarily based on the St. Gothard tunnel.

To access highways, all vehicles under 3.5 tons must pay an annual vignette of 40 francs, while the trucks are subject to a tax whose amount depends on weight and travelled distances (RPLP, ranging around 200 euros for 40 tons trucks). Lorries weighted over 3.5 tons have forbidden their circulation at night and on Sundays

The rail network, meanwhile, has a total of 5148 km of lines, 3011 of which are owned by the CFF (property of the Confederation) and the remaining 2137km by private companies (mostly held by the cantons and with some involvement of the Confederation) . Some of best known private railway companies are BLS SA, RhB or Matterhom Gotthard Bahn.

Currently, the operation of the rail network is done by federal dealership; so, the companies have to take care of both exploitation and infrastructure. Although, market conditions are different for each type of traffic:

> **Passengers**- each link is assigned by concession and CFF has the major part of them in long distances, while the suburban trains are exploited by both private companies and by CFF.
>
> **Goods**-freight traffic is essentially open to competition.

The train paths are attributed by *Sillon Suisse SA*, to all licensed railway undertakings for the Confederacy or the EU (thanks to bilateral agreements on land transport), and the price covers approximately one quarter of the network's costs. Give the source and some figures here…

The remaining three quarters are funded by public entities. More specifically, the Confederation spends annually about 2 billion francs of its regular budget for operating, maintaining and enhancing the capacity of the network (CFF receives 1.5 billion and the rest goes to private companies). These latter also receive approximately 250 million Swiss francs more from the cantons.

On the other hand, the most important investments have some special funds. This is the case of FTP (*Financement des Transports Publics*) funds, which were born in 1998 for the implementation of railway infrastructure projects: New Alpine Crossing, Rail 2000, Connection of Switzerland to the European high-speed network in the East and West, and ZEB. The 2008's infrastructure funds, dedicated to improving the agglomerations' traffic in 2030 are another example.

1.2.2. BRIEF HISTORICAL REVIEW OF SWISS TRANSPORT POLICY

Switzerland's policy in recent years corresponds with the need to solve the great challenges in mobility that the country faced after the sixties. Broadly speaking, the problem should be approached from two distinct fronts:

> On the one hand, the need to supply the strong market demand in passengers' mobility throughout the Plateau and some rural areas. Regarding to the system

profitability, it was absolutely vital that this proposal was based on the use of public transport, particularly rail, because of his profile which answers the two requirements posed by the problem: large capacity and sustainability.

On the other hand, the international connection requirements, primarily to meet the demand for transit of goods across the country. In this case, it was essential to share the environmental impositions.

These two challenges have found their answers in the realization of the E-W and N-S corridors, respectively.

The East-West corridor

As far as the East-West corridor is concerned, the first signs of problems appeared during the seventies, when it was verified that railway was losing competitiveness in relation to the car because of the great boom of the latter. By then, the modal split road / rail, recorded the worst results for railways, because in the last twenty years, it had decreased from 51 to 20% share. Meantime, internal mobility country's demand was growing, so it was essential to offer a solution to both. Faced with this dilemma in 1969, Oskar Baumann presented the first ideas concerning the time's cadence and the possibility of using the High Speed. Nevertheless, that latter point was formulated as something very abstract, since Baumann doubted if this measure could be such a deployment for the country.

Aware of the challenge's complexity, and conscious of the strategic importance of transport policy, the Confederation sought to obtain a more general vision, which will bring together different means of transport, so that created a commission responsible for drafting the *Conception Globale Suisse des Transports*, with the aim to answer questions about: increasing traffic, growing financial needs and coordination between regional planning and sustainable development. Thus, in 1973 in the middle of the oil crisis, the CGST presented two complementary projects: the project of national roads and the proposed NTF (*Nouvelle transversale ferroviaire*), which proposed the high speed connection between Geneva and Lake Constance, according to currents prevailing at the time, led by the French and Japanese schools. However, this project did not fit the Swiss market demand, strongly characterized by "regional balance", and even more, it didn't face the real traffic problem in agglomerations. Mainly for these reasons, was rejected by the sovereign. (Appendix: Interview with Mr. Michel Béguelin).

At this point, Swiss planners realized the matter of necessity to present a completely new system that would be able to revitalize the rail market while meeting the expectations of "regional balance" and sustainability that their society required. For that purpose, it was approved, in 1987, the first phase of Rail 2000, a project that was put into service 17 years later, on December 12, 2004.

The North-South corridor

As previously mentioned, the North-South Corridor arises from the need to address a challenge: connecting Switzerland with international networks, providing solutions to alpine traffic in a friendly manner with the ecosystem.

In parallel to what happened to domestic rail traffic, between 1970 and 1994, there was also a significant decrease in the percentage of transalpine freight traffic (from 50 to 30%) and international passenger traffic through the Alps (reducing third in just 20 years).

In terms of goods, this fact is explained by Swiss' road regulations because at the same time, traffic had almost tripled between the Mont Cenis and the Brenner. In the passenger section, for its part, the decline corresponded to the combination of multiple factors, such as: decreased night trains, the opening of La Manche Tunnel, and the rise of TGV "French style" (much attractive for leisure travels).

Simultaneously, federal authorities had been noting the growth of the European Union around themselves, especially after the creation of the economic space, symbolized by the "Single European Act" some years later. In this context, the government was forced to take steps to avoid dissociating itself from its neighbours and promote their traffic, in consequence, in 1987 the Federal Council commissioned the construction project of the new trans-Alpine rail artery which could strengthen communications with the, at that time, effervescent European Union. Five years later, in 1992, the project NLFA was submitted to referendum and approved by the people.

Another important step towards the change in modal shift in Alps took place in 1994, with the incorporation of their protection as a part of the Swiss Constitution (art. 36th) under the slogan "*Pour la protection alpine contre le trafic de transit*" (to protect the Alps against road traffic) which perfectly reflected the population commitment to promote environmental values.

With the desire to secure funding for this project, among others, on November 29th 1998, it was approved the referendum about funds FTP (*Financement des Transports Publics*), which is the current legal framework in Helvetic Confederation's budget to the transport sector.

Nowadays, the North-South corridor is partially under construction; however, it is already worldwide known as the global road-rail intermodal transport paradigm. Along its course, it overcomes the obstacle posed by the Alps mountain range, thanks to the construction of large railway tunnels which are contemporary engineering standards, such as the Lötschberg tunnel (already in service), and so far unfinished Gotthard tunnel. This is a line of great strategic importance at international level (TEN-T) as the primary means of transporting goods from the ports of the North Sea to the Mediterranean Sea, via the major Italian ports like Genoa.

Having being planned primarily for freight, this ambitious project has involved a complete revolution for the economy in rural Alpine, where there has been an economic resurgence thanks to domestic demand (committing and leisure travels), to the extent that the

distribution rate has achieved to exceed all the expectations, and now it is established in a 60-40% for passengers and goods, respectively.

Moreover, the NFLA in general, and St. Gothard Tunnel in particular, are a constant source of controversy among certain sectors of society by the extra economic issue and the delayed construction, even after having met their strategic objectives.

1.3. **RAIL 2000 – BAHN 2000 – FERROVIA 2000**

1.3.1. INTRODUCTION

Project Rail 2000 is the reflection of most egalitarian Switzerland, as it constitutes a sustainable response to the mobility demand of the domestic long-distance passenger's travels among the most important Helvetic conurbations, in the XXI century. It constitutes a highly meshed rail network that extends throughout the Plain and provides support for a door to door service offer through its correspondences with the metropolitan transport services, putting the national mobility on a level with a huge aggregate of urban agglomerations. Below there is the graph of the project's network proposal. Note that the transfer stations have specific information concerning the interval, as well as existing travel times.

CONNECTION STARS

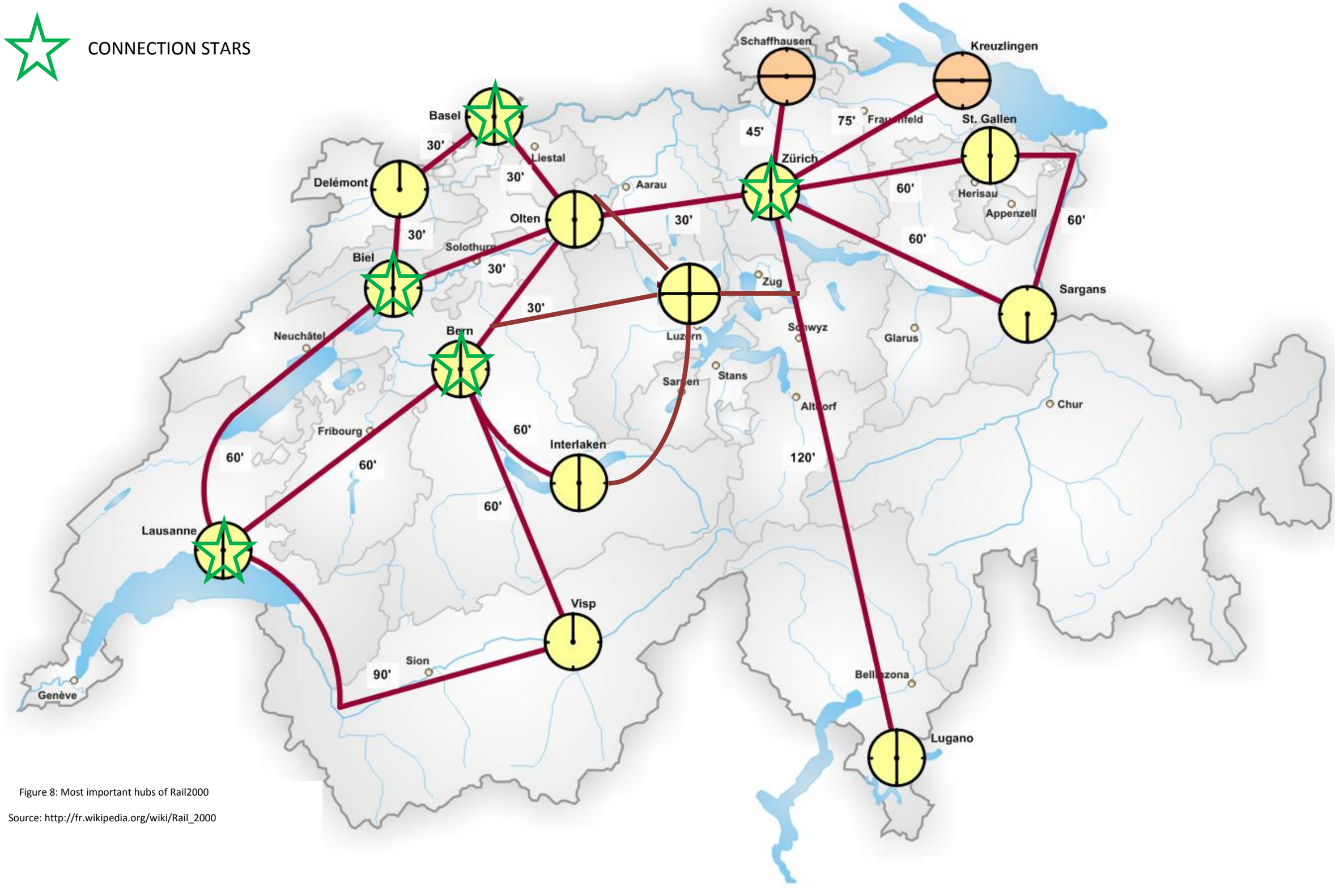


Figure 8: Most important hubs of Rail2000

Source: http://fr.wikipedia.org/wiki/Rail_2000

As far as planning is concerned, the project is part of a series of projects to provide the railroad with the weapons to deal in a more fair fight with the road in their struggle for the passenger transport market (mainly). Thus, there are a second stage, called ZEB; a third stage called RAIL2030; and even a fourth stage, still in gestation, known as RAIL2050. In turn, RAIL 2000 1st stage has a complementary project, BUS 2000, with a minor impact, consequence of the planners' willingness to bring together the different public transport means as subsystems of a global system, in which the occurrence of synergistic effects contributes to the development of a more sustainable mobility. Moreover, in a global context, the different P.T. development projects (in which we find RAIL 2000), are complemented with a set of additional policy measures, which act to the detriment of road or plane transport trying to condition the mobility demand.

Broadly speaking, we can summarize the project RAIL2000 as the will to optimize the supply, acting on each and every one of the conditions thereof, so as to reach the highest level of performance in all aspects (infrastructure, superstructure, schedules, reliability ...). In this sense, the project's aim was a completely new service thanks to the partial transformation and expansion of basic infrastructure and existing rolling stock, by implementing a revolutionary change in the planning's approach: "*un minimum de coûts pour un máximum d'utilité"* (minimum costs for maximum profit), in other words *Plus de technologie, moins de béton"* (more technology and less concrete). The fundamental tool with which the project counts to meet these objectives is the introduction of a new national system of correspondences grounded in a clock-face scheduling.

The starting point of the project stems from a comprehensive planning service, instead of an infrastructure; in consequence, it arises the need for establishing a group of nodes that are capable of converting railway lines in elements of a mesh. This change in the system's perception produces automatically the overcoming of rail's main handicap, whereas, it changes from a one-dimensional transport element (linear) to cover two-dimensional extensions. The first consequence of this transformation is the supremacy of the nodes with respect to the lines, which in terms of rail means a new sense of the term "station". Indeed, the willingness to implement a meshed system, founded on correspondences requires the transformation of the nodes as new hubs of flows exchange (in this case, passengers), which for practical purposes involves the stations' restructuring. This concept has also been incorporated in recent years by institutions such as the UIC (International Union of Railways), thanks to the creation of events like "Next Station" (Appendix: Interview with Iñaki Barron).

The key aspect of the project is the introduction of a new national symmetrical regular-interval timetable, which organizes the exploitation. This tool allows, among other benefits, the rail joint bid in maximizing the flow of compositions by the use of a repetitive structure, easily assimilated by both employees and consumers. This is the result of a comprehensive planning process, in which the Swiss proposal echoes currents emanating from the Netherlands in the early twentieth century.

1.3.2 HISTORY

The project idea was conceived by engineer Samuel Sthäli and the first stone is found in the symmetrical regular-interval timetable of 1982, however, the birth of RAIL2000 took place on December 10th, 1984, when the CFF direction team ordered their planners the completion of the XXI century schedule, from which would result the eventual improvement works on the infrastructure. The premise was simple: to force the railway network geography so that to submit to the demands that the clock-face scheduling required for a system of correspondences nationwide, displacing entire towns on the time axes up separating themselves in multiples of 15 minutes. Thus was forged what would later become the slogan of the project: trains shouldn't run as fast as possible, but they should run as fast as necessary to provide good correspondence between nodes. ("*Pas aussi vite que possible, mais aussi vite que nécessaire.*")

The market study revealed as necessary correspondence nodes Zurich, Basel, Berne and Lausanne, linked through one-hour isochrones, from which would be articulated the national long-distances' offer, as a star.

In 1985, the Federal Assembly granted 5.4 billion Swiss francs for the realization of a project that shared the same principles as DETEC (*Département fédéral de l'environnement, des transports, de l'énergie et de la communication*). These guidelines for transport policy are still today in force and a good example of this is found in the official website of the organization: "*The primary objective is coordinated mobility and sustainable development. The future of mobility lies in a range of modern and ecological transport supply that economizes our energy resources and our territory responding to the economic and social needs of our country.*"[ii]

Despite having the support of the Federal Assembly, the project's first query about the main concept (1985), revealed soon the discontent of certain regions, for not being as privileged as others, which would endanger the realization of the whole project if it was rejected in a referendum. So to get the green light, it was absolutely essential to agree with the regional balance by devising a service that did not discriminate the more rural areas. This aspect played a particularly important role in the line of "Pied du Jura" (where discontent was latent) from where people demanded that the travel time between Zurich and Lausanne were the same as passing by Berne. This fact implied the need for a fifth node of correspondences in Bienne. *Figure 8* shows the final graph of the "stars of correspondences" (Zurich, Basel, Lausanne, Berne and Bienne)

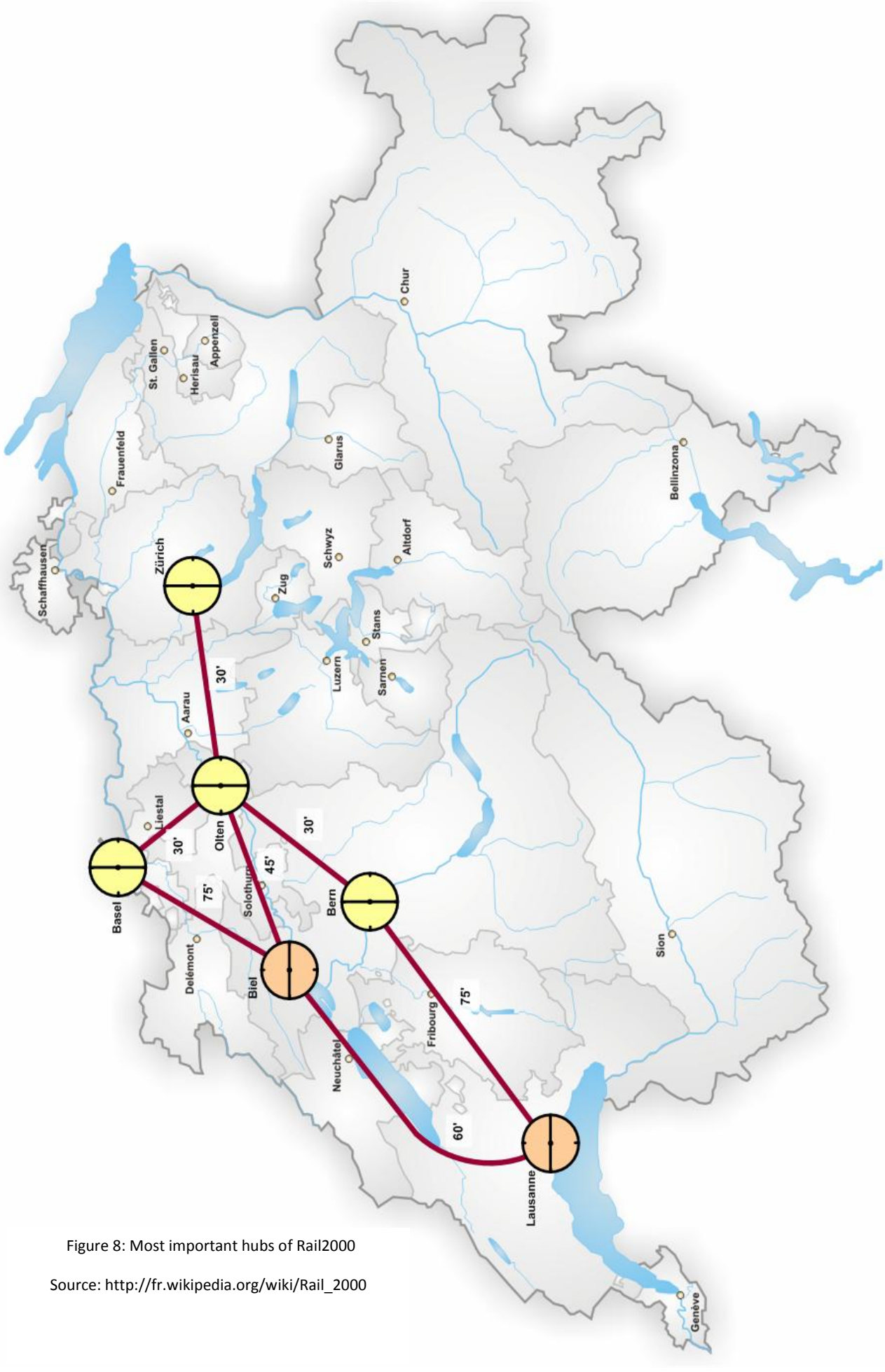


Figure 8: Most important hubs of Rail2000

Source: http://fr.wikipedia.org/wiki/Rail_2000

The creation of the fifth hub (Bienne) posed a new challenge as problems were entailed in several aspects: schedule, infrastructure, funds,... On one hand, it required the travel times' reduction between Bienne and Lausanne since it surpassed in 8 minutes the time allowed by the clock-face schedule, otherwise, they could not ensure correspondences in the Vaudoise capital and the whole system was in danger of going down the drain. It also increased the budget, for example, the link between Bienne and Zurich needed some extra-works, as the renewed section between Solothurn and Inkwil. Finally, additional trains from Bienne to Zurich had no train paths between Rothrist-Olten-Zurich (section already saturated). All of these significant issues required transcendental solutions, mainly in Lausanne and Zurich's hub connections.

The solution to the correspondences problem in Lausanne node is founded on Biel-Lausanne line's improvements and on Lausanne-Geneva line's works, while the congestion at the Berne-Zurich line was solved thanks to the major improvement works in Mattesten-Rothrist and the frequency of traffic optimisation (the time between compositions was reduced to 2 minutes!). Otherwise, it was absolutely essential the restructuring of Zurich node to coordinate all of those measures with the local rail services.

Finally, on December 6th, 1987, the project RAIL 2000 was submitted to a referendum and approved by 57% of the Swiss population, yet due to the project realisation and the introduction of significant improvements in some sectors, the required amount had increased significantly (reevaluated in 1991 by CFF in 16 billion francs), so the DETEC was forced to demand a new solution to CFF, which had to include the maximum number of projects within budget in 1985. The solution adopted ultimately was as follows: a first phase of Rail 2000 that ended in 2004; a second one which included projects that had not been able to make at the beginning as well as other objectives; and a third stage with other extensions. These last two stages have been integrated into the bosom of the project called "Development of railway infrastructure" (ZEB).

The project funding was approved in federal vote in 1998 (Creation of funds FTP, *Financement des Transports Publics*) and its implementation is feasible thanks to the federal approval of the ordinance concerning the RPLP on 29th November of the same year, which contributed with 63.5% of the budget.

The service improvements were introduced gradually (except in relation to the national schedule). For example in 1997 thanks to the work in Aarau's station, in the urban tunnel and the second double-track to Rupperswill, the new semi-cadence schedule was in force in Zurich around the node, particularly in Zurich-Berne and Zurich-St.Gallen lines

Later, in 1999 the two levels compositions were introduce between Lucerne and Zurich; and in 2001 circulated the first tilting train between Zurich and Lausanne, via Bienne. Subsequently, in 2003, it was opened a new double-track between Zurich and Thalwill.

Finally, on December 12th, 2004, it was opened the segment Mattstetten-Rothrist and entered into force on final national schedule, which closed the First stage of Rail 2000, after a period of completion of 17 years. The process was conducted in stages: first, the traffic over long distances; then regional traffic; after that the commuters; and finally the domestic traffic and long-distances. In summary, on December 12th, the timetable came into effect on long-distances traffic and regional milieu (which was restructured as a result of the project Rail 2000). On Monday 13, it was time to face the commuting trips and a day later, goods.

To conclude, we must praise the close collaboration between all stakeholders (transport companies, users, Confederation, cantons, ...) that contributed decisively to the fact that the commissioning was carried out without major problems.

Returning to the project objectives, as discussed above, RAIL 2000 pursues a desire for excellence in all aspects. A proof of this is given by the slogan of the campaign in the referendum of 87: "*Plus rapide, plus frequent, plus direct et plus confortable*."

> *Plus rapide*: thanks to the new sections (infrastructure) and the tilting material (rolling stock), this represented a gain of time of 17% over 20 cities and 8% of the total network.
>
> *Plus frequent:* by introducing the cadence in an hour/half-an-hour and it increased the frequency of trains on the line between Berne-Zurich.
>
> *Plus direct*: the new node (Bienne) and the works as Mattstetten-Rothrist to exploit 4% more in direct links. Were also proposed new relationships between Valais and Olbrland; between Valais and Aargau; Pied du Jura between St. Gall; and between Geneva and Lucerne.
>
> *Plus comfortable*: thanks to the renewal of the stations and part of the rolling stock.

Overall, there are 6 aspects of the offer that have an important impact on achieving the highest level of competitiveness:

1) <u>New infrastructure sections</u>

Despite not being a construction project, RAIL 2000 provided for a number of improvements needed to assume the desired schedule. Hence, we have counted more than 120 venues, among which are highlighted:

a) **Rothrist-Mattstetten** line - Defined as the first Swiss high-speed line, it allows Bern-Olten's join in just 25 minutes. Its execution was described as a priority due to the classic line's state (over 150 years old and liaison between many towns) that forbade the compositions to complete the travel between Bern and Zurich in under an hour. With its commissioning was reduced the travel time between these nodes from 72 to 57 minutes. It has no intermediate stations throughout its 45 kilometres

and nowadays it has the ETCS-level 2 system (introduced in 2006 after the implementation of the project) that allows convoys running at 200 km / h. It is the work of the project RAIL2000 par excellence.

b) Double line between Zurich and Thalwi

c) Third line between Genève and Coppet

d) Zurich's central hub. Especially remarkable are these improvements because they exemplify one of the biggest consequences of RAIL2000: the expansive nature of the project that has the ability to energize the rest of the transport chain.

2) New national regular-interval coordinated timetable.

The regular-interval timetable was introduced in Switzerland on May 23, 1982 with resounding success, but it was not until the arrival of RAIL2000's project that reached its maximum yield and spread nationwide with the implementation of a regular-interval coordinated schedule. Its foundation is the implementation of a systematic repetition structure of frames of reference.

In a clock-face network, the trains classified within the same class are constantly circulating with the same travel time, so their stops and crossings are the same throughout the day; but even more, the coordinated nature involves the rapport between different lines' schedules in order to optimize the number of matches.

Each station who offers this kind of service is called "nodal point" or "hub" and this supply is characterized by a simple running system that allows correspondences among large lines and regional convoys. Consider the example in more detail: if two national trains (major lines) will cross at a nodal station at "T", it is necessary that all regional trains arrive at the station at (T-t) and depart again in (T + t) to make possible the connections with all the lines.

A characteristic feature of networks with clock-face scheduling are the "mirror trains" (*Figure 9*), in other words, to ensure compliance with the clock-face schedule optimizing the rolling stock and the correspondences, the trains running on the same line in opposite directions must be coordinated so that the departure and arrival time of one over the other does not differ by more than a few minutes. This is how the symmetrical schedules are built: "mirror trains" cross at 00min./30min. (with a cadence of 1 hour), or at 15min/45min (half-hourly cadence). These latter trains also cross other trains in the same line at 00min. and 30 min. A strength of this system is that allows optimizing the exploitation because it clearly defines the areas of intersection (very useful in one-line sections).

Note that at all times we have assumed a 30-minute multiple cadenced passing through the nodal stations every hour; this is because it has been proven to be the system easier for users. On the other hand, it is necessary to emphasize that slots in which demand is insufficient you can apply a cadence of 2, 3 or even 4 hours.

There are numerous benefits of implementing a cadenced time though, the most obvious is the simplicity of the system for employees and travelers. From the operator point of view, we highlight the improved planning and use of resources. For example, in the Swiss case, the introduction of time led to an augmentation cadenced productivity by 20% in 1982. In

part this improvement occurs by reducing the waiting time at terminal stations, which implies a better use of personnel and rolling stock (removal of unnecessary shunting movements). In addition, it facilitates intermodality and inter-urban networks, which in turn can benefit freight trains, having the ability to access to certain train paths on a regular and continuous way (optimization of management) and allows better regulate critical situations. Another important factor is reducing the number of sidetracks required on sections of single track.

Among the main disadvantages we found the susceptibility of the system to temporary slowdowns (like maintenance work), and the difficulties it presents to the progressive development of infrastructure. There are also challenges in the stations: it requires a big over-sizing because of concentrating the entire flow of travelers in the interval [T - t, T + t] and hinders the creation of new ones. On the other hand, the imposition of the nodes correlation sometimes forces users to perform unwanted and cumbersome correspondences (we cannot forget that the worst time valued by users for a trip is the correspondence's waste of time).

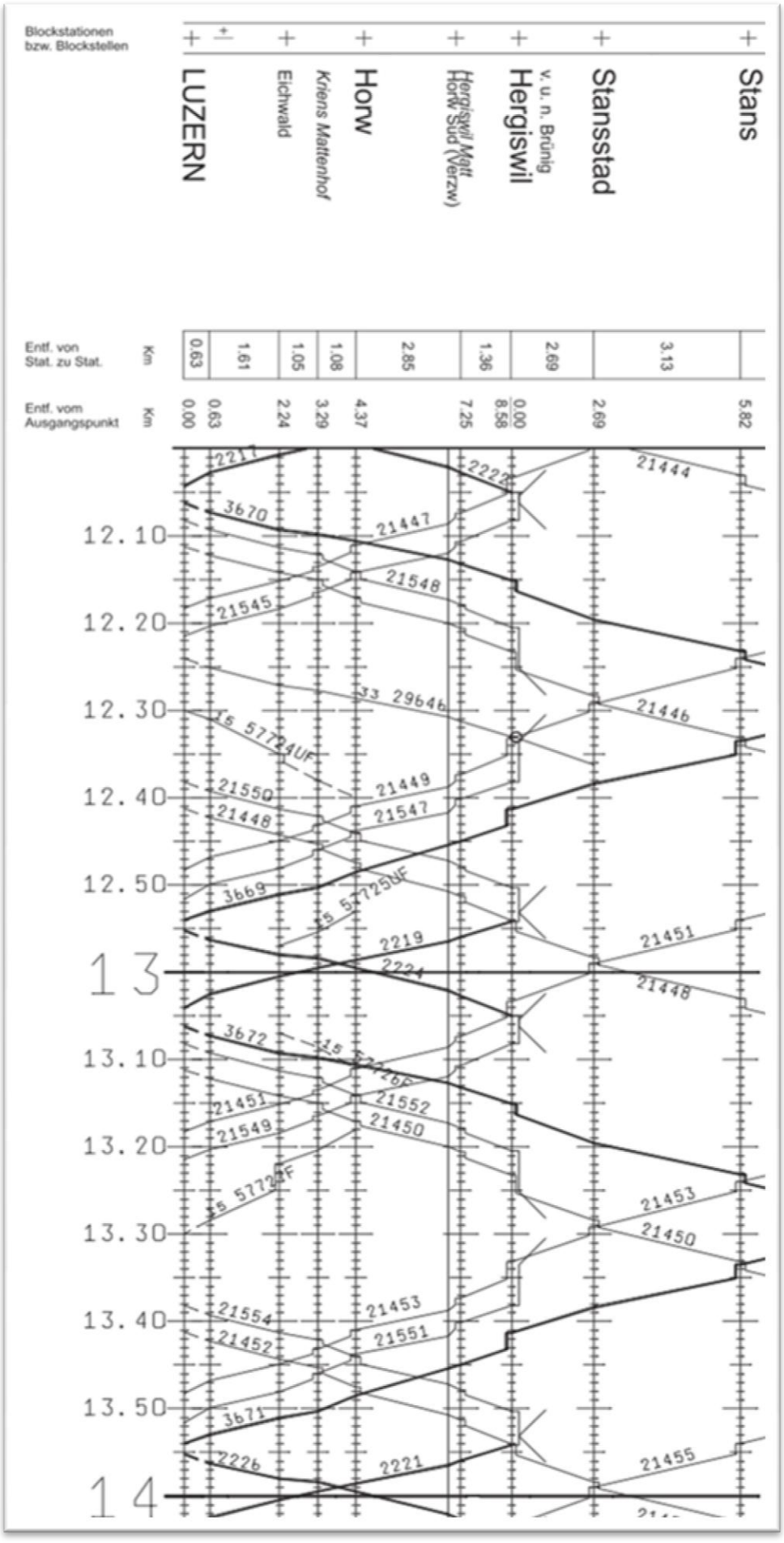


Figure 9: Fragment of Die Zentralbahn schedule between Lucerne and Stans from 12:10 to 14:00.

Source: http://www.tableaux-horaires.ch/fr/

3) New political tendency to face the transports planning.

The resulting intermodal proposal of BUS2000 + RAIL2000 sets a precedent in the history of modern Europe from the point of view that it shows a more global perspective of the public transport service which integrates all possible means and relations between them. It is true that in terms of BUS2000 few were the actions taken, even so, it is especially remarkable the appearance of postal services (operated primarily by POST) and services of "buses to the demand."

Besides the obvious improvement of using an existing infrastructure (road infrastructure) for operating a public transport service over long distances, this proposal compensates for the stiffness of the rail infrastructure (strongly conditioned by geography) and its rolling stock. Indeed, the road network and coaches have a greater flexibility of layouts and dimensions, respectively, thus allowing better align supply for demand in case of deficient situations. In turn, the combined use of both public transport means produces synergic effects and also contributes to the better exploitation of each one of them individually. For example, it allows to replace trains by coaches in the off-peak (more profitable), which in turn, releases certain train paths for the use of merchandises.

4) New rolling stock

Broadly, the priority guidelines of CFF in Rail 2000 in terms of renovation of the main lines' rolling stocks passed through four key points:

Compositions reversibility. To avoid the previously discussed unnecessary maneuvers in terminal stations.

Increase the commercial speed of certain lines. To achieve this challenge they proceeded to incorporate trains with bascule boxes that reduced travel times, in order to reconcile the classic infrastructure and the new schedule.

This point is a clear example of the willingness of the project: *"Plus de technologie, moins de béton"* as mostly of Swiss railway network dated then from the nineteenth century, and although the curvature radii were designed generously, their layout did not allow much higher speeds for uncompensated acceleration problems perceived by travelers (what would had compromised the comfort). The chosen cars were ICN, able to travel up to 200 km / h with 451 seats and with an hour cadence on the line "Pied du Jura": Genève-Lausanne-Bienne-Zurich-St. Gall., As well as Bâle-Bienne line.

Increase of capacity. In this sense, they opted for the inclusion of compositions of two levels, namely IC 2000, wich with the same length offer 40% more seats than ordinary compositions. The two levels cars emerged after a long career in metropolitan networks (in Switzerland were introduced in Zurich's RER) This model is unique because their access is at the same level that lower floor so, the internal circulation takes place at the upper floor.

Proposal for international cooperation policy. With the intention of laying the first stone for the barriers elimination concerning international technology in rolling stock (willingness of trains standardization).

5) Continuation with its current high level of transport's reliability

Widely known for its 98% effectiveness.

6) New system of funding the transport

Several aspects are remarkable in that sense. First, note that RAIL2000 marked a change in the historical trajectory of transport investments: it was the first time that the amount allocated by the Confederation to railways was comparable to the road's funds, which meant an increase from 0.5 to 4.5 billion francs for P.T between 1970 and 2005. (for the same period, road investments went from 2.0 to 4.3 billion francs). This information is given in *Table 9*

YEAR	ROAD[2]			RAILWAYS[1]			RATIO RAIL/ROAD[3]
	TOWNS	CANTON	TOTAL	CFF	OTHERS	TOTAL[5]	
1950	60.8	73.2	134,0	88.5	9.0	97.5	1:1.4
1955	92.2	142.1	234.3	99.4	13.7	113.1	1:2.1
1960	182.8	194.4	490.4	128.4	11.0	139.4	1:3.5
1965	378.4	417.2	1 549.6	256.4	45.6	300.2	1:5.2
1970	546.4	478.5	2 054.0	292.9	75.5	368.4	1:5.6
1975	650.8	644.1	2 484.4	618.3	51.9	670.2	1:3.7
1980	680.7	683.7	2 575.8	485.0	34.2	519.2	1:5.0
1985	737.9	773.1	2 653.6	817.1	103.3	920.4	1:2.9
1990	1 006.9	1 109.7	3 674.4	1 840.3	127.7	1 968.0	1:1.9
1995	790.2	1,040.4	3 894.9	1 994.6	314.1	2 308.7	1:1.7
2000	870.5	1,148.7	4 229.1	2 375.7	545.0	2 920.7	1:1.4
2001	783.2	1,169.	4 176.8	2 394.3	812.3	3 206.6	1:1.3
2002 [4]	751.8	1,060.47	4 122.3	2 855.9	881.2	3 737.1	1:1.1
2003[4]	718.0	953.2	4 065.6	3 022.2	854.0	3 876.2	1:1.0

[1] Investment in buildings and facilities including renewals and routine maintenance
[2] Construction, improvement, development, land acquisition and maintenance
[3] Railways' total compared to Road's total
[4] Preliminary data (rail and vehicle fleet)
[5] Rail2000, AlpTransit and noise reduction included

Table 9: Swiss Infrastructure investments' history, in terms of modal split

Source: OFS, CFF, ATG, BLS, LITRA

On the other hand, the creation of a new law, FTP, and its incorporation into the constitution to ensure the project financing in November 1998, gave way to a new era in which intermodal competition and the principle of internalization of externalities laid the foundations for a new mobility policy.

A sign of the relevance of the above mentioned is the origin of "Financement des Transports Publics" funds, predominantly from car's taxes, which is outlined in *Figure 10*.

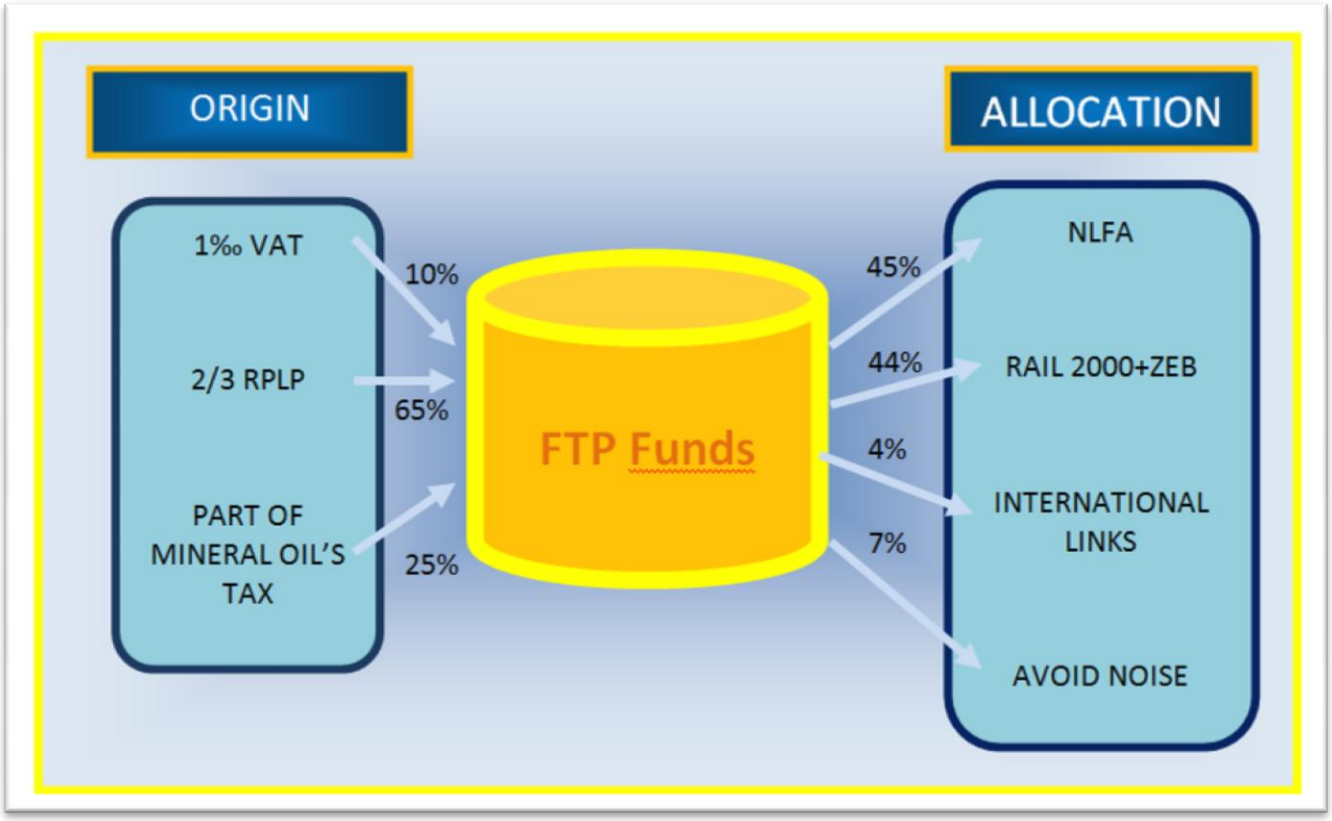


Figure 10: Origin and Allocation of FTP funds

Source: personal compilation

1.3.3. CONSEQUENCES CONCERNING THE TRANSPORT SUPPLY

The impacts on the offer of the project Rail 2000 are impressive: after December 12, 2004, 12% more trains traveled on the network which means an increase of 14% of train-kilometers. On the other hand, trains' times of departure and arrival were modified at a rate of 90% becoming the most important timetable change of the railways' history.

For more than half of CFF's traffic in long-distance relations, the travel time was reduced by at least 5 minutes, and, in 30% of cases, the gain of time was a quarter of an hour or more. In *Table 10*, we find the specific data of some links:

JOURNEY	TIME REDUCTION
Bern-Basel	12’
Zurich-Coire	19’
Genève-Luzern	34 ‘

Table 10: Travel time reductions from Rail2000

Source: personal compilation based in “Les cheminements de la politique Suisse des transports: RAIL 2000”

However, despite the fact that project Rail 2000 was focused on railway's long-distance journeys, its effects on supply are not limited to this area, because as Professor Ulrich Weidmann says, the project RAIL 2000 also "*incited an increase of supply of regional transport.*"

Indeed, looking at the overall breakdown of the lengths of the different means of transport in 2004, we verify a relative importance of all the networks on the aggregate value. This incidence is both a consequence and a cause of Rail 2000: a cause, while already in 1985 there was a strong interdependence between the different transport operators at regional, national and international milieu (to take an example, the 45% of CFF's passenger traffic was exploited by integrated transport tickets with other national and international enterprises); a consequence, whereas coordinated interregional railway services serve, at the same time, as a catalyst to encourage improvement in regional supply and even the incorporation of the exploitation's model by the whole chain of public transport: postal bus (BUS2000), boating, urban transport ... We find a clear illustration of this fact in regional traffic systems (RER) which has been strongly reinforced, in most of the lines of the seven cities (Zurich, Bern, Basel, Luzern, Zug, Geneva and Lugano) where the half-hourly cadence has been instituted, even more, with the cadence of 15mi. in the peak of some lines.

1.3.3.1. Impact on infrastructure

In terms of rail network, as mentioned above, some improvements have been made although the primary objective of the project was to expand the supply trying to achieve the maximum performance in each element of the transport system, not to build a new infrastructure. Even so, a big part of these 5,900 million francs were invested by CFF for the construction of new additional 160 km of tracks and for double, triple or even quadruple old sections. Among these new connections, the line Mattstetten-Rothris is, by far, the most ambitious work within the project (it has cost 1.68 billion francs).

On the other hand, some railway track's systems have been renovated, as well as, the platforms of 37 stations.

In *Table 11 there* are some technical data that characterize the Swiss railway network after the project Rail 2000:

NETWORK DATA			PROPERTY	INDEX/RATIOS	
Network diameter	350 Km		COVERAGE	**Coverage ratio***	0,21
Total length	1651,65 Km		CONNECTIVITY	**Eta (total length/num. real edges)**	82,58
Num. of edges in the REAL NETWORK	20 units			**Beta de Kanski (num.real edges/num. hubs)**	1,43
Num. Of edges in the VIRTUAL NETWORK	105 units			**Gamma (num. real edges/ num. virtual edges)**	0,19
Num. Of hubs	14 units		ISOTROPY	**Detour index's average**	1,33

Table 11: Technical data of Swiss railway network after Rail2000

Source: Personal compilation

Note the coverage ratio has been calculated as a the quotient between the diameter of the network and the total extension; and the Detour index's is the quotient between de real distance and the straight line distance that exists between two connected hubs. Values used to calculate these index are shown in *Table 12.*

EDGE	ROUTE	TRAVELLED DISTANCE (km)	REAL DISTANCE (km)	DETOUR INDEX
1	GENÈVE-LAUSANNE	60,26	52	1,16
2	LAUSANNE-BIENNE	104,5	84	1,24
3	LAUSANNE-BERNE	97,18	80	1,21
4	LAUSANNE-VISP	136,66	96	1,42
5	BIENNE-OLTEN	60,08	56	1,07
6	BERN-OLTEN	66,84	56	1,19
7	BIENNE-BASEL	63,44	54	1,17
8	BASEL-OLTEN	39,2	34	1,15
9	OLTEN ZURICH	62,76	48	1,31
10	ZURICH-WINTERTHUR	31,26	21	1,49
11	OLTEN-LUZERN	55,76	44	1,27
12	BERN-LUZERN	95,52	66	1,45
13	BERN-VISP	123,71	80	1,55
14	BERN-INTERLAKEN	59,17	44	1,34
15	ZURICH-LUGANO	215,18	190	1,13
16	ZURICH-CHUR	115,91	96	1,21
17	WINTERTHUR-ST.GALLEN	57,35	48	1,19
18	ST. GALLEN-CHUR	106,02	64	1,66
19	ZURICH-LUZERN	73,04	40	1,83
20	LUZERN-AATH.GOLDAU	27,81	18	1,55
	TOTAL	**1651,65**		**1,33**

Table 12: Basic values used for calculate Detour Index

Source: Personal compilation

If we examine more closely the data given above, these confirm that we are dealing with a network with a large coverage, i.e. strongly meshed (coverage ratio close to zero) and complex (Beta Kansky between 1 and 3) oriented toward a service of correspondences based on the star-nodes or hubs (index gamma = 0.19)

Finally, in terms of the network's isotropy and homogeneity, the detour index is 1.33, not very high considering that it is a mountainous country predominantly. This is a consequence of two aspects: most of the network runs the Plain and the large presence of railway tunnels.

1.3.4. CONSEQUENCES CONCERNING THE DEMAND

1.3.4.1. Impact on travel demand

The Swiss rail transport demand has been progressing in parallel with the commissioning of the different project's components, so that we note a growth rate of around 30% between the first step (year 1997) and the last works (year 2005). This spectacular growth has managed to exceed the most optimistic forecasts, and it has its highest expression in the current railway's network situation which is reaching maximum capacity.

Figure 11 and *12* show the above commented demand's changes, specifically, in person-km for the rail market and its relationship with the number of train-km offered. Note the demand's response shows a certain delay with respect to improvements in the supply, this time corresponds to the period of market stabilization, i.e. the time required for society to confirm the advantages of the new proposal.

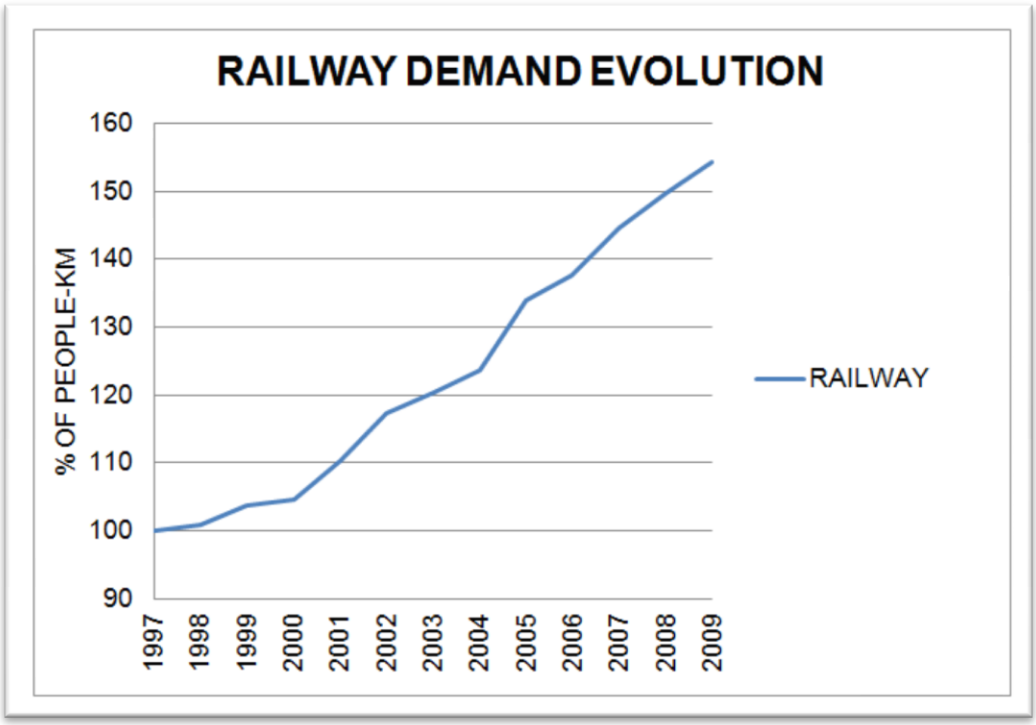


Figure 11: Impact on railway demand's evolution of Rail2000

Source: Personal compilation based on « OFS-Encyclopédie statistique de la Suisse »'s data

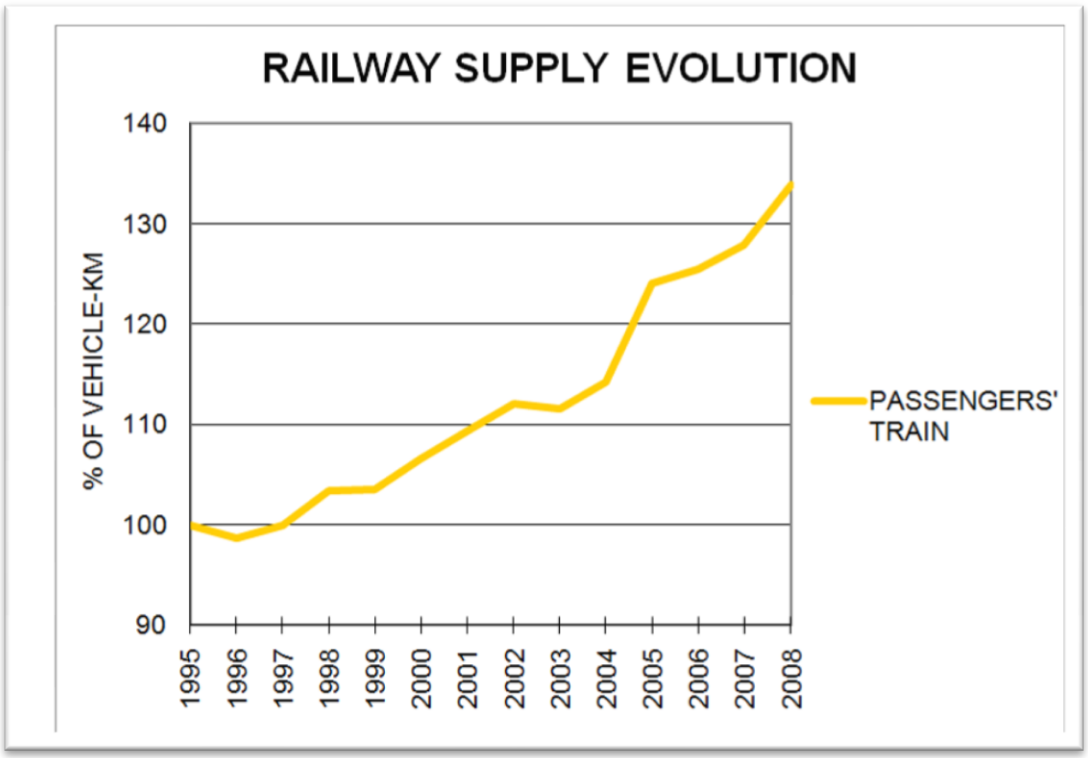


Figure 12: Impact on railway sypply's evolution of Rail2000

Source: Personal compilation based on « OFS-Encyclopédie statistique de la Suisse »'s data

The baseline scenarios have been chosen for 1997 and 1995 (respectively) and their attributed percentiles are 100. From there, we see the evolution of the rail market in parallel with the gradual introduction of the project improvements:

- **1997** (Aarau and Rupperswill works and introduction of the half-hourly cadence between Zurich-Berne and St. Gallen) - we observe an inflection point of growth in the train's share early the following year.
- **1999** (two levels cars between Luzern and Zurich) - leading to a new phase of progressive increase that finds its ultimate realization from 2000.
- **2001** (pendulum trains between Zurich and Lausanne via Bienne) - it reaches the 110 points while maintaining a cumulative growth that would last until 2002 approximately.
- **2003** (new double-track between Zurich and Thalwill) - new turning point in the percentage of vehicle-km, leading to an increase in rail market share since 2004, exceeding 120% of 1997 values in the transport of person-km
- **2004** (commissioning of the new national clock-face schedule and opening of the line Mattstetten-Rothrist) - resulting in the most spectacular stage of growth of passenger in the last 50 years

Without a doubt, the most pronounced change has happened after 2004, good example of this is the fact that only six months after the inauguration of the project, on June 9, 2005, it was recorded an average growth of .5% in number of CFF's passengers in contrast to the previously calculated growth rates that ranged between 2 and 4%. Some specific lines, such as Zurich-Bern, experienced a growth of up to 11% during the first six months.

In parallel, there was an increase in sales of tickets and travelcards: the GA Travelcard's sales (at that time represented a 70% CFF's income) increased to 280,00 units in December 2004; and in April 2005, was counted an augmentation of 50,000 new Half-fare travelcards, compared to the values of the precedent year. This resulted in an increase of 3.7% of the CFF's income for the first six months after Rail 2000.

As far as current developments in the demand side, this is reflected in the series of graphs below which shows the temporal development of rail traffic, according to the scenarios for the years 2005 *(Figure 13)*, 2008 *(Figure 14)*, 2010 *(Figure 15)* and the forecast for 2030 *(Figure 16),* respectively.

Figure 13: Passenger's traffic flow in 2005

Source: INFOPLAN-ARE, « Modélisation des transports MT-DETEC » ; OFS, GEOSTAT ; Swistopo

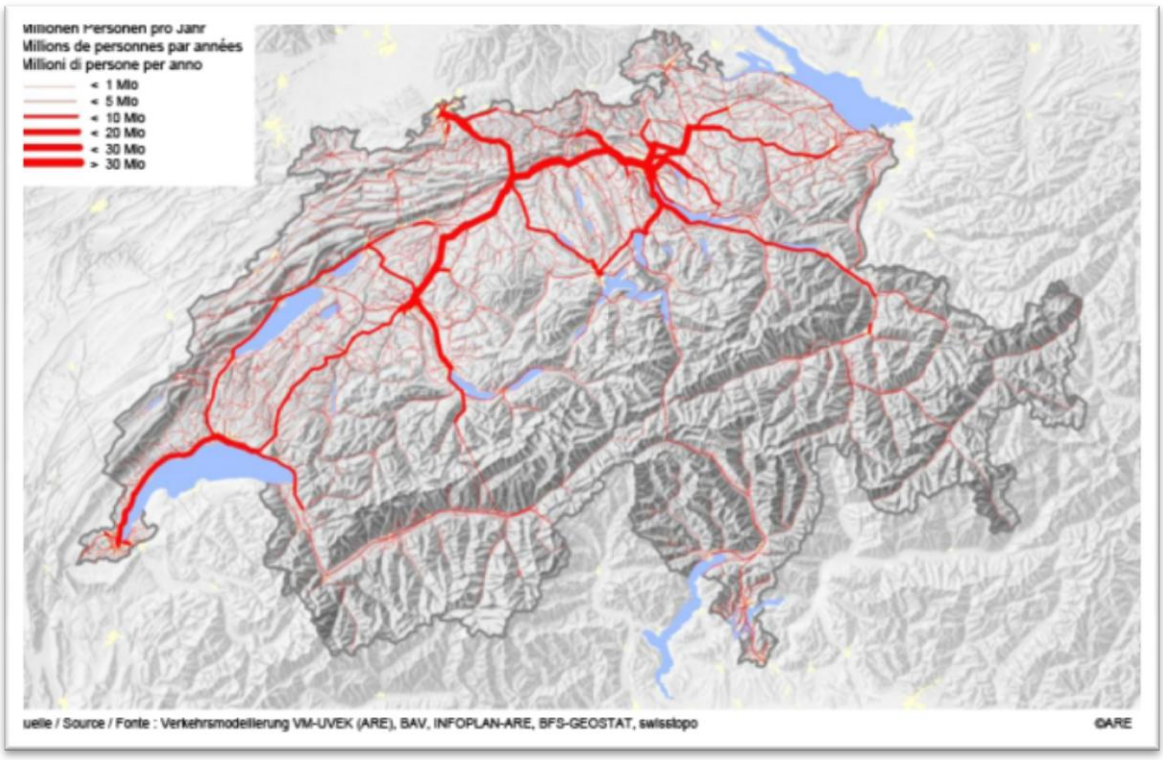


Figure 14: Public Transport of passengers in 2008 (Département fédéral de l'environnement, des transports, de l'énergie et de la Communication)

Source: Verkehrsmodellerung VM-UVEK (ARE), BAV, INFOPLANE-ARE, BFS-GEOSTAT, swisstopo

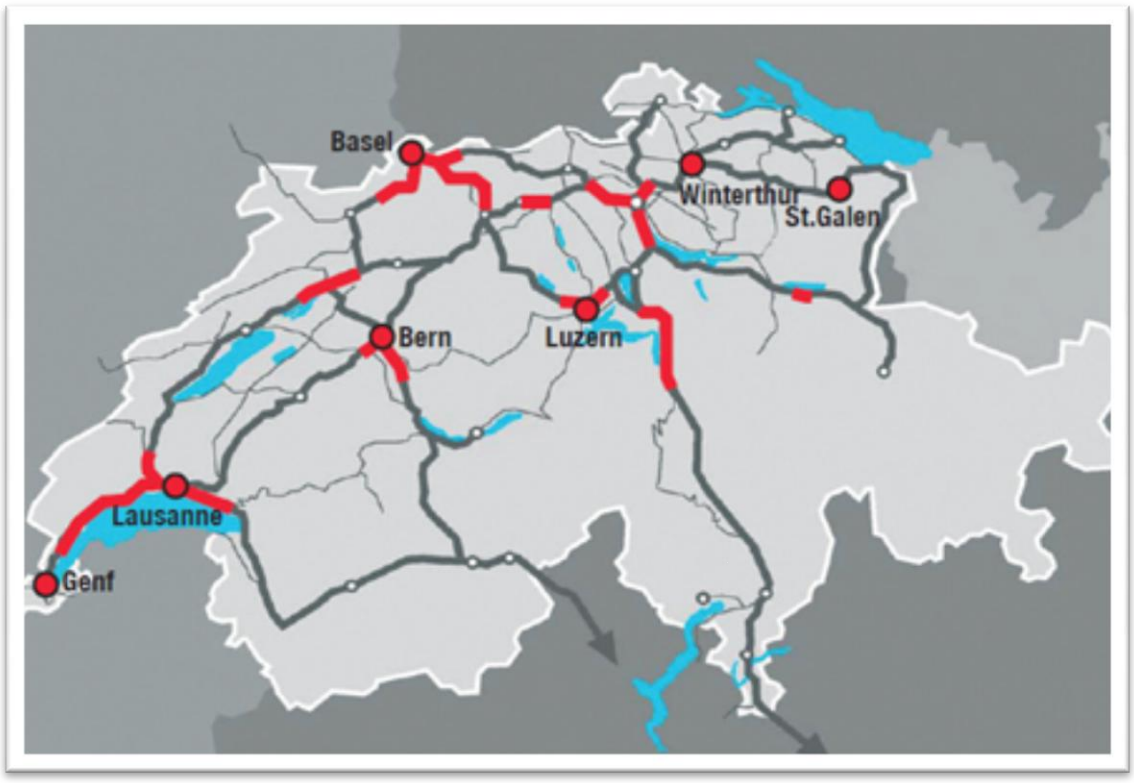


Figure 15: Swiss bottlenecks in 2010's scenario.

Source: DETECT

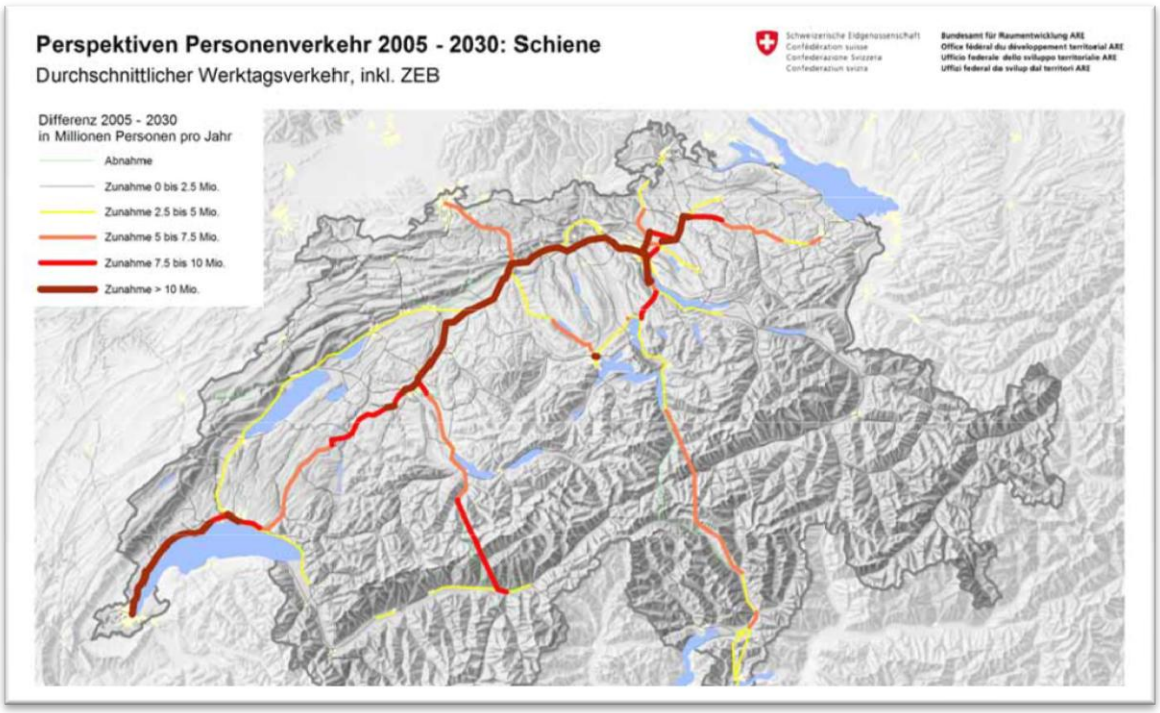


Figure 16: Prospect of passenger's demand increase from 2005 to 2030 in rail

Source: “Infrastrukturnetze Nervenstränge des Landes”, Doris Leuthard

It is noted as currently there are already some overload problems at some points of the network, especially around large cities, among which we highlight the situation of Zurich and the Lemanic Arch. Moreover, if that tendency continues, the passengers railway market will arrive at an alarming situation in the year 2030, according to Minister Leuthard's forecasts (since the expected increase in demand of 45% compared to year 2000 values). This dramatic surge in rail's use is largely a consequence of the Rail 2000 project improvements in terms of the offer. This latter was also said by Paul Blumenthal (Member of the manager's office at CFF SA and head of the passengers’ section) during the transport Forum in 2006, where he stated: "*the introduction of Rail 2000 shows perfectly that an improvement in the supply induces an extension of the market*"[ii]

Indeed, as the ETHZ's professor, Mr. Weidmann explains, the current rail network congestion is due to 5 main aspects.

1) The supply improvement by the densification of the schedule and the correspondences, which has induced a demand increase, accompanied by a change in mobility patterns

2) The Swiss population increase by 17% over the past 20 years, largely because it is an increase of economically active population that makes a greater amount of trips per day.

3) The change in land uses and zoning, with a centralization of jobs.

4) The maintenance of the general price of travelcards and the introduction from 1987 of the Half-Fare Travelcards. Both are tickets that reward the heavy use of the service to get the maximum return of them.

5) Finally, it is important to note that the First stage of Rail 2000, as previously mentioned, is part of a series of projects planned to take place in 30 years. Thus, the first stage was dimensioned taking account of an immediate second stage, which nowadays it has not still been done.

1.3.4.2. Impact on mobility patterns

In terms of modal split, we could conclude that the project's objective has been fulfilled: to provide rail passenger transport over long distances with a competent offer that in turn, increases its market share against the road transport.

As shown in OFS's graph *(Figure 17)* and table *(Table 13),* the sharpest increase in the percentage of vehicle-km corresponds to the public transport's data. Essentially train (+21% between 2000 and 2007) and public road transport (+13% for the same period. This reflects the incidence of BUS 2000). For the same period, the road has only increased by 7% and plane has lost market quote (-29%, 2000-2007). The latter is due to the "11-S" and to a lesser extent, the interregional character of RAIL2000's offer, which is an alternative to aircraft use for domestic travel.

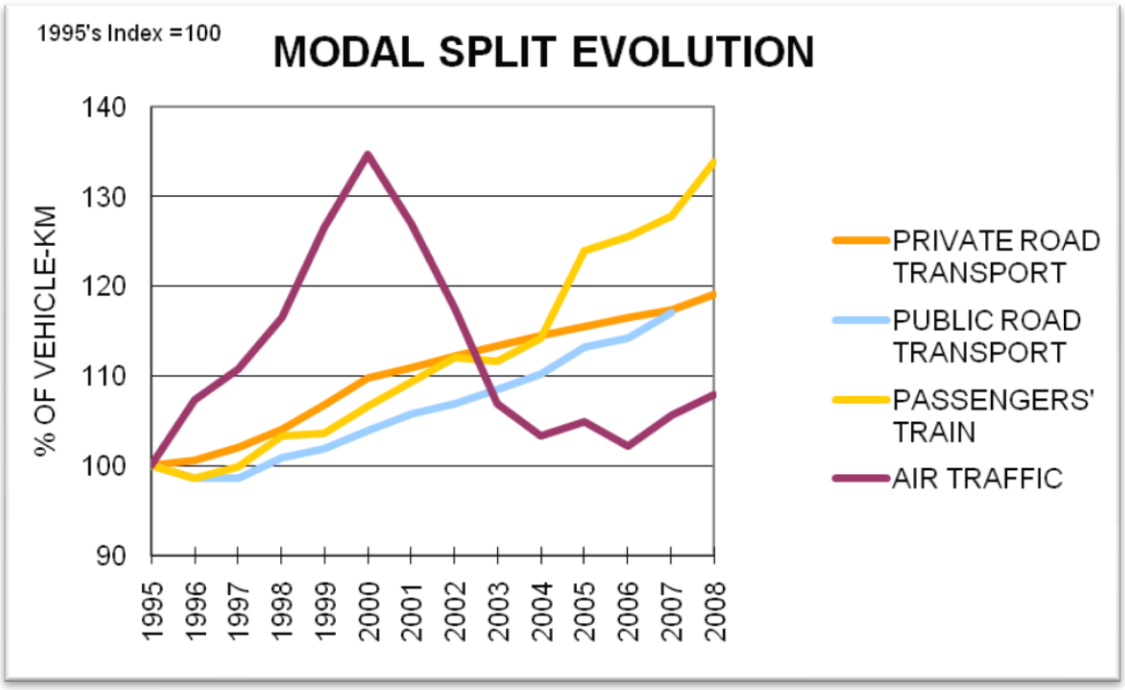


Figure 17

Source : Office fédéral de la statistique; Mobilité et transports 2010

Kilometer provision of passenger transport vehicles

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Passenger train (train-km)	100	99	100	103	104	107	109	112	112	114	124	126	128
Road P.T (vehicles-km)	100	99	99	101	102	104	106	107	108	110	113	114	117
Road Transport (vehicles-km)	100	101	102	104	107	110	111	112	113	115	116	116	117
Air Traffic (traffic movements)	100	107	111	117	127	135	127	117	107	103	105	102	106
Bike (vehicles-km)	100	101	101	102	103	104	101	98	95	92	88	89	89
TOTAL	500	506	513	527	542	559	554	547	535	534	546	547	557

Table 13

Source : Office fédéral de la statistique; Mobilité et transports 2010

Studying the number of people-kilometers transported (unit that best characterizes the demand), growth variation among different modes of transport is even greater, as shown by *Figure 18* and *Table 14*.

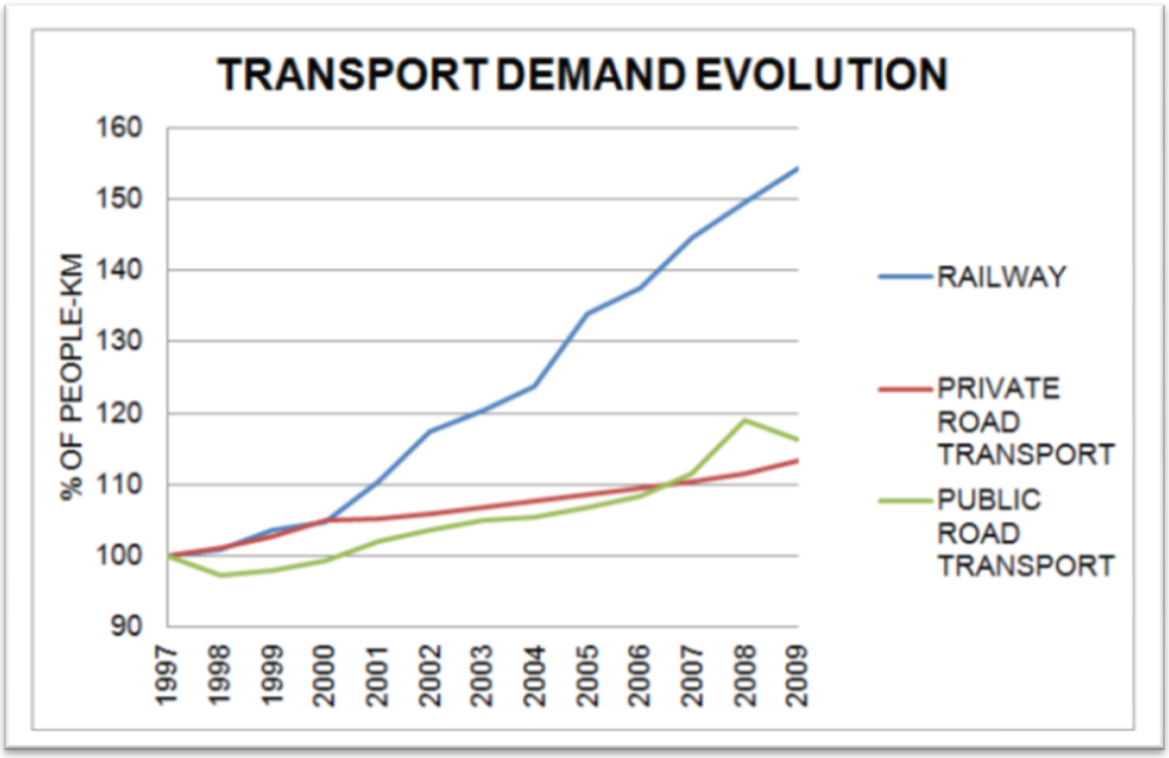


Figure 18

Source : Personal compilation based on « OFS-Encyclopédie statistique de la Suisse »'s data

Kilometer provision of passenger transport vehicles

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Passenger train (passengers-km)	100	101	104	105	110	117	120	124	134	138	145	150	154
Public Road.T (passengers-km)	100	97	98	99	102	104	105	105	107	108	112	119	116
Road Transport (passengers-km)	100	101	103	105	105	106	107	108	109	110	110	112	113
TOTAL	300	299	305	309	317	327	332	337	350	356	367	381	383

Table 14

Source : « OFS-Encyclopédie statistique de la Suisse »

As to travel's reasons is concerned, we may conclude that trips have increased proportionately in all sectors. A comparison for the OFS results among 2005, 2000 and 1994's data, shows an augmentation of travelled-km; while the motivations distribution has remained fairly constant (*Figure 19*). This is attributed to the previously commented dynamic character that service improvements has on the rest of the transport chain. Note that options like "others" or "caring services" were not possible in the 1994's survey.

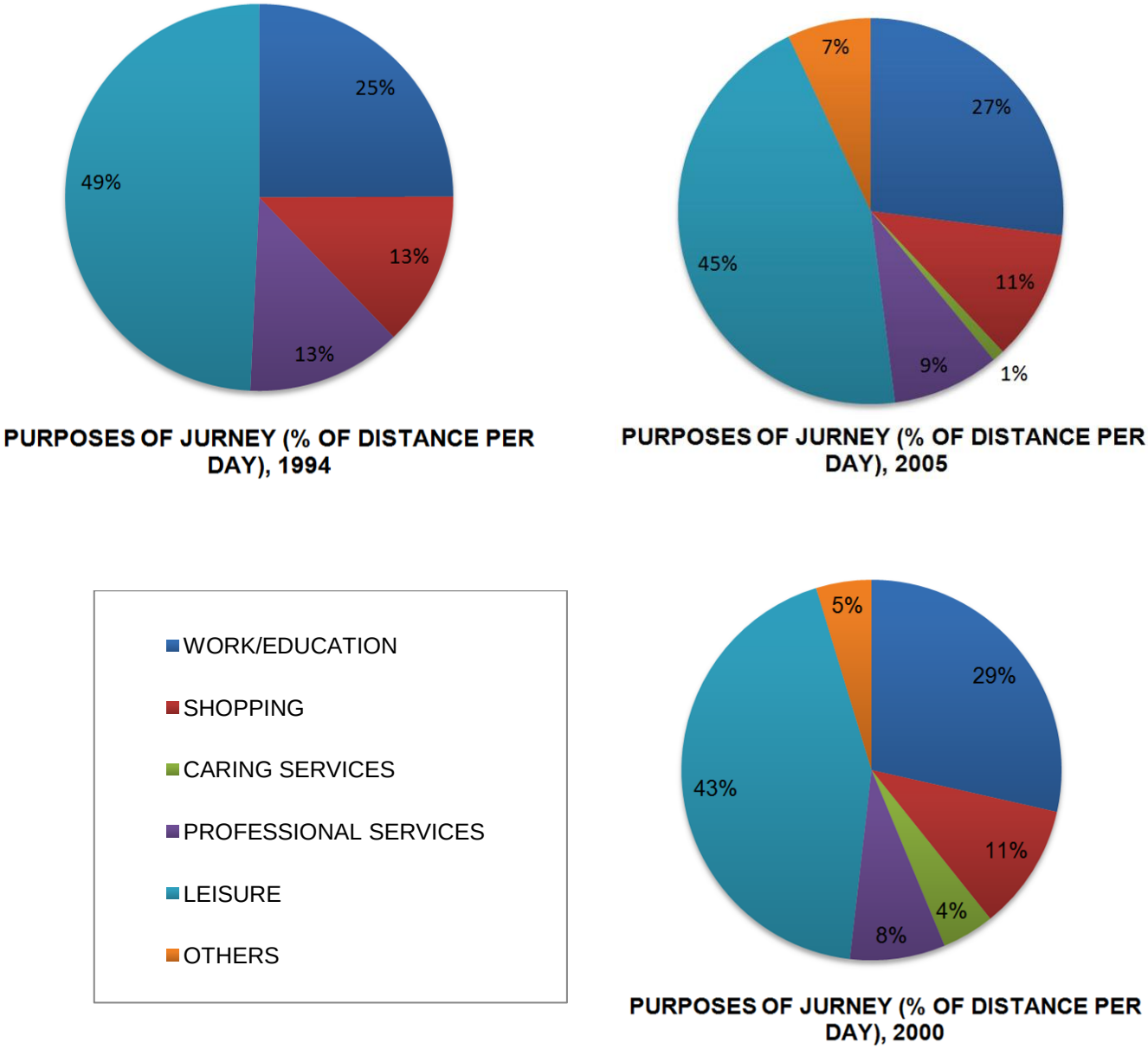


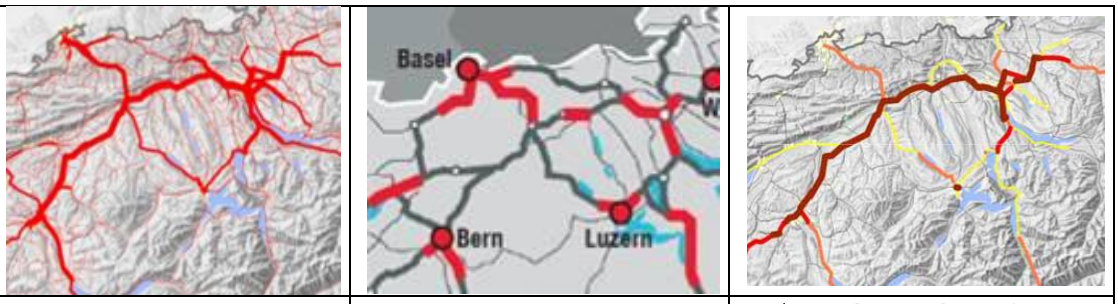
Figure 19: Purposes of jurney evolution

Source: personal compilation based on OFS's data

1.3.5. CONSEQUENCES CONCERNING THE SOCIETY

The project has several interesting social implications that are perfectly reflected its evolution. On the one hand there is the factor mentioned by Professor Weidmann "centralization of jobs around the two great centers of population: Zurich-Bern couple and Lemanic Arch ". We verify that fact in *Figure 20* and *21*, because of its consequences: the network saturation in these points. (Proof of the increased mobility).

ZURICH-BERN



2008, 30 mio. pax/year	2010, surcharged points	△10 mio. pax/year from 2005

Figure 20: Demand's evolution around the Zurich-Bern region

Source: personal compilation

LEMANIC ARCH

2008, 30 mio. pax/year	2010, surcharged points	△10 mio. pax/year from 2005

Figure 21: Demand's evolution around the Lemanic arch region

Source: personal compilation based on OFS's data

Furthermore, there is a revitalization of rural areas, mainly in the Alpine valleys. In this sense, just as Monsieur Michel Béguelin says, outlying rural areas (especially in the canton Valais) have experienced a rise in land prices due to the existence of high quality return journeys.

Finally, we also find a "rapprochement" between the Francophone and German-speaking region, exemplified by the increased number of journeys over Bienne-Lausanne and Bern-Lausanne lines. Undoubtedly, this augmentation is closely related to the two points above, and the transport's ability to create virtuous circles of mobility. It is also remarkably the flow is expected to increase further following the reduction of travel times between Lausanne and Bern.

2. VIDI

"The quality, accessibility and reliability of transport services will gain increasing importance in the coming years, inter alia due to the ageing of the population and the need to promote public transport. Attractive frequencies, comfort, easy access, reliability of services, and intermodal integration are the main characteristics of service quality. The availability of information over travelling time and routing alternatives is equally relevant to ensure seamless door-to-door mobility, both for passengers and for freight."

White Paper, 2011[iii]

LEARNED CONCLUSIONS

2.1. PLAN THE SERVICES FIRST, THEN THE INFRASTRUCTURE.

In 1973 the CGST presented a proposal to build two high-speed lines, one of them, between Geneva and Zurich, with the intention of increasing the rail's modal share against road transport, along the E-W corridor (which is focused on supply the strong national market demand in passengers' transport). The response of the people in its referendum was a so emphatic refusal that even ended with the CGST. Among other reasons, the project's rejection was provoked by opting for the construction of a linear infrastructure rather than a nationwide transport service. (Anisotropic actuation instead an isotropic service which shares the regional equity).

This marked a turning point in the Swiss transport policy history, as it was a wake-up call for society to its planners. Unfortunately, little has been learned in that subject in some countries such as Spain, where the Ministry of Public Works has recently revealed: "*There is nothing worse than a harbour without boats, an airport without planes and a train without passengers*[iv]", referring to real catastrophes of Spanish public investment like Castelló's Airport (opened without even operating licenses) or High-Speed line between Toledo and Cuenca (removal of the service seven months after being opened by having an average of 8 users).

In this regard, on July 9th , 2011, the Avui+ newspaper echoed in their digital publication the statements of two top planners and public transports' pricing professionals, such as Professors Francesc Robusté and Àlvar Garola of the ETSECCPB (UPC). In them, the experts referred to the need to "*recover the rigor*" in terms of social cost of public works because "*the benefits to society must outweigh the costs*.[v]"

In this sense, it is particularly interesting the Director of the Passenger Section at the UIC's opinion, the illustrious Iñaki Barron who says: "*That's an important point of reflection: it is necessary to plan transport services (how we will move), and then the conclusion will be to build a group of infrastructures*". He adds:" *We have the habit of planning the infrastructure and then we'll see the service. That's a catastrophic mistake, and in this issue, there are needs for improvements in terms of transports' service planning, mobility and infrastructures*".

2.2. SOCIAL INVOLVEMENT WITH THE ENVIRONMENT

Everyone knows that mobility has a major impact on the environment: in 2009, the Swiss transport sector was responsible for the consumption of one third of global energy and 37% of CO2 country's emissions. In this sense, it is no wonder that more and more, the authorities are busy trying to enact laws that regulate the mobility patterns prevailing in the society towards a new more sustainable behaviour.

In an international milieu, we can establish the turning point in environmental policy in 1972, with the publication of "Limits to Growth"[vi] by Meadows, MIT. The report recreated thanks to computer simulation variables of population growth, economic growth and the ecological footprint increase for the next 100 years. The conclusion was: "*if the current increase in world population, industrialization, pollution, food production and exploitation of natural resources remains unchanged, it will reach the absolute limits of growth in The Earth over the next one hundred years ". "On a limited planet, the dynamics of exponential growth (population and GDP per capita) are not sustainable."*

The report was known worldwide, to the point that was the basis for the convening of the first UN conference on international environmental issues. The United Nations Conference on the Human Environment (known as the Stockholm Conference was held there from 5th to 16th June, in 1972) marked a change between prior to and after having taken place in the development of international environmental policy. Attended by 113 countries and over 400 non-governmental organizations, is now widely recognized as the beginning of modern consciousness and public policy of global environmental problems.

In Switzerland, the answer to such devastating revelations didn't take a long time, as only a year later, in 1973, the CGST (Conception Globale Suisse des Transports) presented the project proposal Nouvelle Transversale Ferroviaire. With the aim of stabilizing long-term resources' consumption, the proposal was intended to change the rate of modal split between road and train, set in 1970 by 80% / 20% passenger-kilometre, respectively.

Nowadays, the paradigm of sustainable transport policy passes through the passage of legislation that favors the use of more environmentally friendly modes, such as rail or boat, to the detriment of private road transport. A clear example of this aspect are the guidelines set out in the last White Paper by the European Transport Commission: "*The challenge is to break the dependence of transport systems on oil without sacrificing efficiency or compromising mobility*"[vii].

However, and as Iñaki Barron suggests, social behaviour cannot be imposed "*whatever is imposed, it is bad, things must be done naturally*", so a priori, it should be the society who is willing to develop a more sustainable mobility. In this sense, it is also interesting to echo the comments made by Mr. Keir Fitch, who points out the need for the development of involvement with the environment in the societies of Western Europe: "*particularly in this cold countries of Western Europe in terms of NIMBYs. (You know what NIMBYs are: Not In My Back Yard). I mean, if you see the kind of reaction that you had in Germany to the Stuttgart TrainTransit Project which pulled down the Government, although it was doing the kind of things that we think are sensible in railway policy terms*"

As far as Switzerland is concerned, this social will to reconcile the development of transport and the environment, has a particularly long history. The best example we find is in Article 84 of the Federal Constitution on the Alps protection, approved by referendum in 1994 by the Swiss people. This law requires the protection of the Alps against the negative effects of

major traffic recorded in them, especially after the opening of the St. Gothard road tunnel in 1980.

This referendum's approval put above the Swiss society as a world pioneer of what is now (15 years later) being described as "empathic civilization." The term "empathic civilization", which matches the title of the book[viii], was coined by Jeremy Rifkin, the economist and EU adviser on climate change, energy security and sustainable development. According to his own perception, Mr. Rifkin calls for a change in the new generations of young people and their ability to bring empathy beyond the religious faiths and national ownership, incorporating also, the huge project that involves The Earth life. Finally, we should wait to verify if, as the writer says, "*Can we achieve awareness and empathy global biosphere in time to prevent global collapse?"*

2.3. SUPPLY'S APPROACH: SYSTEM OF SYSTEMS

The related conclusions in this domain concern to three basic points: first, there is a substantial change in the type of service; on the other hand, there is a change in market perception and; finally, we have the introduction of a new management model of the elements that influence the final product. However, they all correspond to the application of Systems theory in the world of transport, and more specifically in their supply. [1]

Actually, transport's must be understood as a complex system that encompasses all and each one of the different elements that influence on it. Each of these elements is identified as a subsystem, and its definition depends on the quality of the system that is under study. For example, the system constituted by transport's supply can be split into {spatial supply and temporal supply} when the property that is referred is the service's coverage *(Figure 22)*; at the same time, it can be formed by the subsystems {public transportation, private motorized transport and soft mobility}, when we analyze the different markets associated with each means of transport.

Figure 22: Supply's char

Source: personal compilation

2.3.1. The resulting product: A NEW SERVICE DOOR-TO-DOOR

It is essential the re-approach of transportation service, with special emphasis on his characteristic "door to door" through the use of guaranteed connections. These

[1] Systems theory is the transdisciplinary study of systems in general, with the goal of elucidating principles that can be applied to all types of systems at all nesting levels in all fields of research. The term does not yet have a well-established, precise meaning, but systems theory can reasonably be considered a specialization of systems thinking, a generalization of systems science, a systems approach. The term originates from Bertalanffy's General System Theory (GST).
In this context the word systems is used to refer specifically to self-regulating systems, i.e. that are self-correcting through feedback. Self-regulating systems are found in nature, including the physiological systems of our body, in local and global ecosystems, and in climate - and in human learning processes. (WIKIPEDIA)

connections should be conducted both internally (between different compositions within a single means of transport) and in an intermodal milieu (among different means of transport), which can increase the connection and, consequently, the global real network coverage by assembling the different subnets. It is in this last point's spread where the main change in market conception lies, as it becomes a market for markets. However, these are discussed in more detail later.

There are two interesting learned points concerning door-to-door services:

1) On the one hand, as discussed above, the operating model with connections implies the supremacy of the nodes over the edges, and consequently, the creation of new "hubs", where exchanges between different flows of travellers take place. This factor is a modification of the historical treatment of flows inasmuch as it can raise to the level of "hub" some nodes that would have held a secondary role in the network by their limited capacity to generate journeys. According to the Swiss model, this is the case of towns like Olten, Delémont or Sargans

2) On the other hand, it is necessary to emphasize the appropriateness of the use of repetitive structures in the planning and operation, to facilitate these arduous tasks for both: workers and users. In this sense, one of the main tool for the establishment of a connection’s service is the use of a repetitive and systematic schedule: the clock-face schedule, which articulates the whole supply.

   Effectively, broadly speaking, this new approach to the service responds to the desire to reach a more systematic operation model (higher order) by reproducing repetitive structures in two domains: the temporal (time cadence) and spatial (correspondences). As a result of the joint processing of both variables is obtained a more competent transport service that enables an increase in terms of network’s coverage (for example, connections between railway and bus allow an expanded public transport supply reaching areas where railway’s infrastructure cannot be implemented for economic or geographic reasons), and as a consequence of it, there is an enhancement of public transport's use by expanding users' possibilities to carry out a trip. This last aspect also illustrates the occurrence of synergistic effects between different transport agents.

   Furthermore, with the introduction of new model based on connections and regular-interval timetable, we obtain a host of advantages (we avoid: stopped rolling-stock, unnecessary circulations, useless manoeuvres ...) that result in an eventual reduction in costs and, therefore, a higher service profitability. In addition, the greater flexibility of spatial coverage (more suited to the every time's needs) helps to reduce the inherent deficit in the public transport system.

2.3.2.New transport's market perception: ECONOMIES OF SCOPE

In the same way it has been done a generalisation of the network (network of networks) it is essential to implement the same methodology at the market's domain, which leads to a new view of the transport market: market of markets (*Figure 23*).

Figure 23

Source: personal compilation

In this sense it is important to understand the mobility system as a global system that involves other subsystems (for example, each means of transport). In terms of Systems theory, we would be speaking of Supra and Subsystems, respectively.

This broader view also has synergistic effects (mentioned above) because of belonging to the same system: all elements are interrelated so that the actions made on one of the subsystems affect inexorably to the other parties. It is at this point where gradual measures become more important inasmuch as they are capable of producing large effects after the introduction of small changes in the system.

Furthermore, treatment and joint management of all the transport sub-systems contributes to the emergence of Economies of scope[2]. Indeed, the joint production of various transport services contributes to a eventual reduction of unitary costs, while increasing its share of demand (serving a larger number of users). (For more information see "Reliability and excellence at all levels to ensure a service that meets the needs by responding as efficiently

[2] The economies of scope entail a saving of resources as a result of producing two or more services together. Formally, they imply that the average cost of producing a service individually is higher than the production price of it along with other services. This situation can occur when the joint creation of various services optimizes the use of production factors. Specifically, their application to the Swiss transport system implies a combined treatment of the various transport sub-systems into a single joint policy. Especially interesting is their use in the planning of public transport for their impact on intermodal competition.

as possible", and the conclusions of "Testing for Economies on European railways: an efficiency analysis")

One of the major applications of the new perception of "system of systems" we find is in managing intermodal competition (among different means of transport).

2.3.3.New production's chain perception: TIME OF INTANGIBLE ASPECTS

For practical purposes we have verified as project RAIL2000 affects each and every one of elements of the service production chain: infrastructure, rolling-stock, schedule, signalling, ... This is because again, railway is understood as a system of systems, so that the most effective way of proceed to improve the supply is to act on all the aspects that influence its outcome. This concept is represented in *Figure 24*.

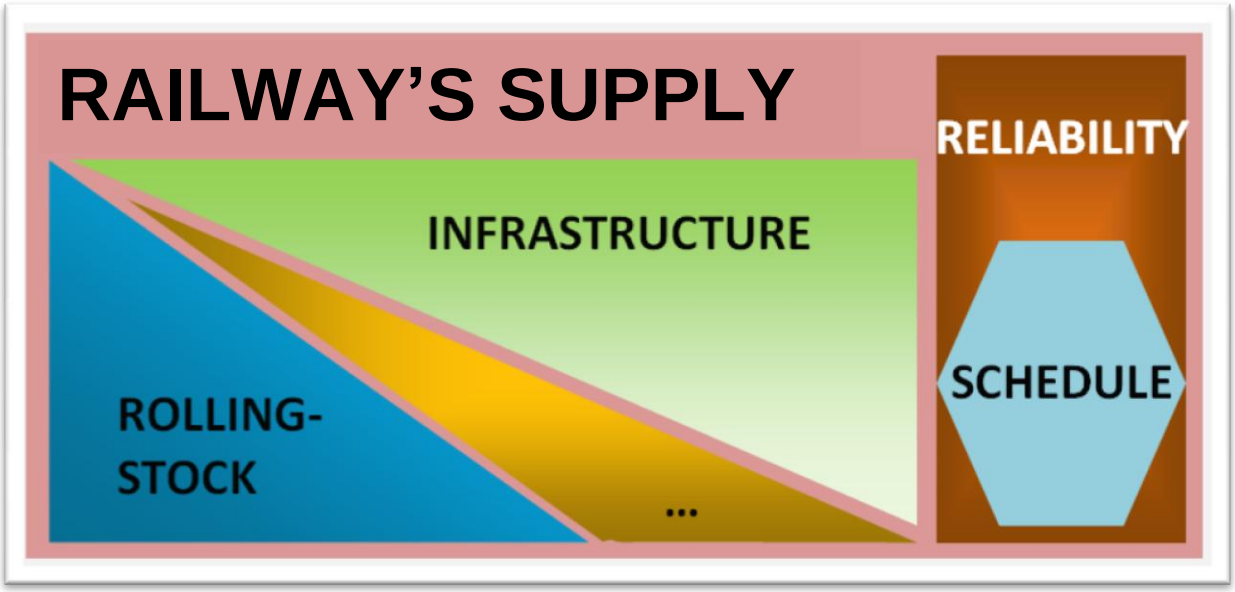


Figure 24

Source: personal compilation

Thus, issues such as scheduling, reliability, or the determination of the nodal points, take on equal importance to the classic elements like infrastructure and rolling stock. Note in this case "intangibles" are which take on a greater importance.

The appreciation of the rail transport service as the combination of an aggregate of elements allows, again, the appearance of synergistic effects that contribute to achieving the maximum profitability of the project from the introduction of gradual steps on each and every one of its aspects

2.4. DEMAND'S APPROACH

In recent years we have seen how certain public transportation systems have achieved better results by combining the traditional development approach linked to the development of its offer, with some legislative measures that directly or indirectly affect the demand. This is due to the complementarity of these aspects (supply and demand) as subsystems of a system.

According to the UIC, this acts are: *" better land-use planning; telematics; electronic road pricing, stronger parking measures; internalization of externalities, investments in better bus systems; and investments in infrastructure to promote public transport, cycling and walking."* ("Transport, energy and CO2", 2010)[ix]

2.4.1. Intermodal competition

Under the theory of systems, each subsystem of a suprasystem is not an element hermetic and unalterable, as it is closely related to their counterparts, so the measures carried out on one of them affect, the other components. This is due to the system's ability to self-regulate. For this reason, it is obvious that measures taken to enhance / reduce the demand are built on the idea of intermodal competition (competition between different modes of transport), as penalties exerted on certain means of transport benefit the rest, whose share is increased.

The intermodal competition must not to be confused with the intramodal competition (competition between different operating companies of a mean of transport). Over the past 50 years, Switzerland has sought intermodal competition in its transport market, imposing a fair fight between the train and the road (between public transport and private road transport, in broad terms) by investing in infrastructure[3] and charging external costs of transport. The EU, meanwhile, has proceeded in recent decades with the liberalization of transport markets. The key elements for the latter are free access to the network for the railway companies and freedom to provide services in air transport. However, liberalization is facing certain limitations on rail traffic and, more specifically, passenger transport, so it must be a balance between the gains in efficiency that produces a hypothetical open market, and eventual loss in terms of synergies (not having an integrated operation, as RAIL 2000 proposes). The Swiss response to this balance has led to the establishment of a railway passenger market based on concessions which prevents competition on the same line.

2.4.2. Internalisation of externalities.

Nowadays, the current international prevailing actions on demand focus on the internalization of externalities (process by which the user of a pollutant agent must face economic social costs resulting from its use), which implies the increase in the price of means of transport that are less respectful with the environment. This leads undoubtedly to encourage the use of public transport (paradigm of sustainable transport), to the detriment of other more polluting means like private road transport or plane. As an order of

[3] Between 1970 and 2005, annual investments for TP went from 0.5 to 4.5 milliard francs. In the same period, the road rose from 2 to 4.3 milliard; so both studs were matched in 2005.

magnitude, the data presented by Switzerland in 2005 show external costs associated with accidents and the environment (no account traffic jams) of the road amounted 7.5 milliard francs, while the values for train were 0.5 milliard francs.

The results obtained by Switzerland in this regard, since the 70's when they started the first discussions on the internalisation of externalities, have certainly been successful, especially for road transport of goods. In fact, the implementation of the RPLP ("redevance poids lourds aux prestations "), upon acceptance of the referendum in 1998, was the world leader. This was accepted by the EC in compensation to the abandonment of the limit of 28 tons for trucks passing through the Alps (long claimed as non-negotiable by Switzerland), and the construction of the NLFA. Its amount corresponds to the external cost of an increase of the maximum weight of 28 to 40 tons, and is intended to finance part of investment in rail freight traffic, thus encouraging the modal shift. As far as passenger transport is concerned, the rates and taxes on fossil fuels and circulation, have also provided a transport market more competitive. Specifically, according to "Ecoplan" in its "Coûts de la mobilité dans les villes"[x] the relationship of average mileage for the different means of transportation is: 76 cents CHF / km for the car, and 35 cents CHF / km for train. Undoubtedly, the consequences are reflected in section "1.3.4.2. Impact on mobility patterns", related to the modal split after the implementation of the project Rail 2000.

In this regard, has also expressed the EU through its recent White Paper, which outlines the need for Member Countries of proceeding with the internalization process:

"*Price signals play a crucial role in many decisions that have long-lasting effects on the transport system. Transport charges and taxes must be restructured in the direction of wider application of the 'polluter-pays' and 'user-pays' principle. They should underpin transport's role in promoting European competitiveness and cohesion objectives, while the overall burden for the sector should reflect the total costs of transport including infrastructure and external costs. Wider socioeconomic benefits and positive externalities justify some level of public funding, but in the future, transport users are likely to pay for a higher proportion of the costs than today. It is important that correct and consistent monetary incentives are given to users, operators and investors*."[xi]

The quoted text shows that this type of action on public transport demand pursue two main objectives: firstly, to ensure an increase in the share of demand to rise the profitability of the service ("*Promoting European competitiveness and cohesion objectives*"); and the other, to promote more sustainable mobility patterns.

The main externalities that produces a transport service are noise pollution, congestion, declining air quality (CO2 emissions, basically) and accidents.

1) **Noise pollution**
   In terms of noise pollution, traffic air, rail and road are the main source in Europe; where according to the EEA over 41 million people suffer from exposure to noise levels above 55 decibels (the indicator used to determine the hassle). It has been demonstrated prolonged exposure to noise levels (even if they are considered low) can involve important issues of hypertension and sleep dysfunction. The European exposition to this effect is shown in *Figure 25*

Figure 25: Map about the noise intensity developed with support from the European Topic Centre on Land Use and Spatial Information (ETC LUSI), located at the Faculty of Sciences of the Universitat Autònoma de Barcelona.

Source: http://www.econduccion.es/es/trafico-principal-causa-de-contaminacion-acustica-en-europa)

Switzerland is also one of the pioneers in the fight against noise pollution. Among its mitigation measures highlights the CFF program to combat noise. So, after the 2015 horizon, CFF will have invested a total of 820 million CHF for improvements in rolling stock, 900 million francs for sound-proof screens and 120 million for sound-proof windows.

2) Congestion

As for the costs of traffic congestion is concerned, these relate to the loss of time for user, stress and pollution. They are defined as private cost, in which the driver incurs, plus external cost, which is the cost imposed on other drivers by slowing them down; and they are basically produced by inefficient decision from the social point of view, in terms of how much, when and where to travel. For this reason, its impacts are more significant during the peak hours when traffic volumes approach the capacity of roads

3) Air quality

Air quality is the externalities associate to the mobility that currently has a greater destructive power due to its involvement in the world, for this reason, is the main fronts in international environmental policy of the last century; and good example of it, is the Kyoto Protocol. Its harmful effects come primarily from the emission of particulate pollutants (mainly nitrogen oxides and hydrocarbons) by the combustion of petrol and diesel engines in vehicles. However, emissions are also significant in the vehicle manufacturing process (138,000 equivalent tons per year, for a conventional factory, as published by the newspaper "La Razon" in July 2011[xii]). In this sense, it is not surprising that one of the major milestones of the EU is to reduce by 70% of 2008 levels of CO2 in the transport sector.

The aims of reducing air pollution in Switzerland are set out in its Law about CO2; and various instruments to proceed with the internalization of this externality are:

- The tax on CO2 (for all fossil fuels from January 1st, 2008, and whose revenues are redistributed between society and business).
- RPLP

There are also interesting plans (drawn during the 90's by the cantons) in favor of forest protection which measures enable the neutralization of the acidification of soils, a major cause of death of the trees.

4) Safety

The massive growth of mobility has risen to the forefront security aspects, especially in road traffic. This has driven the implementation of stringent requirements at all levels, which has systematically reduced the number of accidents and, consequently, their social costs.

However, costs calculation and determination of the internalization process is a complicated job, which results in a different model for each society. Moreover, the results obtained by some experts concerning the effectiveness of the internalization of externalities presents great differences depending on the type of externality involved and the scope. Especially interesting are the conclusions drawn by the illustrious Chris Nash, at its "Modifying transport prices to internalize externalities: evidence from European case studies" (Chris Nash, Tom Sansom and Ben Still, Institute for Transport Studies, University of Leeds, Leeds LS2 9JT, UK) which concludes: "*For inter-urban transport, however, in no case were the changes in mode split from the introduction of efficient pricing very large; the belief that proper allowance for air pollution and global warming would lead to major diversion from road and air to rail does not appear to be supported by empirical analysis. On the other hand, very much more diversion could be expected in urban areas, but more as a result of charging for external costs of congestion and accidents than for air pollution and global warming*."[xiii]

2.4.3. Land uses and road pricing

As with the internalization of external costs, it is very important the influence that legislative action planning exercises on transport demand, because that may encourage the use of some means of transport, in the same way that they can prohibit the introduction of a new infrastructure. In this sense, Switzerland has also a broad and strict legislation due to strong social conscience regarding the impact of progress on the landscape and the environment. In 1969, the Swiss people had already accepted the article 22 of their constitution concerning land's use. It had been promoted by the strong population growth

recorded during the previous decade which, on that time, was fostering a growing land's demand for infrastructure and housing. Then in 1972 they accepted the law on "urgent measures for improving land" which set the milestones for a definition of buildable area. Years later, territorial development led to the expansion of cities around the railway stations after the listing of the adjoining land as building land. Thanks to this, regions as Bern and Zurich have systematically developed areas near the RER stations, while Geneva, meanwhile, installed two separate centers and conference presentations near the airport. These developments are, in general, the joint efforts of private investors, collective and public transport companies who found that cities were the engines of the economy and therefore, an unattractive appearance could be a problem. Similarly, Helvetic cities found since the 60's that the development of the road network was facing limits of feasibility (lack of space) and consensus (environmental protection). For this reason, at the local level, it was also pretended to strengthen traffic management and public transport by facilitating cycling and walking. Thus, the restrictions on the construction of roads and parking spaces with the simultaneous development of the network of trams, buses and RER, have produced a rapid growth in demand. By contrast, in most European cities, traffic management rests heavily on the toll road (Road Pricing). This is the case in cities such as Oslo, London, Stockholm and Rome, where it is used the Road pricing to finance the construction of roads and encourage the development of public transport. The Road Pricing has been categorically rejected by the Swiss Parliament on several occasions, although it is not ruled out by the government to deal with these measures in the future.

Finally, it is interesting to consider the tremendous impact that the introduction of control measures on the public transport's demand, particularly for rails, may have on mobility, but also on the society in general. Obviously, talking about transport policy is to speak of disparity of opinions: each society has its own needs, so the best solutions and systems to develop are also different in each region. For this reason, before promoting any type of action, it is essential that planners submit to review the impact that their actions can have, especially in the socio-economic development.

For example, in American society prevails thes private motorized mobility patterns and only at long distances, the car has lost ground to air transport. Examples include data from 2006 when just 9% of the labor forced mobility were carried out by public transport. In fact, in 2001, American people made 0.1 trips and 32 miles per person by rail. In this sense, the introduction of measures that penalize private road transport would influence negatively on the economy. The same happens in the so-called "peripheral countries" of the EU, where the combination of an infrastructure's policy focused on the roads development or the extended business strategies like "just in time" seriously hamper the introduction of discriminatory measures on road transport. Proof of this, is found in the article published by the newspaper La Vanguardia, in its digital version of May 25, 2011 which confirmed that: "*According to the Association of European Automobile Manufacturers (ACEA), acquisition and circulating tax of cars in the EU-15 amounted to 378,000 million per year, equivalent to 3.3% of GDP in these countries*[xiv]" so that a reduction in car sales would mean major economic consequences. On the other hand, there are other factors, such as commented by Mr. Iñaki Barron, who remembers not only the economic, but also "the social value added" of some means of transport such as the automobile. (Appendix: INTERVIEW WITH IÑAKI BARRON).

2.5. RELIABILITY AND EXCELLENCE AT ALL LEVELS TO ENSURE A SERVICE THAT MEETS THE NEEDS BY RESPONDING AS EFFICIENTLY AS POSSIBLE

Without a doubt, transportation has a big influence on people, particularly from two perspectives: service to society and cost-benefit balance involved. Thus, for both aspects, it is essential to achieve the highest possible excellence.

SOCIALLY- a transit service that is able to gain users' trust by fulfilling its supply base is always synonymous with population's life quality. This is mainly due to increased demand associated with it, and it is resulting in an increased mobility towards new patterns more sustainable and therefore, better quality of life.

This engagement between reliability and increased demand is echoed by the White Paper of the European Union: "*A greater proportion of journeys made by public transport, combined with service obligations, would increase the density and frequency of service, generating thus a virtuous cycle for modes of public transport* "[xv]

In this sense it is fundamental a strict compliance with the schedules of operation, as one of the basics in terms of the quality perceived by users.

ECONOMICALLY-from the economic benefit point of view, the transport sector is very important on the revitalization of the economy, and one of the most important signs lies on its strong relation with the GDP. Examples include data recorded in Brazil in 2007 where, while being qualified as "low", the contribution of transport to GDP was 5.7% (according to the National Association of Railway Transport). Note that Brazil has been chosen as one of the countries experiencing higher growth in transport policy in the last decade (PAC-1 and PAC-2), along a spectacular economic progress: becoming the second largest economy of America and eighth worldwide.

Thus a good public transport operation policy, combined with the strength that produces the reliability of the system are key to increased mobility, both committed and leisure, and hence to increase the economic progress.

In Switzerland's case, according to recent years' data from the OFS (Office Fédéral de la Satistique), we see some correspondence between the implementation of transport policy measures and the GDP increase. Notably, in 2002 when the railway sector contributed 5.4% to the country's GDP and 6.6% to the employment rate. It is also worth noting the shift in 2005 (highlighted by a circle in the figure) after having come into force the project RAIL2000. In this sense, we verify in *Figure 26* an increase of GDP growth at the same time as the project's commissioning because of 16,000 million CHF and 151,000 jobs that RAIL2000 generated.

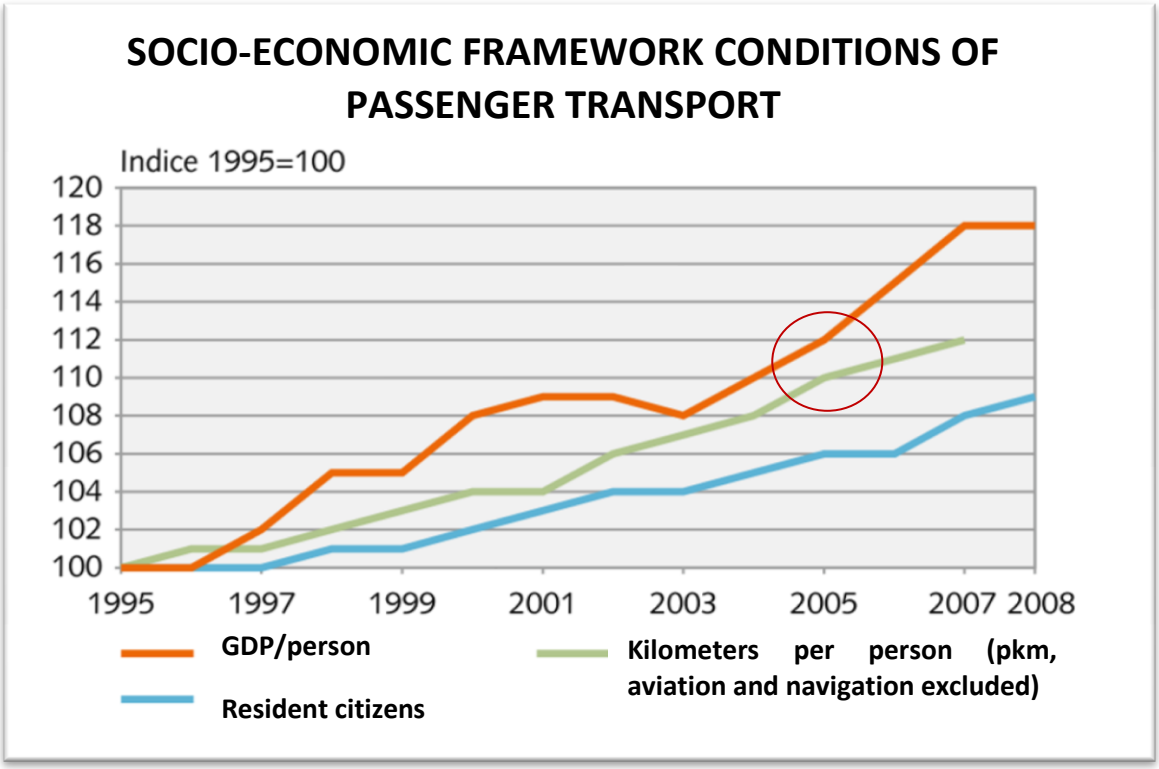


Figure 26: Swiss evolution in terms of travels and GDP

Source : OFS, "Mobilité et Transports, Statistique de poche 2010 »

As far as system reliability concerns, there are many possible answers to the question of what is the factor that makes the difference between Switzerland and other countries such as Spain, France or Italy.

Broadly speaking, all theories point to the implementation of famous "economies of scope" to the transport milieu, combined with the eventual availability of market opening. According to the results of Christian Growitsch and Heike Wetzel, in "Testing for Economies on European railways: an efficiency analysis": "*those integrated firms that are subject to competition do not significantly suffer from managerial inefficiency and are able to generate productivity advantages as a result of economies of scope*." In this sense, the authors specify that this is the case of countries like Germany, Switzerland and Italy.[xvi]

However, ultimately, is the combination of multiple factors which gives the Swiss public transport service a reliability of 98%. According to Mr. Michel Béguelin, a system's expert, this is the will to achieve maximum performance at all levels, with a high incidence of human factor. Proof of this is the project RAIL2000 (maximum excellence at all levels) and motivation that operators have on workers, offering them the possibility of a bright future.

Other specialists interpret this "savoir faire" Swiss as "precision", this is the case of Professor Ulrich Weidmann, from the EPFZ. Anyway, we discern a relationship between the implementation of transport systems less susceptible to disruptions and the network reliability. Systems that are understood to be less susceptible are those endowed with

technical mechanisms or governance rules that are able to reduce the likelihood of incidents and spread of the possible perturbation around the network.

In terms of technical mechanisms, they favour the system's robustness, insofar as they provide it with the necessary tools for a rapid response to a potential incidence (higher manoeuvrability), therefore it is easier to prevent its spread through the network. A clear example of these infrastructure elements in Switzerland are making two ways traffic or centralized control points.

Concerning operation procedures it is possible to achieve better disturbances isolation using some protocols which are more desirables. An important paradigm in the treatment is in the individualized treatment for each composition, instead of working with “unalterable series of trains " that are more vulnerable. (More information at Appendix: “INTERVIEW WITH MR. ULRICH WEIDMAN”.

3. VICI

« Un minimum de coûts pour un máximum d'utilité »

PRACTICAL APPLICATION FOR CATALONIA'S CASE

First, it is necessary to emphasize that we have opted for the implementation of the conclusions learned about Swiss passenger's railway transport policy in Catalonia, by the similarity of scale between the two systems, both geographically and demographically[4]; which allows, in some way, to equate the rail network of middle-distance passenger in Catalonia with Swiss national passenger's service . However, it is true that spatial distribution' pattern of the Catalan population is much more linear *(Figure 27),* extending mainly along the coast, so the much talked about "regional balance" is more latent in Switzerland than in Catalonia. In turn, the latter has a more centralized planning around its capital Barcelona.

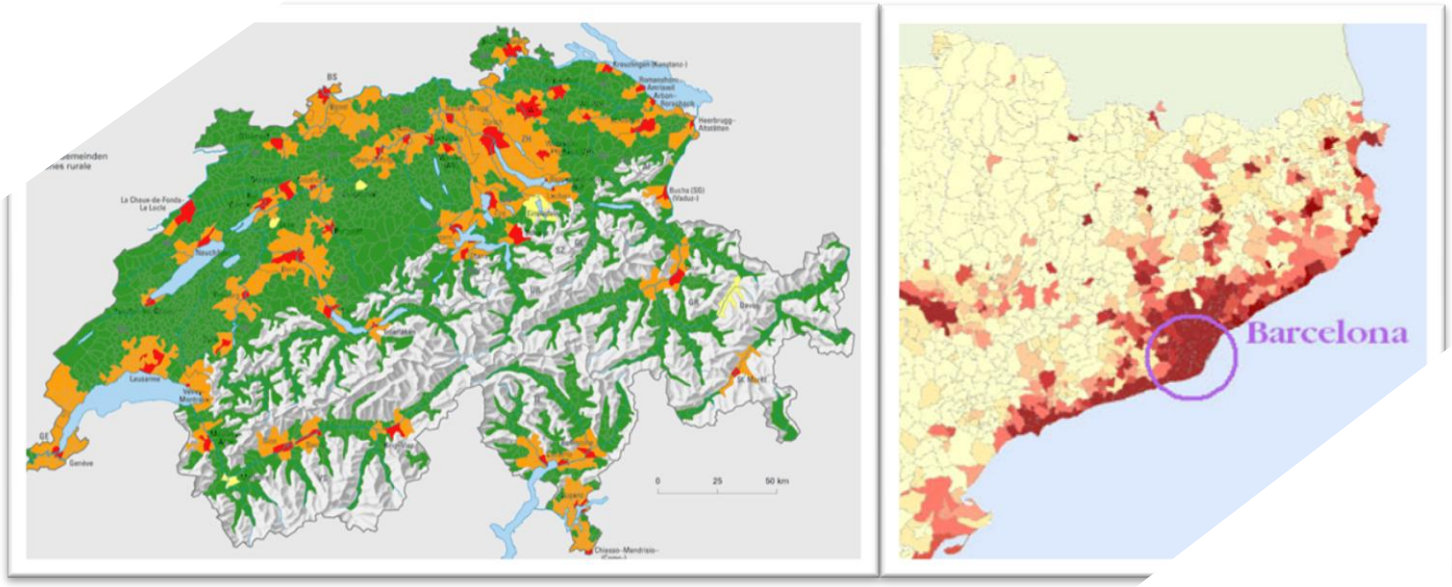


Figure 27: Switzerland and Catalonia's demographic map

Source: personal compilation from Wikipedia pictures

Even so, there are some learned policy's aspects about railway passenger's transport in Switzerland, particularly about project Rail 2000, whose application to the Catalan system has special interest. Without a doubt, a fundamental point of departure should be the idea shared by all experts today: the "need for a service plan instead of planning an infrastructure" and the "society's involvement with the environment" or "the increase of reliability." Although, everyone knows that the latter aspects have a strong cultural component, so its adoption cannot take place as a consequence of an imposition of the overnight, it must be embraced on a voluntary and gradual way by society and its leaders.

[4] Swiss' extension: 41.240 km^2, Swiss' population: 7.725.200 people (2009)
Catalonia's extension: 31.106,5 km^2, Catalonia's population: 7.512.381 people (2010)

However, there are other measures whose implementation is much more direct and simple, so, we are focusing on them. These concern mainly the supply and are particularly interesting given the current economic situation by the high rate benefit / cost they involve.

3.1. NEW SUPPLY'S APPROACH: MAXIMIZING CONNECTIONS

Particularly interesting is the adoption of a system of correspondences between the middle-distance railway's service and other public transport operators. In this sense, integrated operation of the different actors of public transport (mainly rail and bus) results in a service door to door, which in turn, revitalizes the public transport's demand creating the much desired "*virtuous circle of public transport*"[xvii]

The starting point of a model based on connections is an overview of the transport network, resulting of the perception of bonded system composed of subsystems (different means of transport's subnets), and involves, undoubtedly, the supremacy of the nodes with respect to railway lines, with the consequent transformation of the stations in hubs of exchange of passenger's flows. They should concentrate flows from both the other sections of rail passenger transport (suburban and main lines), and other means: coaches and metropolitan services. Finally, it is interesting to recall the power that an integrated supply has on all transport areas, beyond the market segment on which the action takes place.

Needless to say that nowadays, Catalonia has, at the regional level, its passenger's transport policy that promotes widely the use of connections. It is reported in PTVC 2012 (Passenger's transportation plan in Catalonia 2012), where it is exposed as one of the major milestones for rail: "*improve the supply so as to guarantee the connection of stations extended to the Metropolitan Region of Barcelona among themselves and with Barcelona and other main cities, also ensuring a good coordination with road services at those stations where possible*" [xviii]

In addition, statewide, the guidelines set by the European Union, specifically its recent White Paper, are followed which also includes the enhancement of public transport services grounded in the connections. Specifically, one of the guidelines states: "*To define the necessary steps to further integrate the different modes of passenger transport providing multimodal travels door-to-door with a solution of continuity"* and adds: *"creating the framework conditions to encourage the development and use of interoperable, multimodal intelligent systems for timetabling, information, online reservations systems and smart ticketing*."[xix]

In this sense, such as found in the project RAIL2000, the role played by the clock-face schedule and hubs, while essential tools to carry out the connections, is crucial, and for this reason, the following measures mainly affect these two aspects.

3.1.1. RAILWAY-RAILWAY CONNECTIONS: THE IMPORTANCE OF LINKING SUBURBAN SERVICES WITH MIDDLE-DISTANCE SERVICES.

The Barcelona Metropolitan Region covers an area of 3236 km2 and a population of 5,012,961 inhabitants. What in relative terms is 10% and 67% of the total area and population of Catalonia, respectively. It integrates Barcelona, capital of the Region, and cities that surround it such as Hospitalet de Llobregat, Badalona, Terrassa, Sabadell ..; it concentrates the bulk of economic activity.

In terms of passenger transport, in the BMR it is located the Aeroport del Prat (international air hub) and major Mediterranean cruise port (Barcelona's harbor). As far as rail services are concerned, the BMR has 15 suburban lines (operated between RENFE and FGC), which provide service to a total of 739,433 daily trips[5]; and it is source / destination of all regional railway lines: R11, R12, R13, R14, R15 and R16. For this reason, the establishment of connections between the regional rail service and commuter is paramount. On the other hand, Barcelona is one of the most important hubs of the Spanish national network of long distance rail.

The BMR's main hubs of travelers flow between local and regional services are Sant Vicenç de Calders (junction of R2 and R4 commuter lines with regional lines R13, R14, R15 and R16) Manresa (union of the lines R4 and R12) and Maçanet-Massanes (connection between R1 and R2, and R11). While the most important railway hub of Barcelona, for their connection to urban public transport network is Barcelona-Sants.

The main weaknesses found on the connections between the commuter rail services and regional rail services are in the Maçanet-Station and Station Massanes Prat de Llobregat.

3.1.1.1. First proposal: MAÇANET-MASSANES' HUB

The station Maçanet-Massanes is the polar of exchange of railway flows between R1, R2 and the line "Barcelona-Portbou" of middle-distance (R11), while important town of the province. Below are *Figure 28* and *Figure 29*, maps provided by the Generalitat de Catalunya where are represented networks that converge in Maçanet-Massanes.

[5] Data from "*EMQ 2006 de Catalunya*", published by the *Departament de Política Territorial i Obra pública* de la Generalitat de Catalunya, show an average of 23.084.191 daily trips in Catalonia. About the 2% are operated by RENFE and the 1,3% by FGC

Figure 28: Map of commuting lines in Maçanet-Massanes.

Source: http://www.gencat.cat/rodalies/planol.htm

Figure 29: Map of all the lines of Maçanet-Massanes.

Source: http://www.gencat.cat/rodalies/planol_regional.htm

According to the Generalitat, in 2009, the average charge of the R2[6] line was 44,8 million travelers (the most important in suburban network of Barcelona). The R1[7], on the other hand, presented significantly lower values (27,9 million), which has even led to the creation of two possible solutions to overcome the difference of travelers in their more northern sections, with a possible connection between Mataró, Granollers .

As for the Barcelona-Girona-Portbou line refers (R11), the values recorded in the PTVC 2012 for 2006 were 1.123.264 passengers. However, this publication exposes these values are much more lower than actual, due to the heavy burden of tourist mobility not reflected.

[6] The R2-Nord line corresponds to the railway between the Aeroport del Prat and Maçanet-Massanes. For more information, see Figures 42 and 43

[7] La R1 line corresponds to the line between Molins de Rei and Maçanet-Massanes. For more information, see Figures 42 and 43

Note in *Figure 30* the great development that R11 line's demand experienced in the 1998-2004 period, becoming the largest increase of all catalan lines.

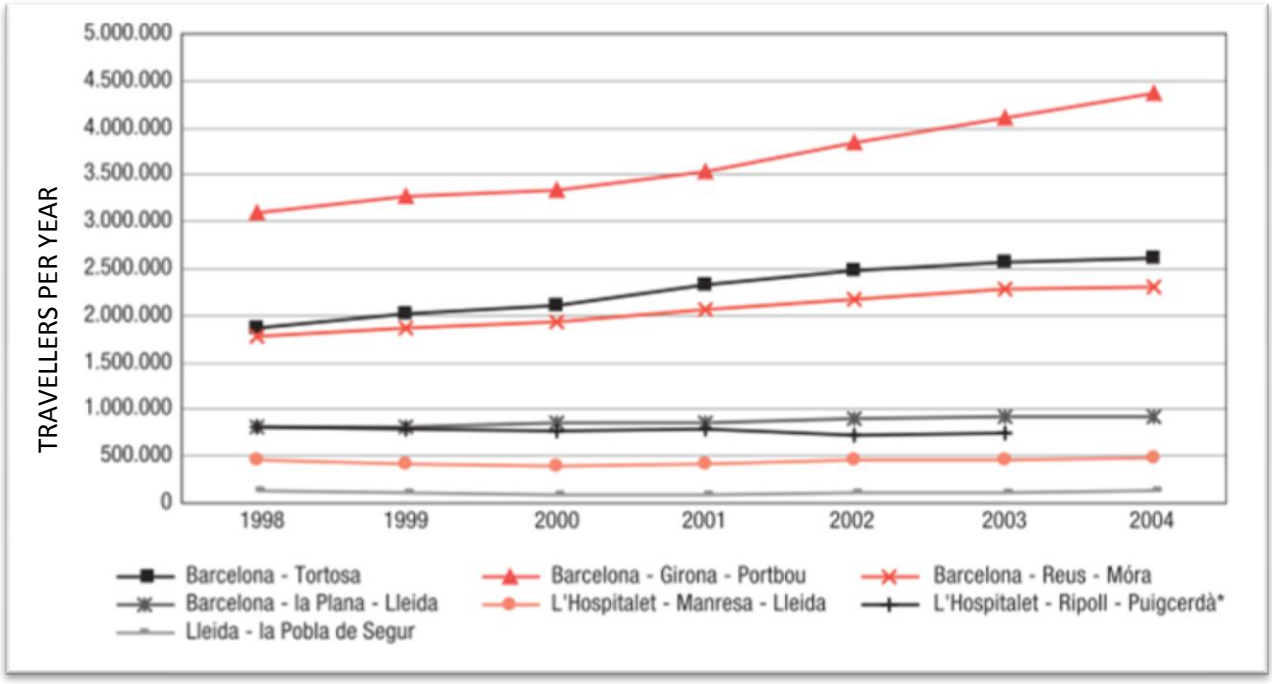


Figure 30: Evolution concerning regional railway's demand for the periode 1998, 2004.

Source: PTVC 2012.

In conclusion, the importance of Maçanet-Massanes station is notorious and well known for Catalan planners, given the significance of the lines that converge there and the potential flow of travelers that its city has. Proof of is the recent performance that has been carried out by ADIF (Railway Infrastructure Manager) to improve their conditioning. However, if you make a small study medium-distance and commuter service's operation times is checked as the synergistic effects of the connections are not properly exploited.

The following tables (*Tables 15, 16, 17* and *18*) contain schedules concerning the different circulations per day:

R11					
Barcelona-Sants →Maçanet-Massanes			Maçanet-Massanes→Girona		
DEPARTURE	ARRIVAL	DURATION	DEPARTURE	ARRIVAL	DURATION
05.56	06.53	57 min.	06.54	07.14	20 min.
06.16	07.24	1 h. 08 min.	07.25	07.50	25 min.
06.46	07.45	59 min.	07.46	08.06	20 min.
07.16	08.34	1 h. 18 min.	08.35	09.00	25 min.
08.16	09.15	59 min.	09.16	09.36	20 min.
09.16	10.24	1 h. 08 min.	10.25	10.51	26 min.
10.16	11.15	59 min.	11.16	11.36	20 min.
11.16	12.24	1 h. 08 min.	12.25	12.50	25 min.
11.46	12.45	59 min.	12.46	13.06	20 min.
12.46	13.45	59 min.	13.46	14.05	19 min.
13.16	14.24	1 h. 08 min.	14.25	14.50	25 min.
14.16	15.15	59 min.	15.16	15.36	20 min.
15.16	16.24	1 h. 08 min.	16.25	16.50	25 min.
15.46	16.45	59 min.	16.46	17.06	20 min.
16.16	17.15	59 min.	17.16	17.36	20 min.
17.16	18.24	1 h. 08 min.	18.25	18.50	25 min.
17.46	18.45	59 min.	18.46	19.06	20 min.
18.16	19.15	59 min.	19.16	19.36	20 min.
18.46	19.45	59 min.	19.46	20.06	20 min.
19.16	20.25	1 h. 09 min.	20.26	20.52	26 min.
19.46	20.45	59 min.	20.46	21.06	20 min.
20.16	21.15	59 min.	21.16	21.36	20 min.
21.16	22.16	1 h.	22.17	22.37	20 min.

Table 15: railway's Schedule operated by RENFE in its service for the line R11, Barcelona-Portbou 's direction.

Source: www.renfe.com

R11					
Girona →Maçanet-Massanes			Maçanet-Massanes→ Barcelona-Sants		
DEPARTURE	ARRIVAL	DURATION	DEPARTURE	ARRIVAL	DURATION
06.11	06.32	21 min.	06.32	07.39	1 h. 07 min.
06.26	06.48	22 min.	06.48	07.53	1 h. 05 min.
07.10	07.32	22 min.	07.32	08.39	1 h. 07 min.
07.41	08.03	22 min.	08.03	09.09	1 h. 06 min.
08.02	08.27	25 min.	08.27	09.39	1 h. 12 min.
08.47	09.08	21 min.	09.08	10.09	1 h. 01 min.
09.32	09.57	25 min.	09.57	11.09	1 h. 12 min.
10.17	10.38	21 min.	10.38	11.39	1 h. 01 min.
11.32	11.57	25 min.	11.57	13.09	1 h. 12 min.
12.17	12.38	21 min.	12.38	13.39	1 h. 01 min.
13.27	13.57	30 min.	13.57	15.09	1 h. 12 min.
14.17	14.38	21 min.	14.38	15.39	1 h. 01 min.
14.47	15.08	21 min.	15.08	16.09	1 h. 01 min.
15.32	15.57	25 min.	15.57	17.09	1 h. 12 min.
16.17	16.38	21 min.	16.38	17.39	1 h. 01 min.
17.02	17.27	25 min.	17.27	18.39	1 h. 12 min.
17.47	18.08	21 min.	18.08	19.09	1 h. 01 min.
18.35	19.00	25 min.	19.01	20.09	1 h. 08 min.
19.17	19.38	21 min.	19.38	20.39	1 h. 01 min.
20.02	20.27	25 min.	20.27	21.39	1 h. 12 min.
20.57	21.19	22 min.	21.19	22.19	1 h.
21.19	21.41	22 min.	21.41	22.39	58 min.

Table 16: railway's Schedule operated by RENFE in its service for the line R11, Portou-Barcelona 's direction.

Source: www.renfe.com

R1 and R2			
Barcelona-Sants →Maçanet-Massanes			
LINE	DEPARTURE	ARRIVAL	DURATION
R2	05:27	06:48	01:21
R1	05:46	07:29	01:43
R2	06:16	07:24	01:08
R1	06:46	08:29	01:43
R2	07:16	08:34	01:18
R1	07:46	09:28	01:42
R1	08:46	10:28	01:42
R2	09:16	10:24	01:08
R1	09:46	11:29	01:43
R1	10:46	12:29	01:43
R2	11:16	12:24	01:08
R1	11:46	13:29	01:43
R1	12:46	14:26	01:40
R2	13:16	14:24	01:08
R1	13:46	15:28	01:42
R1	14:39	16:28	01:49
R2	15:16	16:24	01:08
R1	15:46	17:28	01:42
R1	16:46	18:28	01:42
R2	17:16	18:24	01:08
R1	17:46	19:28	01:42
R1	18:42	20:26	01:44
R2	19:16	20:25	01:09
R1	19:42	21:27	01:45
R2	20:30	21:49	01:19
R1	20:45	22:30	01:45
R2	21:30	22:49	01:19
R1	21:54	23:33	01:39

Table 17: Railway's schedules for the lines R1 and R2, Barcelona - Maçanet-Massanes 's direction

Source: http://www14.gencat.cat/gencat_rodalies

R1 and R2			
Maçanet-Massanes→ Barcelona-Sants			
LINE	DEPARTURE	ARRIVAL	DURATION
R1	06:05	07:44	01:39
R2	06:16	07:36	01:20
R1	06:36	08:14	01:38
R2	07:00	08:20	01:20
R1	07:04	08:39	01:35
R1	07:34	09:13	01:39
R2	07:46	09:06	01:20
R1	08:04	09:43	01:39
R2	08:27	09:39	01:12
R1	09:03	10:40	01:37
R2	09:57	11:09	01:12
R1	10:04	11:41	01:37
R1	11:04	12:41	01:37
R2	11:57	13:09	01:12
R1	12:04	13:39	01:35
R1	13:04	14:39	01:35
R2	13:57	15:09	01:12
R1	14:00	15:37	01:37
R1	15:04	16:40	01:36
R2	15:57	17:09	01:12
R1	16:04	17:39	01:35
R1	17:04	18:42	01:38
R2	17:27	18:39	01:12
R1	18:04	19:41	01:37
R1	19:04	20:41	01:37
R1	20:01	21:39	01:38
R2	20:27	21:39	01:12
R1	21:03	22:41	01:38
R1	21:43	23:21	01:38
R2	21:52	23:11	01:19

Table 18: Railway's schedules for the lines R1 and R2, Maçanet-Massanes - Barcelona 's direction

Source: http://www14.gencat.cat/gencat_rodalies

From the data presented it is concluded that there is no clock-face schedule with a repetitive structure throughout the day, so the main suggestion is to implement an operating model based on this type of schedule, by the multitude of advantages (For more information, see the section 1.3. RAIL2000 – BAHN2000 – FERROVIA2000). The implementation of this model of operation is feasible from the standpoint of infrastructure, as station building and platforms are equipped enough (includes 6 platforms and two extra lines) and the lines are double track.

However, if the idea of a complete schedule restructuring were rejected (we insist in this recommendation), there are simple actions of lesser magnitude which also would improve the quality of supply. They are derived from the disaggregation of the flows of arrivals and departures at node as slots, and have been classified according to their nature in:

- Proposal to anticipate the arrival of certain compositions
- Proposal to anticipate the departure of certain trains
- Proposal to delay the arrival of certain compositions
- Proposal to delay the departure of certain trains
- Proposal for reconsideration of the correspondence.

Here are illustrated the different proposals. The color code is specified in *Figure 31*, in function of the line and the sense that each measure involves. Notice It has been proposed the same train for the two directions of R1 and R2 so that to maximize the use of the rolling-stock, because Maçanet-Massanes is a terminus station.

LEGEND		
BARCELONA → MAÇANET-MASSANES	R1	SAME TRAIN
MAÇANET-MASSANES →BARCELONA	R1	
BARCELONA → MAÇANET-MASSANES	R2	SAME TRAIN
MAÇANET-MASSANES →BARCELONA	R2	
BARCELONA → PORTBOU	R11	
PORTBOU → BARCELONA	R11	

Figure 31: Legend of illustrated proposals

Source: Personal compilation

EXEMPLE OF DELAY THE DEPARTURE OF CERTAIN TRAINS (Table 19)

This measure aims to extend the connections in order to have time enough for the exchange. As already stated concerning the clock-face schedule, it is desirable the correlation time from "T-t" to "T+t", to maximize the flows exchange.

ARRIVALS		DEPARTS	RECOMMENDATIONS
06.48		06.48	
06.53		06.50	To delay 5 minutes departure of this train to allow connections with R11 from Barcelona
		06.54	

ARRIVALS		DEPARTS	RECOMMENDATIONS
		08.20	To delay 16 minutes departure of this train to allow connections with R11 from Barcelona and from Portbou
08.27		08.27	
08.34		08.35	

Table 19: Example of proposals concerning the departure's delay

Source: Personal compilation

Thanks to this simple measure, all Regional network's users from Barcelona (orange) and from Girona's province (cobalt blue), would be able to move to towns located at R1 line towards Barcelona (blue) with a considerable gain of time. We must not forget that in these particular cases, compositions from Barcelona (orange) come from some hubs such as Granollers or Sant Celoni; while Regional trains from Girona (cobalt blue) stop in major cities such as Figueres. In turn, R1's railways have major coastal stations like Blanes, Calella or Mataró.

Moreover, given that during the early morning and late at night (especially) Regional trains from R11 line made the same stops than R2 lines (the composition colored with dark blue is, in fact, the same train than the composition colored in cobalt blue; and the same for red and orange ones) so these measures also would promote a substantial improvement of communications between closed municipalities but located in different railway lines (R1 and R2). This is the case of Granollers, Cardedéu, Sant Celoni, Hostalric… with towns like Tordera, Blanes, Malgrat de Mar, Calella, Vilassar de Mar,….

EXEMPLE OF ANTICIPATE THE DEPART OF CERTAIN TRAINS (*Table 20*)

ARRIVALS		DEPARTS	RECOMMENDATIONS
10.57			
11.15		11.16	
		11.24	To anticipate 7 minutes the depart of this train to reduce waiting time.

Table 20

Source: Personal compilation

In this case, the anticipation of the train's departure reduces the waiting time for users at the station. This simple factor contributes greatly improve the quality of service perceived by travelers since connection's waiting time is valued as the higher cost in multicriteria studies that pretend to model the decision procedure in terms of modal share.

EXAMPLE OF DELAY THE ARRIVAL OF SOME TRAINS (*Table 21*)

RECOMMENDATIONS	ARRIVALS		DEPARTS	RECOMMENDATIONS
To dealy 11 minutes the arrival of this train to reduce waiting time	10.04		10.20	To delay 20 minutes the depart of this train to allow the connections with R11 from Barcelona and from Portbou
	10.24		10.25	
	10.38		10.38	

Table 21

Source: Personal compilation

By applying this measure, synergistic effects would appear concerning demand share as a consequence of the travel time reduction.

EXEMPLE OF ANTICIPATE THE ARRIVAL OF SOME TRAINS (*Table 22*)

RECOMMENDATIONS	ARRIVALS		DEPARTS
	07.45		07.46
To anticípate 13 minutes the arrival of this train to allow the connection with R11 destination Portbou	07.57		08.03
	08.03		

Table 22

Source: Personal compilation

In this example, all passengers from coastal towns (with station at the R1) towards Girona and its vicinity would improve their journey's quality. It is important to note that some of these towns are already part of the Girona's province (as Blanes), so this measure would contribute, in turn, to a better structuring of Girona's metropolitan area.

EXEMPLE OF RECONSIDERATE THE WHOLE CONNECTION (Table 23)

ECOMMENDATIONS	ARRIVALS		DEPARTS
	11.50		
This train is not making any connection	11.54		11.57
	11.57		11.57

Table 23

Source: Personal compilation

As shown in Table 23, with the current configuration of connections only the exchange of travelers from R1 sense Maçanet-Barcelona (yellow) with R2 destination Barcelona (dark blue and cobalt blue) is allowed. Unfortunately, passengers coming from Barcelona by R2 line (red) have no chance to link with any other composition at Maçanet-Massanes' station (they only can go back)

On the other hand, it is interesting to note that the stopping time given by RENFE on its website for different compositions is predominantly 0 minutes. Obviously, this implies the inability to meet the schedule, so it is also suggested to retouch the information provided to users in this sense, although, it is true that the measure does not fall within the set of measures concerning the offer, since it is related to the service's reliability.

The main virtue would file a schedule's restructuration around the node Maçanet-Massanes is the fact that it involves no investment in infrastructure or rolling stock, as it uses existing assets to reach a better level of service. Therefore, its cheap implementation is particularly suitable given the present economic situation in Catalonia.

As far as expectations in terms of results on the demand side, serve as guide, the precedent set by Switzerland thanks to the coordination between project RAIL2000 and RER's services in Zurich, for this reason, the restructuring of these lines near Barcelona is considered very beneficial.

3.1.1.2. Second proposal: EL PRAT DE LLOBREGAT, A LARGELY IGNORED HUB

Similarly to what happened in Maçanet-Massanes node, rail passenger transport service has also some obvious deficiencies in its link to the El Prat Airport (main travelers' airport of the Autonomous Region and second in the Spanish milieu). In this case, it is advisable that station's ascension to "hub of connections" between the local network (R2), four regional networks (R13, R14, R15 and R16) and the access line to the airport (R2 SUD). See *Figures 32 and 33.*

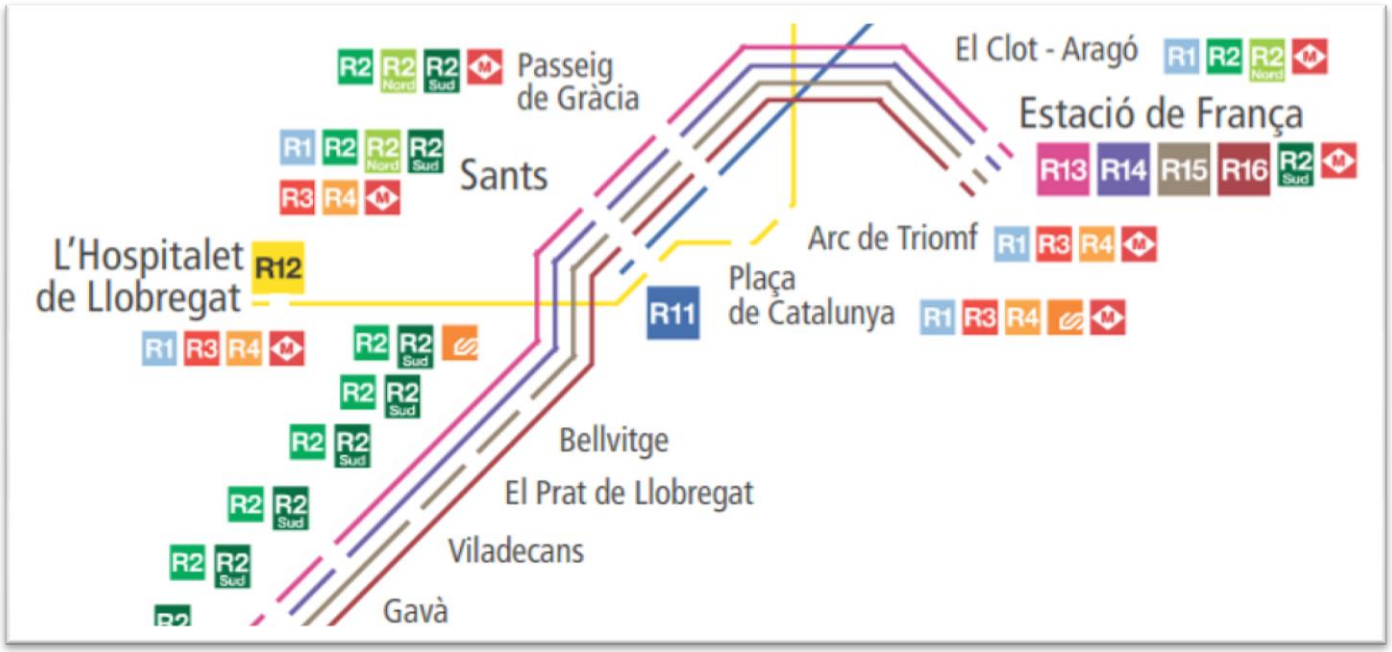


Figure 32: Map of the lines involved in the station El Prat de Llobregat

Source: http://www.gencat.cat/rodalies/planol_regional.htm

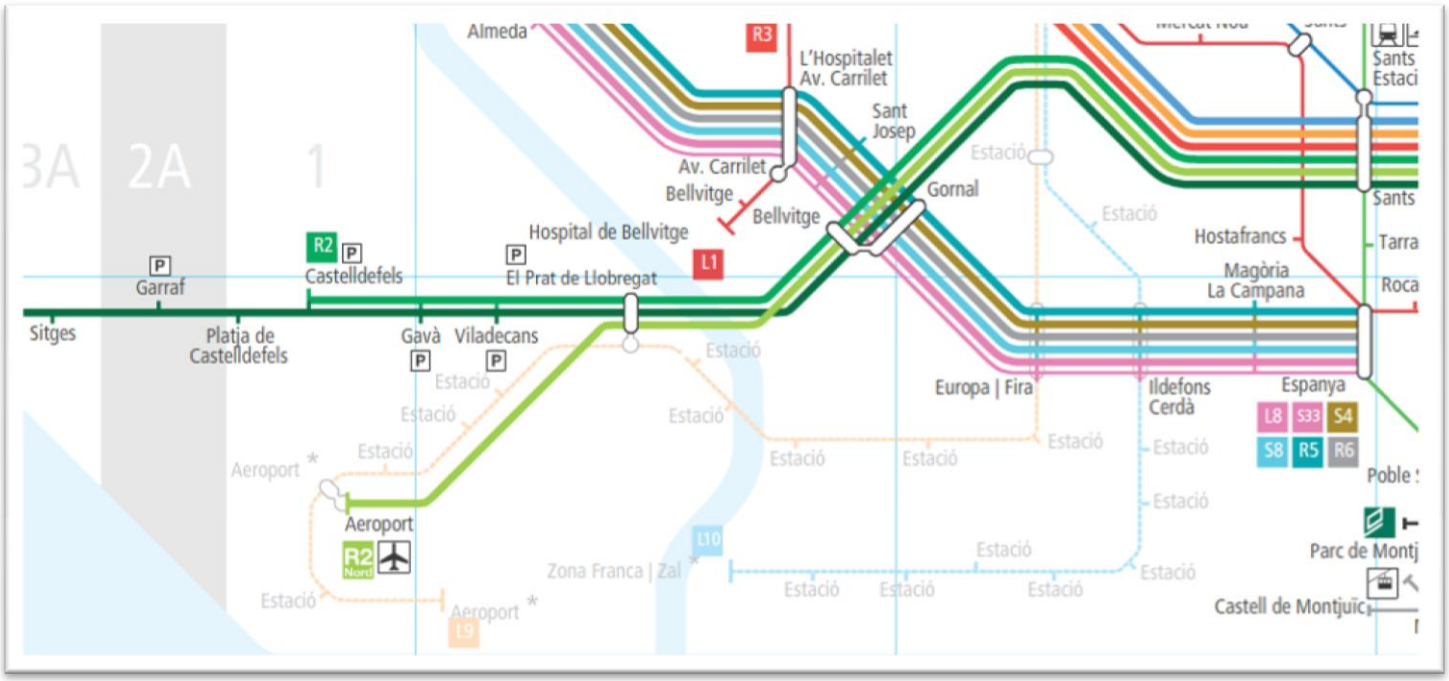


Figure 33: Map of the access line to the airport

Source: http://www.gencat.cat/rodalies/planol.htm

Traditionally it has been denied the status of "connection's hub" to the El Prat de Llobregat Station because of its proximity to Barcelona-Sants Station (main hub of Barcelona and one of the largest generators of passenger's flows passengers); however, this decision implies that all users of air-rail connection (either for suburban service and middle distances) coming from the south of Barcelona are forced to extend their journey around 30 minutes in order to arrive to Sants station (where you can make the change) and return to the station of El Prat de Llobregat, even though her previous train has passed by that station[8].

There are numerous disadvantages on the current operation policy. First, it contributes to overloading the already saturated Barcelona-Sants station, which is forced to accommodate, without apparent need, passengers from the provinces of Tarragona and Lleida seeking access to the airport by public transport. Obviously, there is also a huge setback for travelers since there is an increase in travel's time with the corresponding increase in the price, too. (longer distances).

The only advantage of the current operating model is the reduction of travel time for middle distance's trains and suburban services by not stopping at this station.

Therefore, we recommend the implementation of the hub "El Prat de Llobregat", for its multitude of benefits and because it is considered that the infrastructure is able to perform that task. In fact, according to data from the present PTVC 2012, the airport access line (R2 SUD) has one of the lowest levels of use of the entire infrastructure (just 21%). This is due,

[8] According to official "Rodalies of Barcelona"'s schedules, the travel time between Barcelona-Sants and the station of El Prat de Llobregat is 14 minutes.

in part, to the difficulty of the development of connections, which makes rail less competitive in the race for the intermodal division.

As far as policy directives are concerned, if the recommended proposal were carried out, this would follow the guidelines laid by the EU "*better railway/airport connections must be found for passenger traffic in long distance.*"[xx] (White Paper)

In conclusion, both actions are considered desirable because the improvement in operating schedules or stops made is a measure with a scarce economic impact (highly recommended given the current economic contextualization) but high impact on the level of user-perceived quality. This inevitably results in an enhancement of the use of rail transport.

Finally, it should be noted that the rail service is an intricate system (more information in 2.1 section: “Supply’s approach: System of systems”) so, any type of action on the operation model of a line affect inevitably the rest of lines, therefore to carry out a further study on the feasibility of implementing these improvements, it is imperative to expand the domain of study to the entire railway network of Catalonia.

3.1.2. BUS-RAILWAY CONNECTIONS: Third proposal: BUS STRATEGIC VALUE

The perception of mobility as a transportation system which involves sub-systems of transport implies the possibility to improve connections also at intermodal milieu; in this sense, the role played by public road transport's agents (buses and coaches) is decisive, largely due to the flexibility of its supply and its great adaptation to the geography.

In this regard it is interesting again applying the learned lessons from Swiss transport policy and especially RAIL 2000 + BUS2000, where the idea of a blend between the two services generates the expansion of territory's coverage. Indeed, among the main virtues that the complementary rail-bus offers, we find:

- Substantial increase in coverage of public transport network because of the vast road network (buses' infrastructure). In Catalonia's case, this point has a particular interest since a fast development of road network took place as a consequence of its classical transport policy.
- Greater flexibility in public transport's supply. This occurs in territory and in capacity issues. On the one hand, the adaptability to geography of the road's infrastructure is much larger than railway's infrastructure, so network's resulting meshing is superior. On the other hand, the access to network is easier for road transport and rolling stock has more sizes. (This last point means compositions' dimensions are better adapted to actual demands)
- Possibility of restructuring the railway services. Some railway's loss-making services can be replaced by bus services, so that train's paths are freed for other uses such as freight’s transport.
- Foreseeable increase of public transport's market share over the private road transport in terms of intermodal competition. Obviously, this implies a strong improvement in sustainability.

- In case of problems at the state level with the electricity's production, buses/coaches have a wide range of propulsion systems.

Therefore, we strongly recommend developing and operating specific plans for establishing connections between both modes of transport in major railway hubs. It should be stressed that in terms of rail / bus connections some aims have already been proposed in current PTVC 2012 , however, virtually nothing has been done .

For boosting connections it is essential ensuring good bus stations in the vicinity of railway stations, to facilitate their development. On the other hand, it is interesting tariff unification and integration of the service, as well as performing certain actions on the road network to facilitate buses circulation (this is basically the performance of HOV lanes and the adaptation of the signaling to give preference to its circulation).

Undoubtedly, the proposed measure has the legal backing of both EU and the Generalitat de Catalunya, who express through their official documents:
"*Greater integration of modal networks will lead to better modal choices: more connections between airports, ports, rail, metro and bus. Online information and reservation systems and electronic payment covering all vehicles must facilitate multimodal trips. The wider use of public transport modes will be accompanied by an appropriate set of passenger rights.* "[xxi](White Paper)
"*To promote complimentarily of rail and bus services to improve current services, creating new ones, coordinating their schedules and at the same time, developing services with fewer stops and higher commercial speeds*"[xxii] (PTVC 2012)

Concerning benefits of the implementation, it is interesting the fact that a bus can transport the same number of people than 13 cars, but it just occupies the space of three on road. Furthermore, as UIC points in its publication "Transport energy and CO2": "*Buses are very efficient in terms of fuel used per passenger-kilometre. Even at half or one third capacity, buses typical use far less fuel per passenger-kilometre tan car*".[xxiii] Which means their environmental effects have very positive aspects.

Moreover, the economic viability of a bus service is assumed even for low levels of occupancy (20-30%) according to PTVC 2012, so recommendation's viability is certainly very affordable.

4. CONCLUSIONS

This study is intended to learn from the Swiss passenger transport policy in general, and particularly for rail. In this sense, the lessons learned are numerous, although the main conclusions can be summarized as following:

1.- Society needs a commitment on the part of planners and leaders to their fellow citizen when they make decisions about investing public money for the society's benefit. The starting point is the willingness to meet a real need of citizens' mobility and therefore, the measures taken should be in line with planning a shuttle service that responds to these needs by offering multiple solutions of mobility from an as much as possible profitable perspective. For this reason, the aim should be an integrated public intermodal transport service which maximizes the possible connections between various transport agents. Obviously, the solution must pry maximum coverage both, in spatial domain and in time, leading to the establishment of a clock-face schedule. The role that this planning and management tool plays is key to maximize the community's benefits of an investment. As has been contrasted to the case of Switzerland by studying the results obtained by RAIL2000's project, the implementation of a clock face schedule exceeds the primary objective of planning a service (which is simply to meet the society mobility needs) as its positive effect on society is also reflected in economic issues (revitalizing the economy by the GDP growth), territorial (bringing social and economic country's hubs thanks to reduced travel times) and social (promoting more sustainable mobility patterns)

In parallel with planning adequate public transport's supply measures, it is convenient adopting certain legislative measures to boost the demand. Following this guideline, the Swiss government has worked over the past decades (and specially, simultaneously with the implementation of project RAIL2000) in taking measures to encourage demand through its influence on modal split. These are the measures concerning intermodal competition. For better understanding, it is essential to conceive transportation as a system composed of multiple subsystems that correspond to different means of transport. Undoubtedly, legislative penalties influence inexorably in citizens when they choose their mean of transport. In turn, it is interesting to note that these guidelines are now heavily promoted by the EU, too, and a good example lies in the publication of its recent White Paper. The main measures used in this regard focus on the imposition of taxes on fuel and circulation prices (road pricing), but they are also especially interesting the effects of land policy (use of land).

2.- As much important as transport leaders' work is the role that society plays to promote the use of each mean of transport. At the end of the day, the mobility is the aggregate of the individual decisions that each one makes on whether or not to move and the suitability of each means of transport. Thus, the revitalization of the rail market and the entire chain of public transport in general, should be driven also by citizens, who being aware of the environment's limitations would choose to embrace more sustainable mobility patterns.

3.- Finally, once you have carried out the planning and the implementation of a particular transport service, the correct management at operation level is essential to achieve the expected market share. In this sense, the reliability of the system, the time spent, the frequency of service and comfort play crucial roles in Swiss model, and a good example of this fact is RAIL2000 slogan: "*plus rapide, plus frequent, plus direct et plus confortable*"

Swiss experience and its great success, as well as impressions from the nowadays leading transport policy personalities teach certain measures directly applicable to the Spanish railway paradigm. Specifically, comparable is Swiss national service and Regional public transport in Catalonia (predominantly rail) so, some actions are strongly recommended. These measures propose the enhancement of public transport use through the adoption of RAIL2000+BUS2000's operating model which is essentially the introduction and improvement of clock-face timetable with connections between different sections of rail and bus/coach. Obviously, an operating system focused on connections implies the supremacy of network's hubs on its edges, which effectively translates into a more important scenario the role played by stations. Consequently, it has been proposed to improve the connections between railway compositions and also between them and coaches, with a further study of some stations listed as priorities for Catalonia's network. This is the case of Maçanet-Massanes (station with lines R1, R2 and R11) and El Prat de Llobregat (junction between R2, R2-sud (airport), R13, R14, R15 and R16). In this regard, it is particularly interesting the amplifier character of these measures while with a minimal alteration to the operating schedule (which means identical infrastructure and superstructure) can offer a much higher quality of service through reducing users' total travel time and waiting time. From this point of view, it is concluded that improving the quality of a service is not incompatible with economic adjustment since professionalism and responsibility are the most important aspects.

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