Light Rail in Switzerland: Case Study of Bern Suburban Area

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Bern, the capital of Switzerland, has only 330, 000 inhabitants. It has preserved a comprehensive streetcar and bus network within the historic city. Some suburbs are served by a separate four-line light rail transit (LRT) system, which has been upgraded progressively during the past 30 years and today enjoys a high level of technical and operational success. Thanks to the flexibility of LRT, investments could be concentrated on the sections that needed them most. Special operating concerns were increasing speed and reducing the demand on rolling stock. A new type of car with a partly low floor and enhanced comfort level was introduced in 1993. In the last 10 years, the share of commuter traffic to the city (modal split) improved from 50 to 60 percent. Popular concern about the environment motivated the issue of cheap season tickets throughout Switzerland. This national policy, coupled with the unbalanced peak and off-peak loading patterns typical of metropolitan transit systems, means that LRT fares do not cover all of its costs. Even so, fares cover 60 percent of operating costs.

Although it is one of the world's wealthiest countries, Switzerland has never stopped emphasizing public transportation. The share of the market captured by public transportation is given in the following table:

Segment	*Share (%)*
Nationwide	18
In cities	30–50
Peak hour toward central business district (CBD)	50–80

Reasons for these statistics include the following:

- *Topography.* Towns in valleys and along rivers and lakes are lined up like pearls on a string. One single line of bus or rail can serve these locations economically.
- *Comprehensive network of public transport.* Thanks to federal, state, and local subsidies, not only cities and their suburbs, but all towns and all tourist resorts can be reached by public transportation.
- *Land use planning.* Offices are still mainly in the central business districts (CBDs) of cities. Housing areas have greater density than they do in the United States.
- *Environmental concern.* Switzerland—a typical tourist country—has always been concerned about its environment. As more dead trees in the European forests were detected after 1980, a green movement emerged within most political parties. Voters did express their wishes for better public transportation through popular referendums (*1*).
- *Social behavior.* Even the most prestigious Swiss bank managers use clean and reliable buses, streetcars, or trains to go to work.

The Swiss rail network is summarizing in the following table (2):

Rail Network	*Length (km)*	*Passengers per year (millions)*
Standard gauge	3 707	318
Meter gauge regional	1 402	78
Meter gauge local (streetcar)	181	365

Most meter gauge rail lines may be regarded as light rail transit (LRT), although a great variety exists. In the cities of Basel, Bern, Geneva, and Zurich, streetcars run mainly on the road surface. But in mountain regions, locomotive-hauled electric trains with up to 12 coaches operate on a 375-km meter gauge network. Because they have aluminum bodies, these 16-m-long coaches weigh only 15 T, so this system may still be called light rail. Between these two extremes, there are all intermediate types of LRT for suburban, regional, and even rural services.

LRT lines have been improved step by step, according to available financial resources and operational needs (e.g., separation of tracks from roads). Because of the adaptability of LRT, only a few rail lines had to be closed. However, the scope for new lines is small: in 1992 Lausanne opened an LRT line on a totally segregated alignment (but with at-grade crossings), connecting the city center with suburbs and a new university. In 1995 Geneva is opening a second streetcar line.

The main activity lies in technical and operational improvements. Three features now adopted worldwide were developed in Switzerland:

1. *Open access.* Ascom-Autelca and Sadamel installed in the late 1970s ticket vending and canceling machines at every stop of the streetcar lines. This is now common practice even on regional and suburban trains of the Swiss Federal Railways (heavy rail).
2. *Low-floor streetcars.* The first modern low-floor car was introduced in 1987 by the Swiss manufacturer Vevey Technologies on the Geneva system. This idea has spread to France and Germany as well as to the bus industry.
3. *LRT and bus priorities at traffic lights.* Such priorities were already commonly used during the 1970s (3). In addition, Switzerland was the second country after the Netherlands to adopt coordinated regular interval time tables for all intercity and regional rail services and most connecting bus services on a nationwide basis.

Bern

Within a metropolitan population of 330,000, the city of Bern itself has only 130,000 inhabitants but offers the same number of jobs, mainly in offices. The CBD has a medieval layout. In a circle of 1-km radius around the main station, there are a first-class shopping center and 60,000 jobs but only 6,000 public and private parking spaces. In several referendums, voters have accepted a very constricting parking policy to reduce traffic and maintain ecological goals (4).

The table presents a summary of public transportation in the Bern area:

Mode	*Approximate Journeys per Year (millions)*
Local streetcars and buses	125
Standard gauge commuter rail (excluding intercity trains)	19
Meter gauge commuter rail (LRT)	18
Regional buses	7

Approximately 40 percent of all journeys in the conurbation are made by public transportation. The number of rides by public transportation per capita each day is approximately 1.4 in the city and 0.8 in the suburbs served by LRT.

Bern Suburban LRT

History of Regionalverkehr Bern-Solothurn (RBS)

Four meter gauge LRT suburban lines were opened between 1898 and 1913. They all entered the city on local streetcar tracks on the surface; the cars looked like narrow U.S. interurbans. Although private car ownership grew very fast after World War 2, ridership on these lines grew, too, because of suburban development, limited parking space in the city, and a frequent train service with well-located stops. The growing private traffic and the long trains in narrow streets and on busy at-grade crossings interfered with each other more and more over the years.

Modernization

In the 1960s, a comprehensive modernization program started that was financed and implemented step by step. After each step, taxpayers could assess the progress. The flexible adaption of LRT technology enabled the effort to be directed first to the sections nearest the city center, where traffic volume was highest and improvements were most urgent. In 1965 a tunnel was opened to the city center (main station) for the two most heavily used lines (like the Blue Line entrance to the Los Angeles CBD). In 1974 a third line was diverted into this tunnel, so that today only the fourth line, which is of more streetcar character, still runs on street trackage into the city. The first three lines now run on exclusive right of way, although there are still some mostly full-gate-protected at-grade crossings in the suburban and interurban area. Outside the common trunk route, most sections are single track, although there may be up to 16 trains per peak hour (standard is 8 trains per hour).

In the past 30 years ridership has doubled, from 9 million to 18 million per year. The fare-box recovery rate is approximately 60 percent (operational costs including track renewal).

Elements of Success

Several aspects of Swiss LRT—which may differ from U.S. practice—are described:

- The tree principle (cooperation of rail and bus),
- The cascade principle (adaption of rail service to demand on longer suburban lines using zone express scheduling),
- The drop-and-catch principle (coupling and uncoupling of rolling stock en route),
- The novelties-without-risk principle (low-floor rolling stock with standard trucks),
- The subway principle (layout of the vehicle entry vestibule), and
- The diversity principle (different seating layouts).

All of these elements were copied from other rail operators and developed over the years to fit like a puzzle and create an attractive and economic way of operation.

Tree Principle

RBS's service philosophy can best be explained by the tree symbol (Figure 1): a *trunk* (rail, which has a big

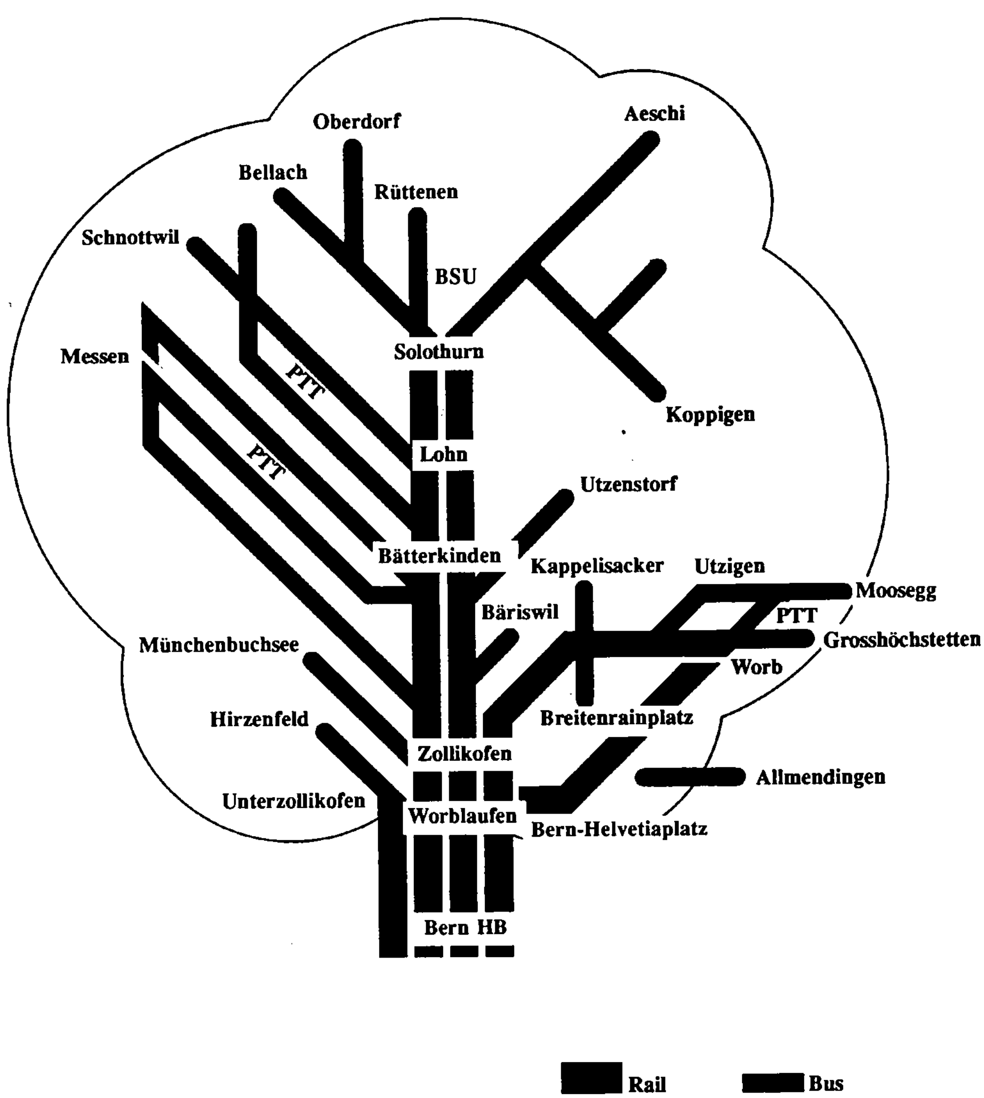

FIGURE 1 Network tree.

capacity but is expensive) can live only if it is fed by *roots* (urban streetcars and buses) and *branches* (suburban and rural feeder buses). Following this principle, RBS created new bus lines with local grants and connected them as closely to the LRT as possible (timetable coordination, through-ticketing, and cross-platform interchanges between rail and buses) (Figure 2).

Cascade Principle

To serve the Bern-Solothurn corridor, RBS has adopted the same practice as the French railways for the Paris suburban area. The corridor is divided into three sections (Figure 3). The first type of train serves the inner suburban area; the second type serves the outer suburban area, not stopping in the inner suburban area; the third type is the interurban, running nonstop to the end of the outer suburban area. This type of service has two advantages:

1. *Economy of rolling stock.* Passenger demand on suburban lines is extremely one-sided. Starting at the city-boundary end, demand is at the maximum, whereas on the last section of the line, only a few passengers are still on the train. Instead of conveying many long trains to the end of the line (or running more frequent services with LRT), the cascade principle caters to the demand on each section and therefore economizes rolling stock (and sometimes staff).

2. *Increase of speed.* Approximately 1 min is gained by leaving out one stop. Therefore, the interurban service between Bern and Solothurn has a commercial speed of 54 km/hr, compared with the standard 35 to 40 km/hr on the suburban services that stop every 1 to 1.5 km. Thus, the cascade principle economizes a further train set, plus it gains time for passengers.

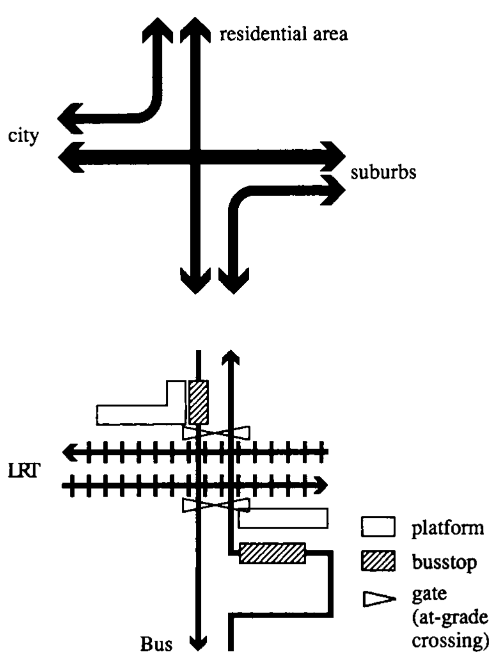

FIGURE 2 Bus-LRT interchange: *top*, main traffic flows; *bottom*, layout (Papiermühle/Bern).

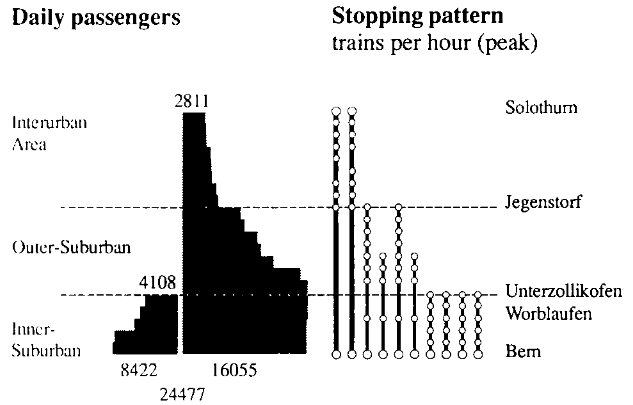

FIGURE 3 Traffic demand and stopping pattern.

Drop-and-Catch Principle

On another line, RBS must run six-car trains on the first section because of capacity needs, but the length of passing tracks and platforms on the outer section limits train length to four cars. At a station before the middle of the line, passengers disembark from the last two cars on the train from the city; these two cars are dropped and the train continues as a four-car set [Figure 4(*top*)]. Passengers bound for the city may already begin boarding the stationed two-car set. Some minutes later, the next inbound train enters the same station track, couples to these two cars, and departs as six-car train toward the city [Figure 4 (*bottom*)].

Thanks to a modern, fully automatic coupling system (+GF+) with remote-controlled uncoupling and braking test, uncoupling consumes only the standard 20-sec stopping time, and coupling and changing of cabs happen within 30 to 50 sec, both without any extra staff.

Novelties-Without-Risk Principle

A 30 percent increase in the number of passengers from 1985 to 1991 made it necessary for RBS to purchase

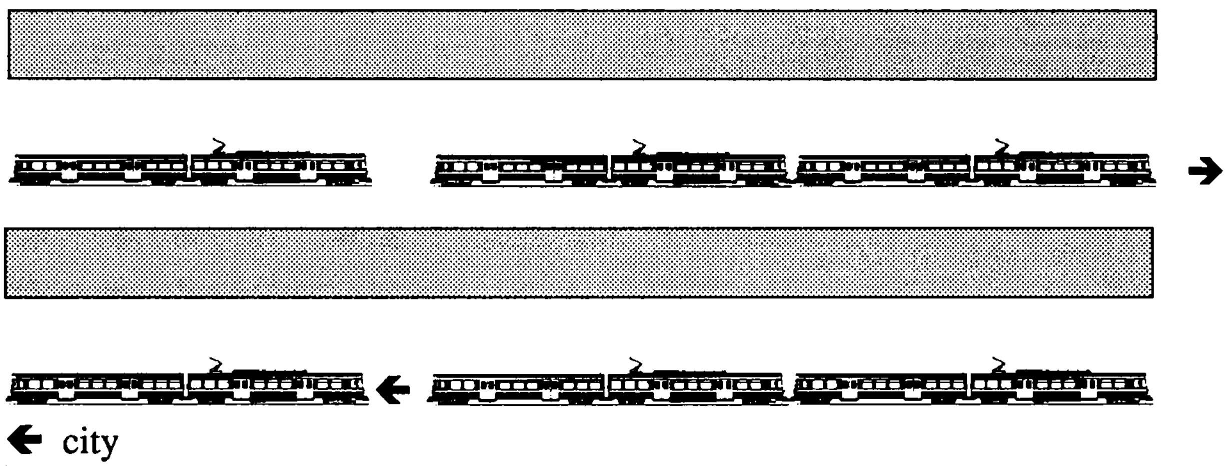

FIGURE 4 Dropping and catching train segments: *top,* from city; *bottom,* 5 min later.

more rolling stock. Schindler and ABB delivered 23 twin-car sets in 1992–1993 to three Swiss suburban railways (11 to RBS). Eight unpowered intermediate cars to form three-car sets were manufactured in 1994 for RBS.

Swiss rolling stock must run for at least 40 years, so a farsighted modern concept had to be chosen. Without

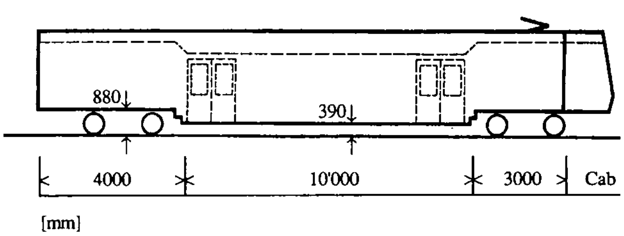

FIGURE 5 Low-floor railcar (half unit).

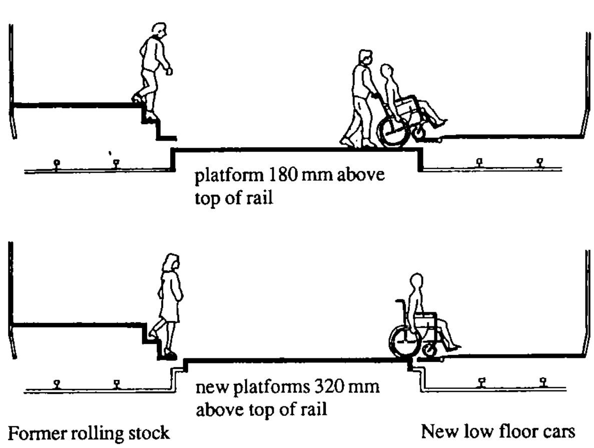

FIGURE 6 Platform heights and access to new rolling stock.

a prototype, however, and with only a few technical staff members, RBS could not take a great technological risk. Therefore, an innovative low-floor concept was selected, but with standard trucks. Sixty percent of the car length is low-floor—39 cm above top of rail (TOR) (Figure 5).

From standard platform height (18 cm TOR), parents with baby carriages as well as most passengers with disabilities (even in light wheelchairs) have easy access to the train. Furthermore, in the future, raised platforms (32 cm TOR) will make the train accessible even for people in heavy electric-driven wheelchairs (Figure 6). These provisions are being made even though in Europe there is no legal equivalent to the United States' Americans with Disabilities Act.

Subway Principle

In the subway principle, both doors are placed in the low-floor part. The "vestibule" is designed according to urban rail principles: an unobstructed space (Figure 7),

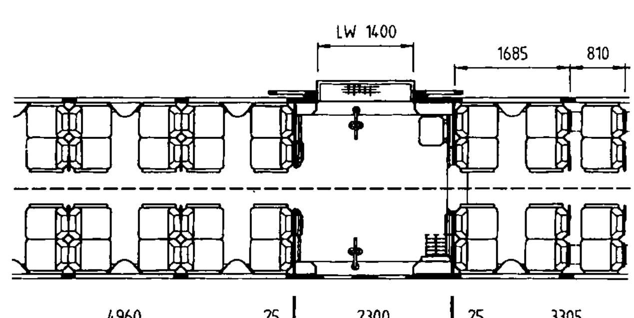

FIGURE 7 Vestibule of new rolling stock.

which can be used for different costumers' needs according to the changing travel hours (e.g., enough space for standees, baby carriages, luggage, and ski and bike storage). The most important and often neglected need is enough room for standees on both sides of the doors, so that standing passengers do not obstruct the entrance. Between this vestibule and the seating area is a glass partition to provide an unobstructed view of the entire car and to show entering passengers the location of free seats. This concept was introduced during 1973–1978, when 21 twin sets were bought for suburban traffic. It proved successful, particularly to deter vandals.

Diversity Principle

To attract automobile drivers as transit passengers for rides up to 20 mi or 37 min, comfort must be better than that of spartan LRT vehicles. But what is comfort? Every passenger has his or her own preferences. Therefore, the new rolling stock offers, in the same body shell, different elements catering to different desires:

- First- (interurban only) and second-class accommodations,
- Nonsmoking and smoking sections (second class only),
- Seats back to back and one behind the other,
- Accommodations with and without tables, and
- A study compartment (no noise).

These combinations give a total of nine different seating layouts. Regular passengers select their seats according to personal preference. It is a pity that such variety, which gives trains an edge over buses, is seldom adopted.

In the same line of thinking, the basic twin set (ideal for inner-suburban service due to good acceleration) can be enlarged to a triple set by adding an intermediate car (without motor drive) (Figure 8). So triple sets—which are cheaper per seat—are formed for interurban service, where lower acceleration is less of a disadvantage because there are fewer stops (Table 1).

The main new technical features of the low-floor cars include

- AC drive (ABB),
- Light alloy body (Schindler), and
- Trucks with pneumatic suspension (SIG).

To reduce the risk of squeaking noises and the higher operation costs in later years, the cars have no articulation. The main feature, however, is the ability of a single staff member to operate six-car trains (120 m including 348 seats and 400 standing passengers).

Conclusions

Between 1985 and 1991, the number of LRT passengers in Bern grew by 30 percent. The modal split of commuters from the suburbs served by LRT to the city grew from 50 to 60 percent between 1980 and 1990. During the same period, traffic volume on many roads remained stable, although the population of the suburbs grew steadily. This success is based on

- Land use planning coordinated with public transportation, especially rail stations;
- Restricted parking policy, first in the city center but now also in the suburbs;
- An attractive offer of public transportation (e.g., coordinated rail and bus schedules and tickets);
- Enhanced passenger comfort to attract automobile drivers: easy access (low-floor) trains and a choice of seating layouts.

This success in gaining passengers unfortunately is not reflected by a smaller deficit: with heavy peak loads and fewer off-peak passengers on one hand and the political pressure to offer cheap commuter tickets on the other, it is impossible to balance the account. But the fare-box recovery rate of 60 percent is far better than

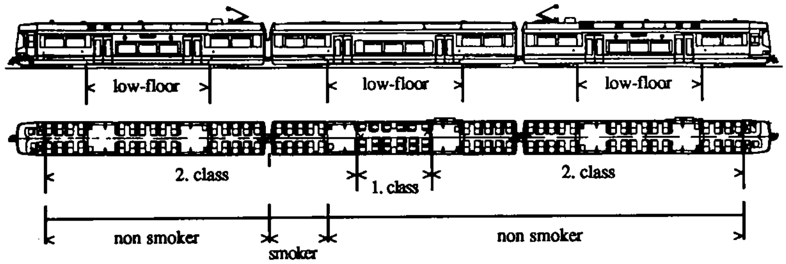

FIGURE 8 Different interior layout of triple set.

TABLE 1 Main Technical Data

	Twin-Set		Triple-Set
Nominal line voltage (direct current)	V	1200	
Maximum gradient	%	4.5	
Minimum curvature	m	50	
Axle arrangement	Bo'2 + 2'Bo		Bo'2+2'2'+2'Bo'
Mass in running order	t	58	80
Number of seats 1st/2nd class		0/120	18/156
Number of traction motors		4	
Continuous rating at motorshaft	kW	640	
Starting tractive effort at wheel rim	kN	107.5	
Maximum power rating at wheel rim	kW	1114	
Maximum speed-operating (design)	km/h	90(100)	
Length over automatic coupler	mm	40000	59730
Overall width	mm	2650	
Door width	mm	1400	
Distance between trucks pivots (one vehicle)	mm	14000	
Truck wheel-base for motor trucks	mm	2000	
Truck wheel-base for unpowered trucks	mm	1800	
Diameter of wheels	mm	720	

that of most heavy rail systems and, thus, further proof of the economy of LRT systems (*6*).

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