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Intercity Rail Fixed-Interval, Timed-Transfer, Multihub System

Applicability of the *Integraler Taktfahrplan* Strategy to North America

ROSS R. MAXWELL

The *Integraler Taktfahrplan* (ITF) strategy for coordinating intercity rail and other modes at multiple timed-transfer hubs is described. The ongoing Swiss experience in establishing a countrywide ITF system is presented, and the ITF strategy is applied to North America, using a region within the United States. The Swiss Rail + Bus 2000 Plan will bring all intercity public transportation modes into a comprehensive fixed-interval, timed-transfer, multihub system, including high-speed intercity trains, regular intercity and regional trains, buses, ferries, and funiculars. Timed connections with urban transit systems will be provided. The repeating schedule, associated with the ITF strategy, allows for two powerful analysis and communication tools: (a) a schedule map and (b) symmetrical train graphs. The schedule map helps planning, marketing, scheduling, engineering, and operations work together as they iteratively design the system. The map, which graphically combines routes and schedules, is easy to understand and sell to policy makers and the public. Symmetrical train graphs help with the detailed engineering and cost-benefit analyses. The ITF strategy first develops the schedule on the basis of the potential market and then selects the most appropriate mode and infrastructure improvements to make any required travel-time savings needed for the timed transfers. Because a view of the system as a whole is provided, the benefits of a large capital investment or an ongoing operating subsidy can be properly weighed. For intercity passenger rail, this strategy provides a way to capitalize on the existing rail resources in a cost-effective manner: to build and fund only what is needed, but also to build and fund what is truly needed.

The importance of a fully integrated public transportation system, where passengers can easily transfer between different routes and modes, cannot be overstated. Just such an integrated public transportation system is being implemented in Switzerland, Austria, the Netherlands, and parts of Germany. This fixed-interval, timed-transfer, multihub system, using intercity rail as the backbone, can integrate all modes, including high-speed trains, maglev, local and regional trains, buses, urban transit, ferries, and in Switzerland cable ways and funiculars. In German it is called *Integraler Taktfahrplan* (ITF) from *Integraler*: integrated; *Takt*: heartbeat, musical beat, or the steady pulse of a fixed-interval schedule; and *Fahrplan*: timetable or schedule, from *fahren*: to ride—hence, “ride plan.”

In the United States and Canada, the intercity surface public transportation system, especially the passenger rail system, has become fragmented. As an insidious consequence, a sense of the whole has been lost. Typically, neither highway nor passenger transport planners look at the whole; rather, they tend to plan one project or corridor at a time, with systemwide planning consisting of ranking the various corridors in order of importance. Highway planners, unlike public

transport planners, do not need to consider the whole, since roads and streets already form an interconnected system, and a highway user can traverse the entire system of roads at will. Therefore, highway departments can plan one project at a time and in the process improve the system incrementally.

Passenger transport, however, has the added burden of coming in discrete components of buses, trains, and ferries, on predetermined routes and schedules. Travel to many destinations may require a transfer or transfers, making schedule coordination crucial. Given these network effects, an incremental approach to passenger transport planning may miss those critical interconnection opportunities that are apparent only when the whole system is viewed.

For example, is it worthwhile to invest U.S.\$300 million to save 6 min of travel time? Only by seeing such a project’s place as part of the whole can one understand its importance. That is to say, if saving 6 min means that an important transfer connection can be made, then it may very well be worth it.

This paper describes a way to analyze, design, schedule, and market a passenger transportation system as a whole. It has three parts:

1. A general discussion, from a systems point of view, of transfer strategies—the different ways fixed-schedule passenger transport components can be integrated into a comprehensive system, including the ITF strategy;
2. A discussion of the experience of the Swiss Federal Railway in planning and implementing its intercity rail ITF multihub system; and
3. A demonstration of the applicability for passenger rail of the ITF strategy for North America using one region within the United States—Northern California—as a case study.

TRANSFER STRATEGIES

The trade-off for any public transport system with fixed routes and published schedules is how to concentrate enough passengers on a bus, plane, train, or ferry to justify making a trip, while at the same time providing enough trips per day to attract potential passengers. There are four basic transfer strategies to connect separate routes into a more complete system, thereby maximizing potential patronage for each trip:

1. Close headways,
2. Mainline trunk with timed-transfer branch lines,
3. Hub-and-spoke system, and
4. Fixed-interval, timed-transfer system.

These transfer strategies include three different types of timed transfers. A public transport system may use a combination of these strategies.

Close Headways

The first strategy is for all routes to have headways (the scheduled time between successive trains or vehicles) sufficiently close so that the transfer wait times between routes are tolerable without attempting to schedule transfers (see Figure 1a).

Strengths

- Multiple transfer opportunities are created, with minimal out-of-the-way travel.

- The schedule for each route can vary throughout the course of the day and week as needed to handle the passenger demand.
- Since the wait times to transfer between routes are tolerable, it is possible to plan one link or corridor at a time. In this sense, public transport planning is like highway planning, and the system can be improved with incremental projects without reference to the whole.

Weaknesses

- This strategy can work for dense urban areas, but not for inter-city travel, since the headways are typically too long, making the transfer wait times too long.
- The same applies to urban areas during nights and weekends, when headways lengthen, as well as for suburban areas, where the typical 30-min or 1-h headways weaken the attractiveness of making a transfer.

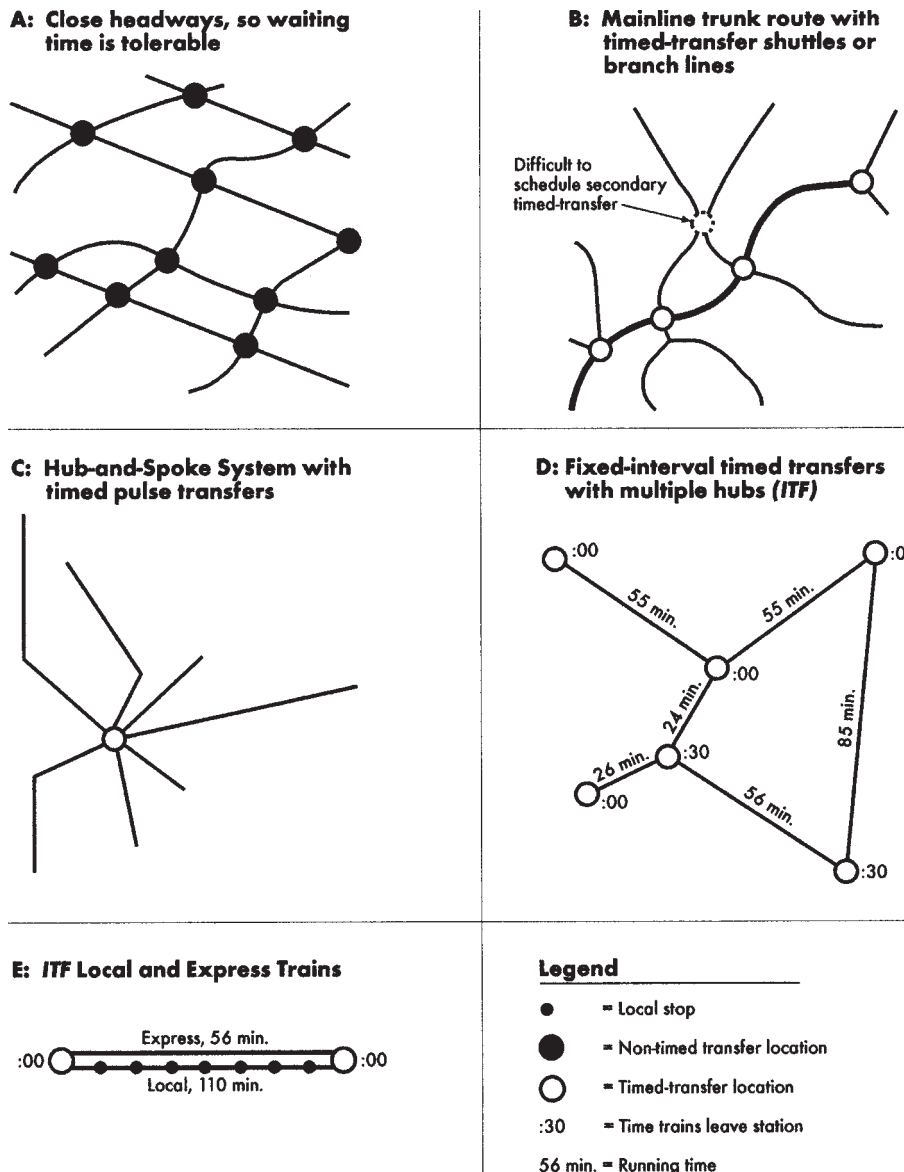


FIGURE 1 Fixed-route transfer strategies.

Mainline Trunk with Timed-Transfer Branch Lines

The second strategy is to have a trunk line or mainline service with timed-transfer feeders or branch lines (see Figure 1*b*). The schedule relationship is hierarchical, with the branch line service timed to match the mainline schedule.

Strengths

- The feeder lines add passengers to the trunk line, making it more cost-effective; by themselves, the feeders may not be cost-effective.
- A branch line bus can wait for a late mainline train, thus guaranteeing a transfer; an example of this system is the Amtrak Thruway Motorcoach connections.

Weaknesses

- The typically irregular spacing of the mainline transfer stations makes it difficult to schedule timed transfers between the branch lines themselves, even if the mainline service is reliable, thus limiting this system to a corridor.
- To the extent that the mainline service is unreliable, guaranteed transfers limit the usefulness of branch lines to provide scheduled public transport service in their own right.

Hub-and-Spoke System

The third strategy is the hub-and-spoke system with timed transfers, which is used by airlines and some urban public transit systems (see Figure 1*c*).

Strengths

- The system provides passengers with multiple destinations while minimizing the delay and hassle to that associated with a single transfer.
- For airlines, the hubs concentrate a sufficient number of passengers for each city, so that each city can be served with more flights per day.

Weaknesses

- Out-of-direction travel is necessary for some trips.
- For airlines, the wide variation in travel times between cities limits the number of viable hubs.

Fixed-Interval, Timed-Transfer System (ITF Strategy)

The fourth strategy, the ITF strategy, uses a fixed or constant-interval schedule to establish timed-transfer pulses at multiple hubs (see Figure 1*d*). The fixed-interval schedule can also establish timed transfers for local and express trains along the same route (see Figure 1*e*). In parts of Europe, the ITF strategy has been used to establish full integration of all surface public transportation modes (1). In North America, this strategy has been used in the United States with some

urban transit properties to develop multiple transfer hubs (2,p.36;3,4). The advantages and disadvantages of this strategy for intercity travel and intraregional travel are discussed in the remainder of this paper.

COMPARISONS

Rail-Based ITF Versus Airline Hub-and-Spoke Systems

For intercity travel, a rail-based ITF system has advantages compared with an airline hub-and-spoke, timed-transfer system. Airlines, subject to the vicissitudes of weather and limited runway capacities, require extra time in their schedules to assure hub connections. In contrast, all-weather rail systems can be fine-tuned to allow passengers to make reliable connections without excessive delay. For airlines, the wide variation in distances and travel times between cities limits the number of viable hubs; with railroads, travel times can, at a cost, be shortened, thus increasing the number of cities used as transfer hubs. Airline hub systems are weakened by direct flights between major city pairs that bypass hubs. In contrast, trains between the major markets can benefit other travelers, since, unlike an airplane, a train can stop at intermediate hubs without an excessive time penalty for through passengers. With each additional hub, more towns and cities become connected to the timed-transfer system, increasing the size of the market. The larger the market, the more frequent the service, making the system even more attractive.

An ITF multihub system also allows for full integration of different carriers and modes, and thus for a more efficient use of resources. For example, Amtrak might eliminate some of its own Thruway Motorcoach connections, since buses or trains from some other agency might provide this connection as part of a comprehensive timed-transfer system.

ITF System Versus Mainline/Branch Line System

A basic difference between an ITF system and a mainline/branch line system is that the ITF hubs have a regular spacing that matches the all-day-long, constant-interval schedule; a mainline/branch line system can have irregularly spaced transfer locations and a varying schedule to meet the demand. On a corridor basis, in terms of both initial and operating costs, a mainline/branch line system is potentially cheaper, but at the price of being confined to that corridor. On a systemwide basis, however, the ITF system has the advantage. It can cost-effectively serve a multicentered region with multiple hubs, leading potentially to a much higher overall patronage.

It is possible to convert a mainline/branch line system into an ITF system by regularizing both the schedule and the transfer locations along the trunk. Regularizing the schedule means establishing a constant-interval schedule that repeats throughout the day, such as trains every hour. Regularizing the transfer hub locations means to think in terms of the overall travel time (running time plus station dwell time) between transfer hubs rather than in terms of the distance between transfer hubs. If trains between two hubs leave every hour on the hour, they will meet halfway between the two hubs on the half hour, and a third hub can be established at this meet point. Thus, as a rule, hubs can be established at a distance that is some multiple of one-half the headway. If the trains run every hour, then the hubs can be a half hour apart (see Figures 1*d*, 2*b*, and 3). Or, if the trains run every 2 h, then the hubs can be 1 h apart, and

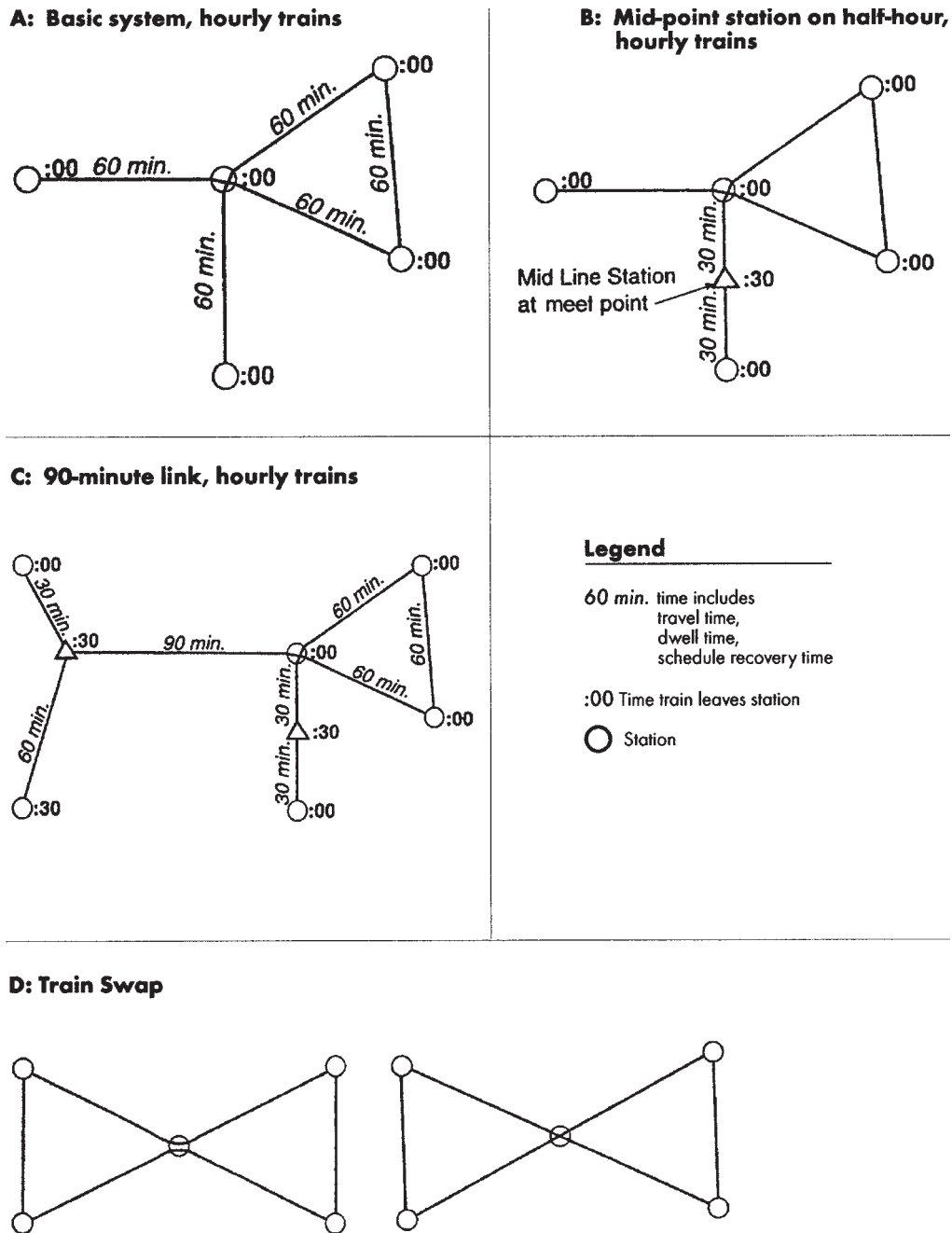


FIGURE 2 ITF schedule maps.

so forth. Converting a mainline/branch line system into an ITF system is an iterative planning process requiring a balancing of headways with the travel times between the preferred transfer hub locations—only this process can be conducted not just for one corridor, but for an entire region.

SWISS RAIL + BUS 2000 PLAN

The following description of the Swiss Rail + Bus 2000 Plan provides a model of the ITF strategy.

Development and Acceptance

During the 1970s, Switzerland experienced a freeway building boom, with all the usual environmental problems, as well as a loss of patronage for the railroads. The Swiss Federal Railway (SBB) recognized the need to counter the freeway building boom if it was to maintain market share, but several attempts were necessary before SBB found the winning combination. The first attempt was a high-speed rail system linking the larger cities in the northern part of the country from Geneva to Lausanne, Bern, and Zurich, with a branch to Basel. Even though it would have been profitable, the plan

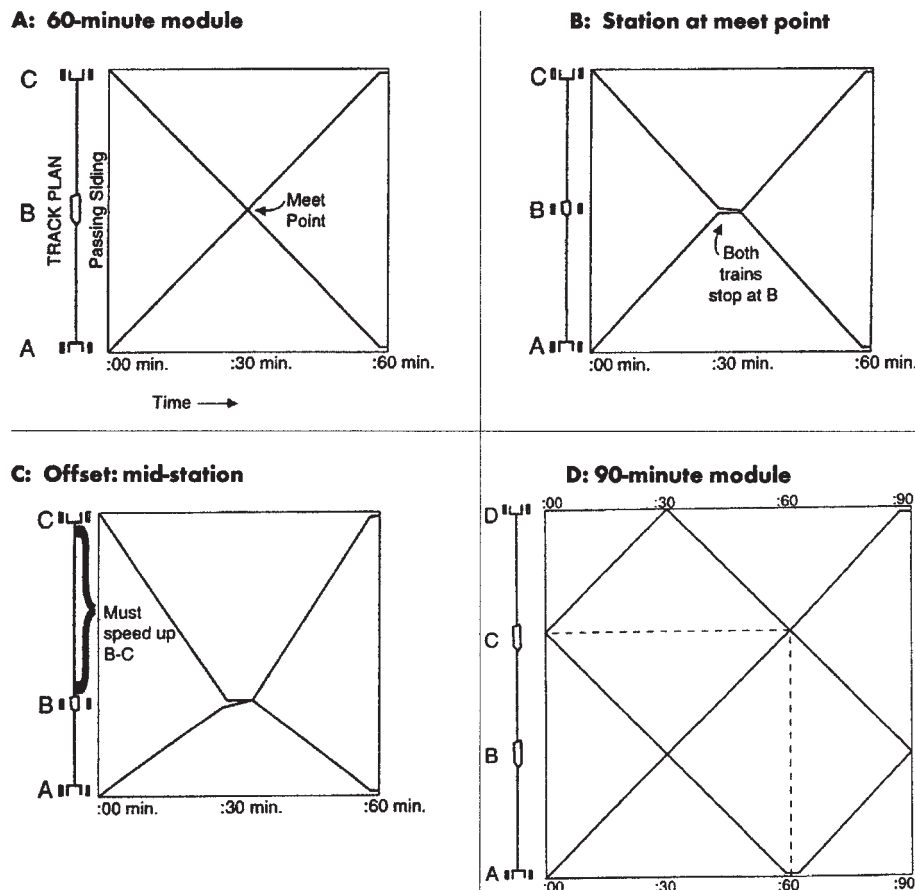


FIGURE 3 ITF symmetrical train graphs for modular scheduling and design.

was voted down in 1983 because some cantons felt left out, and the smaller cities feared that the bigger cities would grow bigger while they would get smaller.

After this failure the SBB revised its thinking and started afresh. SBB realized that it had to both include the entire country in the plan and show benefits the public could understand: printed schedules and travel-time savings. This lesson had been learned in selling the public on the fixed-interval, timed-transfer S-Bahn system for the Zurich region. (The Zurich regional S-Bahn, completed in 1990, is a major success.)

In 1982 SBB had implemented a countrywide timed-transfer schedule that improved direct connections within the constraints of the existing infrastructure. The planners decided to go one step further. In designing the Zurich S-Bahn, the engineers had played with symmetrical train graphs enough to know their power: that for every repeat of the fixed-interval schedule the trains always meet at the same location; consequently, the engineers could design exactly the improvements needed to meet the schedule, no more and no less. Why not, they thought, implement a constant-interval schedule for the whole country? Then they would have symmetrical train graphs for every track segment. They would turn the normal planning process upside down by developing the schedule first and then designing improvements, as needed, to meet this schedule.

The Rail + Bus 2000 Plan integrates the entire country—including the private railways, ferries, cableways and, where possible, urban transit—into a constant-interval, timed-transfer system (see Fig-

ure 4). SBB was able to sell the Swiss federal government on the plan on the basis of the significant travel-time savings of the proposed schedule. Some angry property owners, however, forced a referendum. Faced with a national election, the SBB planners knew that most of the voters did not care enough about the plan to come to the polls. Since, however, the same December 1987 election ballot included referendums on ecological and social security-type matters, the SBB used as campaign spokespersons those people who would vote for these other matters—such as young people, ecologists, farmers, and older women—to promote the plan. The slogan for the plan was “More frequent, faster, more direct, more comfortable.” It passed by 57 percent, with 21 cantons voting yes and 5 no.

Description

The Rail + Bus 2000 Plan is a full-scale attempt to compete with automobiles. The planners, recognizing the reasons why many people avoid using trains, developed ways to counter these objections (5).

- **Delays:** The Rail + Bus 2000 Plan modernizes and speeds up the rail freight system so that freight trains will not interfere with passenger trains. Besides scheduling the whole system to include time windows for both passenger and freight trains, the plan adds new track and improved signaling to avoid any operationally induced delays.

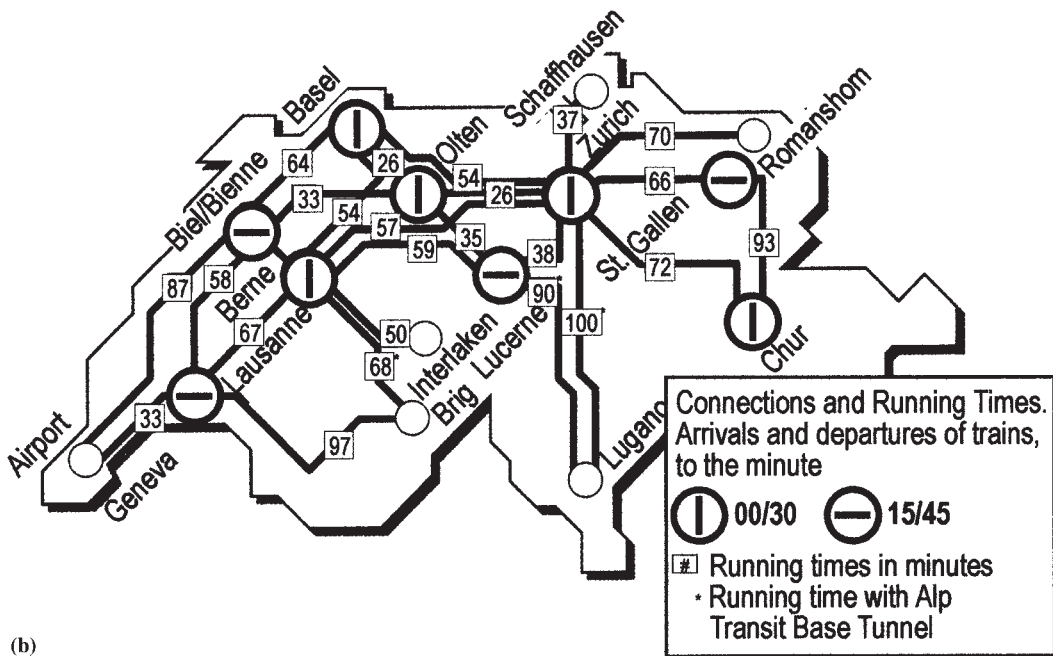
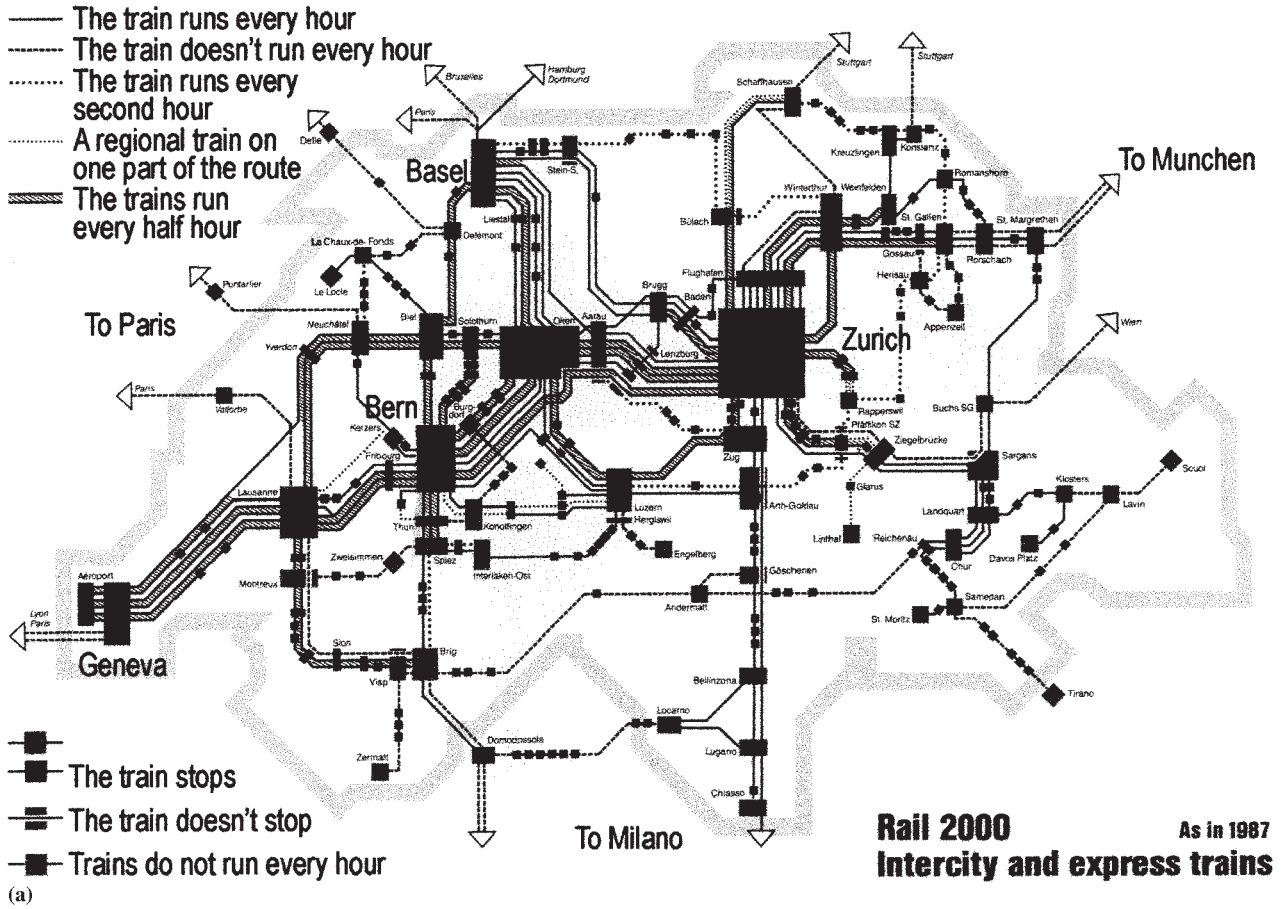


FIGURE 4 Swiss Rail + Bus 2000 Plan schedule maps: (a) train routings and headways; (b) hub timings and running times (5,6).

- Need to transfer: For route segments with half-hour service, the trains alternate between destinations, thereby providing new through trains (see Figures 2d, 5a, and 5b).
- Irregularity of service: The basic regular interval schedule repeats itself for the full service day.
- Luggage and access difficulties: To mitigate these difficulties the plan includes construction of high platforms (550 mm) and new rolling stock.
- Insufficient coverage: Most important of all, the plan includes a multihub timed-transfer system for the entire country. With regular interval schedules the trains arrive at and depart from hub stations during the same pulse with a minimum transfer wait time. The fixed-interval, timed-transfer system allows passengers to link multiple route segments together to travel anywhere in Switzerland with easy transfers.

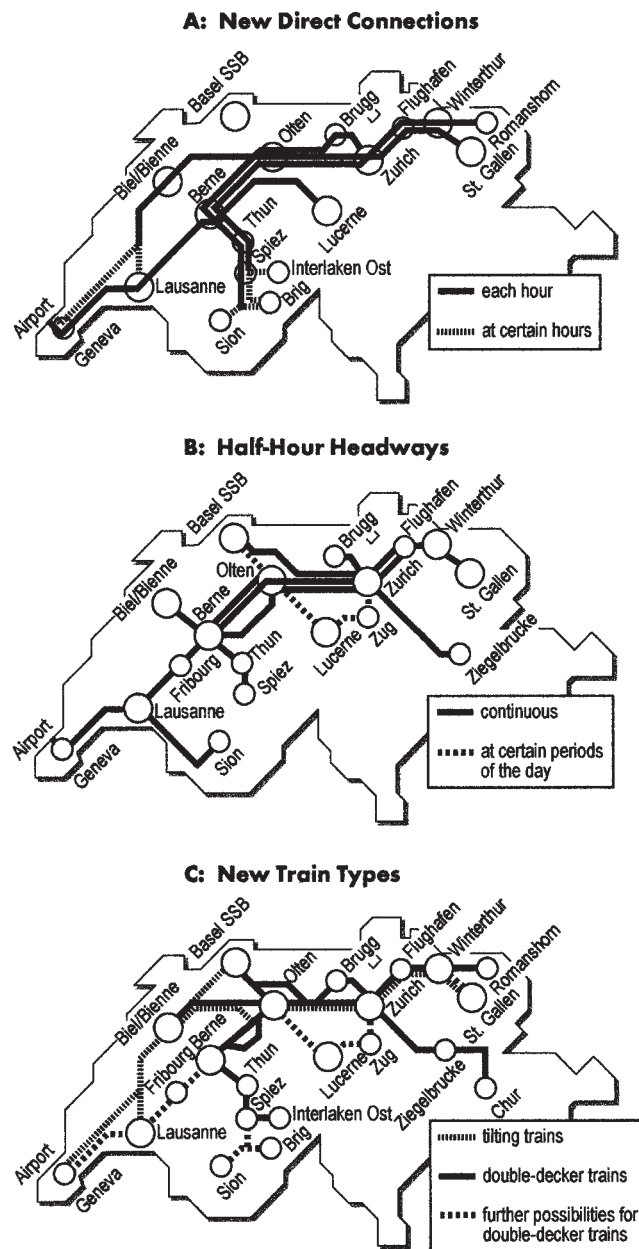


FIGURE 5 Swiss Rail + Bus 2000 Plan features (7).

The ITF fixed-interval-repeating schedule has major cost savings advantages. Each route segment between timed-transfer hubs with its repeating schedule becomes a module that can be analyzed separately. For each module, the proposed train travel times are first set to meet the hub pulse time, and only then are improvements considered, as needed. Any required improvements can be developed in the most cost-effective manner. First, the least expensive solutions would be considered, such as improved rolling stock or improved signaling; only if these improvements are inadequate would the more expensive track alignment and station layout changes be considered. The required travel-time saving needed for a module is typically a composite of these improvements.

In a similar manner, the whole system was analyzed. The SBB planners discovered that the very-high-speed 300-km/h (185-mph) TGV-type trains would not be needed; rather, a top speed of 200 km/h (125 mph) would be adequate—thus saving significant costs, since new rail alignments would be needed only in some locations. The planners ended up with a high-speed network similar to that of the original proposal, but they needed fewer sections of new track. Their slogan is “Only as necessary.”

The SBB planners looked at the whole system—for the first time true system planning of all components was applied to the entire surface passenger transport system. It is the opposite of the typical one-corridor-at-a-time piecemeal planning process that North Americans have indulged in. North Americans can learn a great deal from the Swiss.

Implementation

SBB realized by 1993 that the project would exceed the SFr 8.1 billion (about U.S.\$5 billion) budget. A major new cost item was the sound walls needed to mitigate the impact of higher train speeds. To compound the fiscal problem, in 1992 the Swiss voted to construct base tunnels for the transalpine freight and high-speed European passenger service, in part to show the rest of Europe that Switzerland was a good partner.

To save costs, SBB made the following changes to the Rail + Bus 2000 Plan:

- It took advantage of the half-hour service between the major city pairs to provide on-the-hour-and-half-hour hubs and 15-min-and-45-min-past-the-hour hubs, for example, scheduling 75-min service between the hubs at Lausanne and Bern instead of the 60 min originally planned in 1987 (see Figures 4b and 5b).
- SBB spread the cost by implementing the plan in five stages from 1997 to 2005 (6).
 - It cut service on some of the weaker lines.
 - It cut the fully integrated fixed-interval schedule to 16 h (6 a.m. to 10 p.m.). Early morning service or service after 10 p.m. does not necessarily have a timed transfer.
 - For the less heavily traveled east-west routes, SBB will use tilt-train (Pendolino) technology, thus saving significant track alignment straightening costs (see Figure 5c).
 - For the more heavily traveled east-west routes and other heavy service, SBB has already started to use double-decker trains to save money on station expansion costs. The double-decker trains have sufficient doorway capacity to load and unload in the same time as a single-deck train (see Figure 5c).
 - To spread the operating cost, SBB now requires the regional (canton) and local governments to subsidize the money-losing com-

muter and local trains. The SBB projection is that intercity freight trains will pay their operating and maintenance costs. The cost of most of the new infrastructure, a long-term investment, will be paid largely by the taxpayer (and by truck surcharges for the transalpine tunnels).

Unlike the rest of Europe, where rail patronage is falling, the SBB patronage has held its own at 28 percent of intercity travel—due, in part, to the timed-transfer and schedule improvements and to a half-price pass that one-third of the population uses.

Summary of ITF Strategy Advantages

The integrated fixed-interval, timed-transfer ITF strategy used by SBB has the following advantages:

- Connectivity is maximized. The ITF strategy for intercity rail builds an integrated passenger transportation system that maximizes connectivity, thereby providing the shortest trip times for the most trip-end pairs and the best chance of maximizing ridership. By concentrating intercity trips, the hubs improve the headways and increase the possibility of more through trips. Also, locating hubs in downtown rail stations maximizes the trip attractions within easy access via walking, local transit, and taxi.

- The strategy is market oriented. With a multicity hub ITF system, planners first design and schedule the routes on the basis of the market and then engineer the most cost-effective track configuration, signaling, station design, or rolling stock combination. The capital and operating costs are then iteratively fed back into the route and schedule planning.

- All modes are used. The Swiss strategy can utilize all passenger-carrying technologies, from maglev to local transit, to build a fully integrated timed-transfer system—provided the transfers at stations between the modes are quick and convenient and the running times between stations are reliable. Which technology is appropriate for a particular link depends on the market, the required speed to meet the timed-transfer schedule, environmental considerations, and costs.

- The strategy can speed up trains. If the travel time between two cities is too long for the timed transfer to work, it is possible to speed up the trains by tightening schedules, improving signaling, upgrading rolling stock, and, if necessary, tunneling to straighten alignments. On the other hand, only those travel-time improvements required to meet the scheduled transfers need be implemented. Speed, in and of itself, is not the goal.

- The strategy is marketable. Route plans and travel-time savings are concepts understood by the public and politicians. In their winning referendum battle the SBB planners were able to show the voters how much faster and convenient the connections between all the cities in the network would be.

- The strategy is understandable. The constant-interval schedules with timed transfers are easy to understand and learn and so are more likely to be used, thus increasing ridership.

- Capital decision making is improved. A timed-transfer schedule helps rationalize capital investment decisions. As asked before, is it worthwhile to invest \$300,000,000 in a tunnel to reduce travel time by 6 min between two cities already about 1 h apart? Normally, the answer would be no. But the answer might be yes, if a reduction from 63 to 57 min allowed the 1-h pulse schedule to work, thereby integrating the two cities into the overall system. The ITF strategy provides a rationale for setting capital and operating cost priorities, since journey times and train frequencies dictate the infrastructure improvements needed. Cost-effectiveness can be analyzed precisely,

and major investments can be justified where needed to connect the system, but only where needed—to neither under- nor overinvest.

- System planning is improved. The SBB schedule maps show the train routes and transfer locations (see Figure 4). Figure 2 shows the features of an ITF schedule map with modular schedules. Figure 2a shows the basic system with hourly trains leaving on the hour. Figure 2b shows for a 60-min headway a midline station at the train meet point with the trains leaving on the half-hour. With 30-min headways, the meet point is every 15 min. SBB takes advantage of this, to have hub pulse times at major hubs, either on the hour and half hour or at 15 and 45 min after the hour—see the clock faces in Figure 4b showing the transfer pulse timings. Figure 2c shows the impact of a 90-min travel time on station start times. Figure 2d shows how the modular system allows trains to be swapped to serve alternate destinations. Other pulse times are possible depending on the distances between transfer nodes, the market, and the acceptable operating cost. For example, pulses of 20, 40, 60, 80, 100, and 120 min would also mesh.

- Engineering is rationalized. A fixed-interval, timed-transfer schedule allows for a drastic simplification of the engineering process, since the train schedule for each section between hubs repeats itself (typically every hour). The repeating schedule rationalizes engineering by breaking design down into manageable chunks, or modules. The track, signals, stations, and rolling stock need be rationalized for only a single repeating worst-case peak-hour module that includes any extra peak-demand trains, European high-speed or IC trains, and windows for freight operations. The train graph for each time period will be symmetrical with a crossing pattern (see Figure 3). These symmetrical train graphs allow for very detailed engineering to analyze exactly the station design, track plan, signaling, alignment modifications, and rolling stock needed to meet the schedule and to engineer out any operationally created delays. Figure 3a shows a basic 1-h symmetrical train graph on a single-track line with long passing sidings. Figure 3b shows a station stop at the halfway meet point. Figure 3c shows how to handle an off-center station. Figure 3d shows a 90-min symmetrical train graph.

- Communication is improved. The schedule maps and symmetrical train graphs summarize in a graphic way the relevant information and thus become the communication tools among planning, marketing, operations, and engineering during the design of the system.

- The timed-transfer hubs can be brought on line in stages.

APPLICABILITY OF ITF STRATEGY TO NORTH AMERICA

U.S. Public Transport Usage

The Swiss have a dense and well-used public transport system with excellent coverage. Two-thirds of the households are within 5 min of public transit and 97.4 percent are within 1 km (7). Only the Dutch have a denser network, and only the Japanese use trains more. The usage of public transport in the United States (which is typical of public transport usage in North America) is at much lower level, with only the core of metropolitan areas well served; the population lives in spread out, low-density, automobile-oriented cities. Given these facts, is the Swiss ITF rail strategy applicable to North America? To be cost-effective, such a rail system needs to capture market from both the airlines and the highway system.

Rail systems can complement air passenger service, thus freeing landing slots at congested airports by substituting for the expensive regional air carriers and for medium-distance air service. For example, in the California Corridor, at 300 km/h (186 mph) a high-speed

train between downtown San Francisco and downtown Los Angeles would take 3.5 h, assuming long tunnels under the mountains and three intermediate stops in San Jose, Fresno, and Bakersfield. The trip would take 3 h when and if 380-km/h (225-mph) trains are feasible. In Germany, where high-speed trains have reduced travel time to under 3 h, the air travel patronage has decreased by 44 percent (8,p.135). Maglev would capture yet more patronage. In a modular ITF system, the technology serving a link is immaterial as long as transfers at the hubs are quick and easy. Thus, maglev could be integrated into the system and should not be considered a competing technology. For each link, the essential technology issues are the distance, cost, market, ease of transferring, and desirableness of through routing.

Luring automobile travelers to rail is more complicated. Much of the North American population lives in multicentered megalopolises with typically low-density housing and scattered origins and destinations. But an automobile-oriented life exacts a heavy price: congestion, delay, and air pollution, not to mention dependency on foreign petroleum. In a multicentered metropolitan area, a timed-transfer, multihub system would provide better service than the traditional city-centered radial transit system. Given the congestion on suburban freeways, a reliable and fast rail-based backbone service could tie the public transit systems of a metropolitan region together and connect them to nearby metropolitan regions.

In California and other corridors, including the Florida Corridor (FOX), the Midwest Network, the Pacific Northwest Corridor, and the already established Northeast Corridor, there are initiatives to establish high-speed train service using existing trackage for part of the trips. There are also numerous initiatives to reestablish urban, inter-urban, and intercity train service along existing rail corridors. However, the metropolitan area initiatives tend to be corridor focused, or existing-track focused, with reference to the larger system only in terms of possible transfer locations. What is needed is an approach that analyzes the system as a whole, including the scheduling of transfers.

Case Study: Intercity Rail System for Northern California

The northern section of the California Corridor provides a case study for an application of the modular ITF rail strategy. The San Francisco Bay Area, including the Sacramento area, is similar to the populated northern part of Switzerland in terms of population, geographic size, and geographic constraints forcing development into natural transit corridors. The potential exists for an integrated multihub, timed-transfer system with a rail-based intercity backbone. More to the point, it is possible to incorporate the proposed California Corridor High Speed Rail into an integrated timed-transfer system, thereby maximizing its productivity.

Currently the passenger rail system is incomplete, with gaps and little coordination. Bay Area Rapid Transit (BART) serves the core of the San Francisco Bay Area. San Francisco, Sacramento, and San Jose have light rail systems. The CalTrain Peninsula Commute service connects San Francisco and San Jose with hourly trains. Amtrak operates four trains a day between Oakland and the San Joaquin Valley, terminating at Bakersfield. The Capitol Amtrak service provides six trips a day between Sacramento, Oakland, and San Jose. The Altamont Commuter Express service connects Stockton and San Jose with two trips each way. Other plans are not as advanced, but none of them are part of a truly coordinated system. Some potential service improvements, such as rail service over the

Dumbarton Bridge, were put on hold due to insufficient patronage, but if this service were part of a larger, truly integrated system, then there would be a much better chance for it to prove its worth (9).

South of the Tehachapi Mountains, a separate set of rapid transit, commuter, and intercity rail service is growing in Southern California. In both Northern and Southern California, plans, funds, and interest in an improved passenger rail network are growing. High-speed rail and maglev connections have been proposed. The time is ripe for Swiss-style rail planning to integrate all the various existing and proposed rail services.

In this case study, no particular hubs, routes, or modes are advocated, but only an approach—a methodology of how to integrate the system. The steps are as follows:

1. Establish a schedule map to locate the transfer hubs and the basic pulse interval. In the San Francisco Bay Area, potential hubs at San Francisco and Oakland are both about 1 h from the third potential hub, San Jose, using existing trackage and existing 127-km/h (79-mph) commuter trains. In the Sacramento–San Joaquin Valley, using higher-speed trains, potential hubs would be Sacramento, somewhere in the Stockton/Modesto area, Fresno, and Bakersfield—all potentially 1 h apart. Thus, a 1-h interval for timed transfers seems appropriate and easily achievable.

2. Analyze the speed required to tie the hubs together into a constant-interval schedule and set the pulse start times—that is, whether the trains leave on the hour, on the half-hour, or at other times. For example, between San Francisco and San Jose, local commuter trains operating with a top speed of 127 km/h (79 mph) and making 27 intermediate stops travel the 75 km (47 m) in 90 min. The fastest express train with five intermediate stops makes the trip in 63 min. A nonstop train could make the trip in approximately 56 min, and thus connect the two cities into a 1-h timed-transfer system. A high-speed train going 200 km/h (125 mph)—given the existing right-of-way and the suburban setting, faster speeds may not be feasible or desirable—could make the trip in an estimated 28 min, or 35 min if it also stops at the San Francisco International Airport.

Figure 6a shows, at a conceptual level, an initial constant-interval, timed-transfer system for Northern California. The schedule plan assumes no tunnels and 180-km/h (110-mph) diesel trains where needed. Notice that between Sacramento and Fresno, in order to balance the 60-min-between-hubs schedule, the rail hub would be at Modesto and not Stockton. Also, notice that, because of the 70-min travel time between Bakersfield and Fresno, Bakersfield is not a timed-transfer hub. BART transbay service would connect Oakland and San Francisco—a good connection between BART and the intercity rail service in Oakland and in San Francisco is essential for the system to work properly.

Figure 6b shows a possible first cut at a long-range ITF system assuming 300-km/h (186-mph) high-speed trains with tunnels under the Tehachapi Mountains, under the Coast Range between Fresno and San Jose, and under the East Bay Hills between Martinez and Richmond on the Sacramento-to-Oakland link. Notice that at the hubs of Stockton and San Jose and to the south the trains would leave on the hour, whereas at the San Francisco, Oakland, and Sacramento hubs the trains would leave on the half-hour. The travel time between downtown Los Angeles and downtown San Francisco, Oakland, or Sacramento would be 3.5 h, comparable with door-to-door air travel times.

A multihub, rail-based, timed-transfer system can be developed in stages for northern California, with or without a high-speed rail

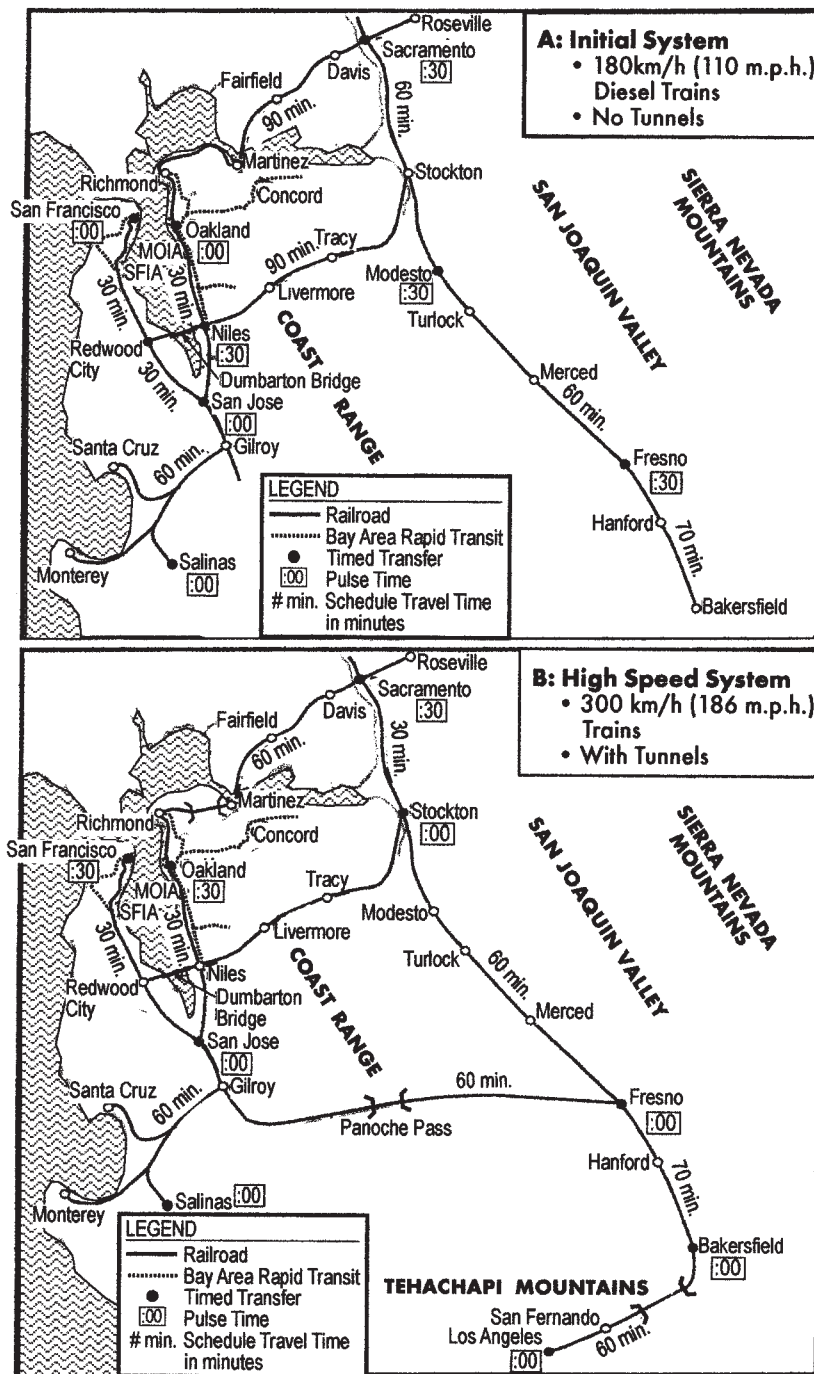


FIGURE 6 Application of ITF strategy to Northern and Central California.

link (in a very expensive tunnel under the Tehachapi Mountains) to Southern California.

CONCLUSIONS

North Americans can learn from the Swiss. North America has an underused rail system resource, constructed in the 19th century by competing private railroad companies, which had minimal incentive to cooperate. Railroads had a monopoly on travel and tried to max-

imize profits, not service. Public and quasi-public passenger transport companies exist now, yet attitudes from that earlier era continue to inhibit rail service development. A fully cooperating system, in which every component functions as a piece of an integrated whole, remains a dream.

The Swiss ITF approach (coupled with interagency revenue sharing) coordinates the various components of the public passenger transportation system, pulling them into a cooperating whole. By viewing the system as a whole, the benefits of a large capital investment or an ongoing operating subsidy can be properly weighed. Exist-

ing resources can be capitalized in a cost-effective manner. Like the Swiss, North Americans need build only what is needed, but they should build what is truly needed to develop a fully integrated system. To build only to meet the market on a corridor-by-corridor basis runs the risk of underinvesting and thus failing to maximize the public good.

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