

INTEGRATED TIMED TRANSFER -A EUROPEAN PERSPECTIVE

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The high speed advantage is being recognized as a competitive advantage of high speed ground transportation (HSGT) by both its advocates and detractors. Other competitive advantages of HSGT, however, especially its Internal Distribution Advantages, are seldom included in the debate. Unlike airplanes, trains can go through a metamorphosis and turn into subway trains once they reach a metropolitan area and go underneath city streets, directly serving high density areas with as many stops as may be required by the traveling public. Unlike planes, trains can also split up into many pieces once they reach a metropolitan area, each piece serving a different commuter rail corridor. These may be critical competitive advantages, especially in North America. It is difficult to argue the point that airplanes provide faster point to point connections in all corridors of interest to HSGT, that the air infrastructure is already in place, and the advantage of a downtown to downtown connection is much more relevant in Europe or Japan.

Very much related to the concept of the Internal Distribution Advantage of HSGT is the notion of having high speed infrastructure be the skeleton, the framework that ties all the different public transportation systems together into one complete whole. Rail lines form the backbone of both the long distance and local public transportation system in Europe and Japan. They connect the different hubs served by buses and other modes of transit in different cities. In North America, even many small- and medium-sized urban areas have somewhat well functioning public transit services. But the backbone, the skeleton of a public transportation system that ties all these distinct local transit services together into one complete and usable system is missing.

This is the basic idea behind Integrated Timed Transfer (ITT). It is the author's opinion that developing HSGT systems within the framework of ITT could improve their chances of success dramatically.

Within the framework of ITT trains, buses, boats, and other means of local and long distance public transportation do not only operate on a fixed interval schedule, but also connect with each other in a way to minimize transfer times. That is accomplished with the establishment of certain hubs, not dissimilar in principle to airline hubs, where all vehicles arrive and depart at approximately the same time. But while a major airline may have to contend in its scheduling with only one or two major hubs, a passenger railway would optimally establish an almost unlimited number of hubs. The goal behind this type of scheduling approach is to "blanket" the

country with hubs in order to minimize transfer times at as many places as possible.

It is this "blanketing" the country with hubs that distinguishes ITT from regular timed transfer. Note that to have a timed transfer (TT) system it is only necessary to have one hub for a single mode; however, an ITT has many (20, 30, or even 100) hubs where different modes arrive and depart at the same time. Furthermore, the phrase Integrated Timed Transfer, unfortunately does not include the notion of fixed interval scheduling. There is no short English word like "Takt," which is also used to describe musical beat and conveys the notion of a constant stream of trains, or buses for that matter, at regular intervals. Since this word is so hard to translate directly into English, it is sometimes used without translation, e.g., "Towards a European Taktfahrplan. It is important to remember that "Integrated Timed Transfer" includes the notion of fixed interval scheduling.

Switzerland provides a good illustration of the basic principles. Notice in Figure 1 how geography made it possible for the hubs in the basic triangle Basel - Zurich - Bern to be about an hour apart from each other. From 2005, approximate running times between these cities will be 55 minutes. But also notice that in order to integrate most of the other cities into this system, a half hour headway is necessary.

In summation, for a timed transfer (TT) system only one hub is needed, at which vehicles of a single mode arrive and depart at the same time at least once a day. For an Integrated Timed Transfer (ITT) system,

it is necessary to have a multitude of hubs, blanketing a whole region, at which vehicles of all modes arrive and depart at the same time at fixed intervals.

Advantages

First of all, ITT is a logical complement to high-speed ground transportation service. To sum it all up in one sentence it makes little sense to spend \$100 million to cut travel time by one minute, only to let passengers wait 40 minutes for connections to their destination stations.

To better understand the advantages and disadvantages of ITT, it is very instructive to examine issues involved in the introduction of ITT in German long distance traffic. The backbone of long distance public transportation in Germany consists of 5 lines of hourly InterCity trains that meet each other at five different hubs to exchange passengers. However, since InterCity trains only arrive and depart at the same time with other InterCity trains and not at the same time as InterRegio or local trains, Germany does not have a systemwide ITT.

The advantages of the ITT are more obvious than its disadvantages. For this reason it is often seen by politicians as a cure-all, which it certainly is not. To understand the advantages, consider two different surveys on what people consider important in long distance travel, and on why people use or do not use rail. Business travelers say rail is too slow, leisure travelers say it is too expensive, and both say it is not flexible enough. It is this complaint of lack of flexibility, both in the sense of more frequent service and better spatial coverage, that ITT addresses.

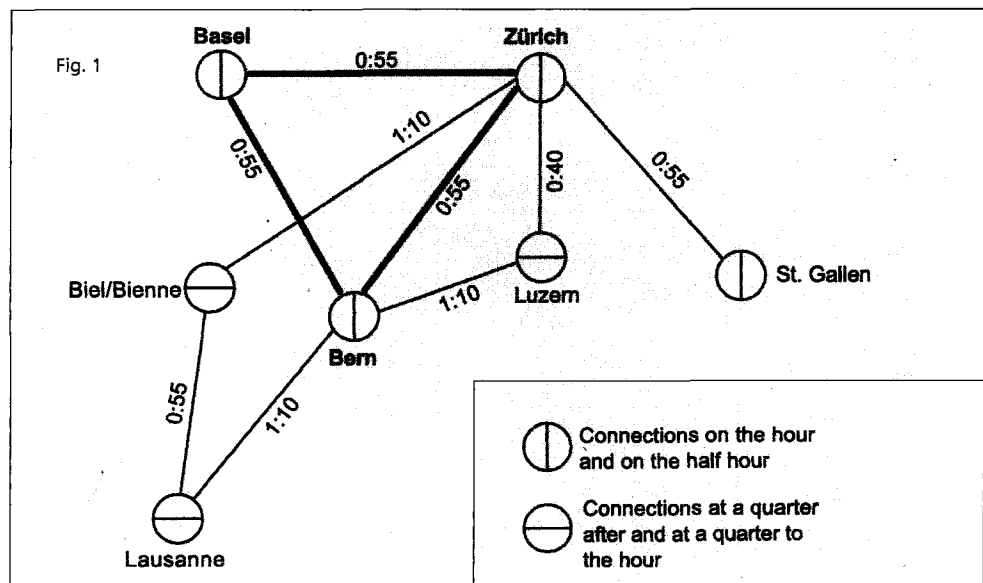
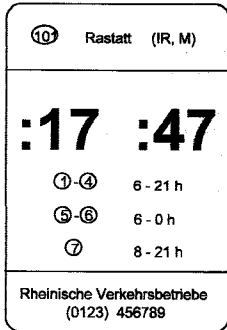


Figure 2 depicts a proposed bus stop sign which may also be seen as an invitation sign to get "on board" the ITT. The top line shows that the destination is Rastatt with connections to InterRegio and Metro trains. Every passing driver can tell, e.g., that the first bus leaves weekdays at 6:17. If a passenger knows that the bus stop is 1 hour and 13 minutes away from the nearest "mega-hub" Karlsruhe, the hub where InterCity trains meet, and that Karlsruhe is exactly 3 hours away from Hannover, the passenger knew he would arrive in Hannover at 10:30 if he/she left from that bus stop at 6:17. This assumes a certain amount of knowledge of the travel times and routes on the part of the motorist.

Fig. 2



This assumption is not unrealistic considering the high importance given to public relations and advertising campaigns during the introduction of regional ITT systems in Germany. This bus stop sign makes passing motorists very aware of their alternatives. It would

begin to overcome one of their main objections: "I am not going where the bus goes." With ITT, passengers do not only get on board a single line, but rather a whole system.

Note that the bus stop sign in Figure 2 does not already exist, but is being proposed by the author. It is language independent and could be used, as is, in every country in Europe. It could be easily adapted to North America by changing the 24 hour time into the AM/PM format, and by writing out the days of the week instead of denoting them by numbers (e.g. 1-4 would become Mon - Thu). Many routes that are unprofitable on their own may become profitable if integrated into a system like the ITT. Sometimes, a simple IT system might make routes feasible that otherwise could not be served. After the introduction of the hub and spoke system for airlines, many small communities received improved air service by being connected several times a day to a major hub with quick transfers to a multitude of domestic and international flights.

Disadvantages

With all its advantages, ITT also has serious disadvantages. In the Frankfurt region, 85% of all passengers per day per direction use the system during only 1.5 peak hours. By design, ITT assumes a relatively uniform usage of the system throughout the day. With a simple pulse timetable, the headway can easily be adjusted to the demand, maybe every 60 minutes during off-peak and as often as every 5 minutes during peak hours. That is not as easily done with ITT, since it might require running a 30-minute pulse all day in order to make the system work.

Another survey in the Frankfurt region showed that 70% of daily commuters never change trains. For these 70% the ITT would be completely irrelevant. If some

trains were slowed down in order to make hubbing possible at certain points, it would even mean a downgrade of service for these commuters. Of course, the possibility should not be overlooked that the present percentage of commuters who do not have to change trains may only be high because without an ITT public transportation is not attractive enough for those who would have to transfer.

The introduction of ITT in Germany, Switzerland, and Austria often included enhancements like regular service all day Saturday and Sunday on minor routes. With centralized train control, fixed cost may not increase significantly to provide this service. However, many of these minor routes were not well automated, which meant an increase in cost that could not be offset by increased revenues. In an extreme case the Austrian railroad had the following experience with its "Austro-Takt": 30% increase in service, 20.4% increase in cost, 11.5% increase in demand, and 6.8% increase in revenue.

ITT is not immune to general disadvantages of timed transfer systems. Schedule reliability is reduced, since a delay on a single line may have a "snowball effect" on all connecting lines. Experience with airline hubs shows that in case of a weather problem at a major hub schedule reliability disintegrates.

The Achilles' heel of the ITT is that it does not use present facilities very efficiently; although again that is the case with any TT system. All vehicles descend on the hub at the same time, stay only for a short while, and then leave. The hubs are empty for the rest of the time. To continue the comparison with air travel, to make a hub and spoke system work, mega airports like Dallas-Ft. Worth, Chicago, or Denver are needed; New York's LaGuardia would be much too small. Many European rail stations could not simultaneously accommodate trains from every line passing through it. The only alternative is to operate the hub schedule in three waves. *First wave*: all trains terminating at that station drop off passengers and wait in a holding area away from the main terminal area. *Second wave*: all trains passing through the station as an intermediate stop exchange passengers. *Third wave*: trains from the holding area come back to the main terminal, pick up passengers and start their return trip. The all-cargo airline Flying Tigers used a similar system at its temporary hub in Chicago, before moving to its permanent facility in Columbus, Ohio.

Also note that the ITT is supply and not demand driven.

First, it is important to figure out what kind of timetable with which pulse would make hubs possible in those cities where hubs are desired. That is a theoretical exercise. The *second step* is to find riders for the theoretical system.

Some ways railways have found to overcome these disadvantages is to use multiple units instead of locomotive hauled trains. Multiple units can easily be combined and separated during the day to adjust to different demand levels. Another way is to use yield management in order to induce passengers to travel during off-peak hours. And a third way is to realize that a 100% level of ITT implementation would be inordinately expensive and, therefore, be

satisfied with a lower level of implementation. Some minor routes in Switzerland are served only every 4 hours. That might mean some passengers traveling cross country from a station on one minor route to a station on another minor route might not be able to connect without waiting a substantial amount of time. That is unfortunate, but unavoidable for at least some travelers.

Minimization of the Number of Transfers

It is important to note that while an ITT system is designed to minimize transfer times, it should also be designed to minimize the number of transfers. This is because passengers do not like to change vehicles en route. It is well known that there is a penalty associated with a change of trains in long distance travel.

After the introduction of the TGV Atlantique, some conventional trains from Paris to Atlantic seaboard cities were replaced with a combination of high speed TGV trains and diesel trains. Conventional trains have the advantage because at the end of the electrified line the electric engine at the front of the train can be switched to a diesel engine. Passengers can stay on the train. On the other hand, if a TGV high-speed trainset is used for the electrified portion, at the end of the electrified line passengers have to change from the TGV across the platform to a diesel train. Researchers found the transfer penalty to be equivalent to between 40 minutes and one hour of in-vehicle time.

The German long distance train timetable for the year 2000 was tested against an origin and destination matrix with 185,124 cells. The simulation showed that 61.6% of long distance travelers never have to change trains, while 79% of those having to change only need to change once. This was made possible because of line switching. Even though the headway is 60 minutes, InterCity trains, e.g., only follow the same route every 4 hours.

The Economics of ITT

For a long time transportation planners in Europe were faced with a downward spiral in public transit. In order to reduce subsidies infrequently used services were cut. The decrease in service reduced ridership and revenues. Previously well used services were now underutilized and the cycle began anew.

Switzerland's Rail 2000 concept, which was approved by the voters in a special referendum on 6 Dec 1987, showed a way out of this dilemma. The basic idea is that due to economies of scale and network effects it is possible under certain circumstances to reduce public subsidy by increasing service.

Network effects can most easily be explained by an airline example. Adding one spoke to a hub-and-spoke-system adds more revenue to the system than just the additional revenue generated by the origin-destination traffic between the end of the new spoke and the hub. New traffic will be generated between the new city and all of the existing points the airline has been serving all along.

Economies of scale can be illustrated with the following example. The additional cost of adding service in the late evening or on weekends is considerably lower than adding that same service during peak hours. For new rush hour traffic additional vehicles would have to be purchased and maintained, while new service during off-peak hours can be provided with existing equipment. Magnifying the difference in economics between peak and off-peak services is the fact that most peak-hour travelers use reduced rate tickets like monthly commuter passes or student discount cards, whereas most off-peak customers pay full fare. Summarizing the combined effect it is claimed that e.g. the series 628 diesel multiple unit with 15 passengers during off-peak hours is economically equivalent (in terms of marginal revenues minus marginal costs) to the same unit fully occupied during rush hour. This shows the fallacy of trying to reduce subsidies by eliminating services during off-hours. In many instances the marginal revenue decrease will exceed the marginal cost savings and the subsidy increases.

Because of economies of scale and network effects it is possible to reach a point from which marginal revenues exceed marginal costs and the subsidy decreases while service is being increased. In Switzerland, additional revenues only covered 73% of the variable cost of service improvements in 1991. Most recently this ratio has increased to nearly 100%. Substantial parts of the Swiss ITT system will not be operational until 2005, so the system is still very far from reaching all its network effects.

Of course there is a limit to how long service improvements will result in reduced subsidies. From a certain point on increasing frequencies and adding spokes to a system will increase marginal cost more than marginal revenues. At that point the ITT-potential has been exhausted.

Possible Applications In North America

How important it is to include Integrated Timed Transfer in the planning and decision making process in the United States is illustrated with an example from the San Francisco Bay Area. ITT is clearly not possible without intermodal stations. Yet, two brand new Amtrak stations have just been built in both Emeryville and at Oakland's Jack London Square that do not interface with the region's primary rapid transit system, BART (Bay Area Rapid Transit). Amtrak operates three daily "San Joaquin" (Oakland - Bakersfield) and four daily "Capitol" (San Jose - Oakland - Sacramento) trains. Until recently, they passed only 100 m (300 ft.) away from the West Oakland BART station. Here, BART's Richmond, Concord, and Fremont lines all merge onto the same track to run underneath the bay to San Francisco. Travelers can not only catch a train to San Francisco every 5 minutes (!), they can also reach every single BART station from here without transferring. Yet, the new Amtrak station was not built in West Oakland. New stations were built 4 km (2½ miles) north at Emeryville, and 2 km (1¼ miles) south at Jack London Square in Oakland. The station locations were determined based on issues of urban

renewal, not ridership analysis. Note that neither station is located anywhere near BART and both stations are only served by a few bus lines.

Rail lines form the backbone of both the long distance and local public transportation system in Europe. They connect the different hubs served by buses and other modes of transit in different cities. In North America, even many small- and medium-sized urban areas have well functioning public transit services. But the backbone, the skeleton of a public transportation system that ties all these distinct local transit services together into one whole public transportation system is missing. In many instances, these intercity or interregional services may not be feasible because of low population densities. An ITT, even one based on a 120-minute minimum headway, may not be desirable in those cases. It is, however, in multi centered urban agglomerations like the Bay Area or in rapidly expanding, congested corridors like San Jose - Oakland - Sacramento, which the Capitols were supposed to serve, where ITT would improve the overall transportation system dramatically.

San Jose and Sacramento have gone through great pains to integrate their new light rail systems with their existing bus services. Yet, the Capitols do not connect with either the San Jose or the Sacramento light rail systems. In the San Francisco/Oakland/East Bay area served by BART, their only connection is in Richmond, at the northern end of the system. While it is fairly easy to travel within the San Jose, or Sacramento, or San Francisco/Oakland/East Bay area, it is very difficult to travel between them.

The end result for potential passengers is that the Northern California public transportation system continues to be so disjointed that it is almost unusable for many interurban connections. Experience shows that people who do not already own an automobile have to rent one when they travel between Berkeley and San Jose. It is important to see this statement in the context of the 1994 Regional Transportation Plan projecting annual expenditures of \$1 billion for mass transit operations. Note also that there are more than 30 independent public transit operators regionwide.

The political basis for the implementation of ITT systems in Germany are entities called "Verkehrsverbund", roughly translated as Transport Association, or Transit Federation. The first one was formed in 1965 in Hamburg. They are combinations of all public transit agencies in a given region, including all the local and regional services of the German railroad. It is these entities that decide fare levels and timetables. The customer only deals with one single ticket which can be used on all public transportation modes in the entire region. For the passenger it is not apparent that the services are operated by different companies. Membership in this association is not always what the companies that provide the service would really prefer, since they obviously lose a lot of power to the higher entity. But all public operating subsidies and capital improvement funds are routed through these

Transport Associations, so individual operators have to join. The Transport Associations provide the political framework in which ITT implementation is made possible.

A first steps in the right direction have been taken in Northern California. Effective 1 January 1997, 27 agencies are to work together to consolidate ticketing and telephone operations. They will also have to consolidate other services, e.g., eliminate overlapping bus routes. The local Metropolitan Planning

Organization, the Metropolitan Transportation Commission (MTC), is authorized by the bill to withhold money from agencies that refuse to eliminate redundant services. The bill was strongly opposed by transit unions and some operators. Some opponents warned that a super-bureaucracy would be created, usurping power from local districts. The bill certainly did not create a Bay Area Transit Federation. Passengers do not go to the MTC to buy tickets and timetables. It remains to be seen how effective the bill is to tie the different transit services together into one system and to add needed checks and balances to the system to make construction of white elephants like Oakland's Jack London Square station less likely in the future.

In the meantime the Southern Pacific/Union Pacific track was moved much further away from the station to make room for the realignment and reconstruction of the earthquake damaged Cypress Freeway. Another option for BART to serve the I-80 commuter corridor from downtown San Francisco the same way the Long Island Railroad serves Eastern Long Island from Penn Station would be hard to implement because BART does not use standard gauge (1435 mm). BART's gauge (1676 mm) is wider than even that of Spain (1668 mm).

As a last point, note that in 1992 Amtrak carried 0.1%, and intercity buses 0.6% of total passenger-miles. The numbers indicate that there may be a point when competition stops being effective. The animosity between Amtrak and Greyhound remind of U.S. railroads fighting each other for a shrinking passenger base some 50 years ago. Instead of working together to compete against automobiles and airlines they decided to do everything on their own. History tends to repeat itself. Cooperation, for example in a regionwide Integrated Timed Transfer system, may serve Amtrak's and Greyhound's customers and ultimately the operators themselves much better. Cooperation in ITT systems would give travelers for the first time in almost 30 years an alternative to renting cars for virtually any medium distance trip away from home, and thereby increase the passenger base substantially. Amtrak does have its own feeder bus service, but the idea behind ITT is not for every competing company to operate its own feeder service, on the contrary, the idea behind ITT is to integrate the services of all agencies in a way to make transfers appear seamless to the customer. 