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THE LAST MILE FALLING THROUGH THE CRACKS –
A Case Study of the San Francisco to San Jose Section of the California High Speed Rail System

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ABSTRACT

High Speed Rail (HSR) has been able to capture substantial market share in Asia and Europe, where downtown to downtown connections offer a great advantage over the competing air mode. Downtown-to-downtown links do not provide a great access advantage in decentralized widely dispersed US metropolitan areas. The integration potential of HSR with the urban and regional transportation system needs to be carefully studied.

This paper proposes a conceptual framework, the Six Stages of Integration, to assess to what extent a regional rail network is able to help HSR reach its ridership potential by offering connectivity to all parts of the metropolitan area. It examines transportation systems which were able to advance to progressively deeper levels of integration achieving maximum synergies. This conceptual framework also sheds light on the regulatory and/or institutional hurdles which have thwarted the natural development of other systems.

The paper comes to the conclusion that while systems integration is more critical to HSR's success in the United States than in Europe or Asia, the institutional and regulatory impediments to its implementation are considerably higher in the US than in most other countries. Many of these obstacles stem from systemic problems in the planning process combined with weak institutions that are unable to compensate for their shortcomings. As a result best practices from Europe and Asia are often largely ignored. Additionally, technical challenges peculiar to North America inhibit a natural symbiosis between local/regional rail and HSR.

INTRODUCTION

The proposed California High Speed Rail System provides a unique opportunity for the most populous state to rebalance its transportation system. Intra-metropolitan feeder flights into Los Angeles International Airport performing a function elsewhere handled by rail are just one of the many outward symptoms of the present imbalance. But HSR is not likely to be successful without taking advantage of its inherent competitive advantages (*1*, p. 3), nor without carefully taking into account some of the most pertinent findings in the mode choice literature of the last 40 years.

MOTIVATION FOR INTEGRATION ANALYSIS

Transfer Penalties

People do not like to change trains. Even in an entirely urban setting, where people generally travel without luggage, the disutility of having to change transit vehicles en route is substantial. A comprehensive Central Transportation Planning Staff study in Boston clearly distinguishes between a time-independent transfer penalty of 13 minutes in-vehicle time, and an additional waiting time penalty of approximately 2½ times the in-vehicle time (*2*). The Boston study states confidently that “a transfer penalty for broken trips of 13 min could be established at the 95% confidence level.” When it comes to passengers with luggage, as is usually the case in intercity travel, the transfer penalty is even more startling, Harvey (*3*) was able to quantify the deterrent to using public transit as an airport access mode created by the amount of luggage. He found that the implicit price of each additional piece of baggage per person, which is the fare reduction required to offset the disutility of having to handle the additional bag, was $ 11.17 for non-business travelers.

Quarter Mile Rule

Most commuters realize that having to drive to the railway station is the price to pay for living in single family homes in the suburb. But they refuse to change a **second** time to another mode of transportation once downtown. Most office workers are only willing to take public transport if they can walk to their final destination. Hutchinson found that for daily commuters access time to the transit system from their homes is far less important than egress time from the transit system to their offices. Go Transit commuter rail in Toronto provides a good example for Hutchinson’s findings. In spite of being directly connected to one of the most efficient subway systems in North America, Go’s ridership potential is limited to the number of work locations within an approximately 700 m radius around the main railroad station. Most of the literature points to the fact that the ridership already drops off dramatically beyond 400 m. This phenomenon is generally referred to as the “Quarter Mile Rule.”

Illustration

Rail access into downtown San Francisco provides a good illustration for the findings above (FIGURE 4 (d) and (e)). Bay Area Rapid Transit (BART) is an electric railroad providing frequent service (7½ min rush hour headways on one line) mainly from East Bay cities to San Francisco. BART serves all four Market Street stations in the center of the business district. Caltrain is a commuter railroad to Peninsula and South Bay cities including San Jose with about 20 peak hour trains per direction plus limited mid-day and weekend service. Most work locations in downtown San Francisco are within a quarter mile of one of the four Market Street stations. On the other hand, only few of the Caltrain commuters are able to walk from the edge of downtown to their final destination. (The spelling of Townsend Avenue in TABLE 1 has been changed for emphasis). Diridon station is located in an as yet marginal neighborhood about 1 km outside of downtown San Jose, and is separated from it by an eight lane aerial freeway. BART does not serve San Jose.

TABLE 1 Downtown San Francisco and San Jose Station Ridership

Downtown Station	Operator	2008 Average Weekday Riders	Percent of BART Market Street Total
S.F. Embarcadero	BART	33,014	
S.F. Montgomery		32,519	
S.F. Powell		30,733	
S.F. Civic Center		22,229	
		118,495	
S.F. 4th and Town's End	Caltrain	8,306	7%
San Jose Diridon		2,750	2%

Sources: (*4*), (*5*)

Political Realities

The systemic problem of the typical triple focus on engineering/capital costs, ridership/operating costs, and environmental impacts is that it fails to see the system as a whole. Systemwide ridership studies are completed without knowing the exact station locations or the level of integration with other modes. Engineering studies focus on construction cost and community impacts (FIGURE 1). Neither one of the two tracks considers the important findings of the mode choice literature mentioned above.

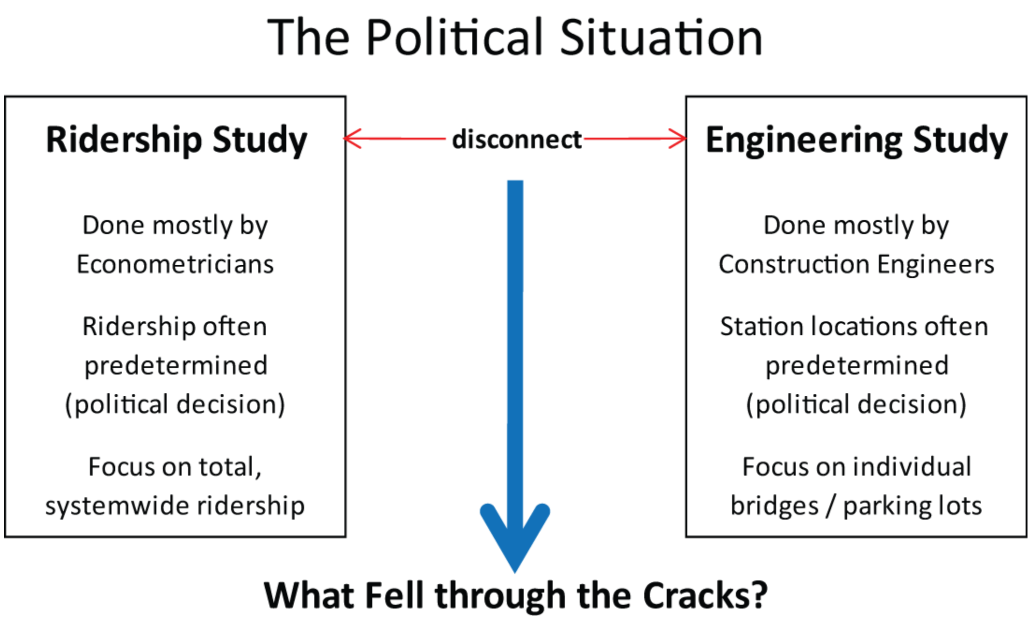


FIGURE 1 Systemic Problem in the Planning Process.

The envisioned connection between HSR and San Francisco International Airport (SFO) is a good example. Airport bound HSR passengers are to change at Millbrae to BART, which will take them to the International Terminal, where in turn they can transfer to the airport people mover system (FIGURE 4 (d)). Two transfers with heavy luggage are not likely to attract many travelers. Before the opening of BART's airport extension in June 2003, the Millbrae – SFO shuttle was touted as the airport connection for Caltrain passengers. Due to low demand the shuttle was discontinued in February of 2004. It was known as the "ghost train" (*6*). The same shuttle would be reinstated to bring HSR passengers to the airport. Ridership impacts are not the only consideration in the design of High Speed Rail systems, and the level of integration with other modes is not the only determinant of ridership. However, to gain market acceptance, every product needs to leverage all of its competitive advantages.

THE SIX STAGES OF INTEGRATION

This paper suggests six consecutively deeper levels of integration (FIGURE 2 (a) and (b)) with correspondingly more compelling synergies. It starts with Stage 0 – No integration and culminates with Stage 5 – Convergence or "One-Seat-Ride."

Stage 0 – No Integration

Stage 0 dates back to the time of outright competition between railroads, which resulted in different stub end terminals throughout a city. Current examples are New York's Pennsylvania and Grand Central Station, Boston's North and South Station, and Baltimore's Pennsylvania and Camden Station. Stage 0 has no *intra*-modal integration.

Stage 1 – Union Station

Union Stations add *intra*-modal spatial integration with a single intercity railway terminal. Union Stations are not necessarily *inter*-modal. In Washington, DC the intercity bus (Greyhound) depot is at a different location from Union Station.

Stage 2A – Intermodal Terminal with Agency Demarcation Lines

Stage 2A adds *inter*-modal spatial integration. A good example of an intermodal terminal with agency demarcation lines is the previously mentioned Millbrae station south of San Francisco. Caltrain is on the West side of the terminal, BART on the East side. The demarcation line caused by the different fare collection systems of the two agencies runs through the middle of a platform. The second demarcation line is between the rail station and the airport property. A shuttle bus serving one of the long-term parking lots picks up passengers right behind a high fence that Millbrae station patrons cannot cross. BART is the official connector between Caltrain commuter trains and the people mover system on the airport property.

The joint use Market Street stations in downtown San Francisco illustrate Integration Stage 2A as well. BART has a center platform on the lower level, the San Francisco light rail system (MUNI Metro) has a center platform on the level above. A BART passenger transferring to MUNI Metro first has to take an escalator up two levels to the concourse level, leave the BART paid area, then enter the MUNI paid area and go down one level again. Stair cases from BART to the concourse are separated by thick iron bars from the MUNI platform. A more logical configuration would be two directional platforms, one for a cross platform transfer for passengers traveling East and the other one for those traveling West.

Consecutively Deeper Levels of Integration

	INTEGRATION LEVEL / EXAMPLES	FEATURES
0	**No Integration**	
	New York	separate stub-end terminals throughout the city
	Boston	difficult rail to rail transfers
	Berlin (before 1886)	huge footprint in urban core
1	**Union Station**	
	Washington, DC	single stub end terminal
	Los Angeles	low thru-put per platform track
	Denver	big footprint in urban core
2A	**Intermodal Terminal**	
	with Agency Demarcation Lines	designed for operational convenience
	Millbrae	separate fare collection system
	SF Market Street Stations	long walking distance
2B	**Intermodal Terminal**	
	w/o Agency Demarcation Lines	designed for ease of transfer
	all stations within	common fare collection system
	regional transit federations	short walking distance
3A	**Cross City Line**	
	for Suburban Trains	most downtown work places located within walking distance
	Philadelphia	leverages "Quarter Mile Rule"
	virtually all Metro Areas	convenient access for reverse commuters
	in Europe and Southeast Asia	high capacity using a small footprint
3B	**Cross City Line for**	
	Suburban and Intercity Trains	most downtown hotels and attractions within walking distance
	Berlin, Hamburg, Brussels	
Best Practices **4**	**Pulsed Hub System**	
	Switzerland, Austria, Germany	shortest transfer time
5	**Convergence**	
	Interurban tram-trains in Karlsruhe	no transfers - one seat rides

(a)

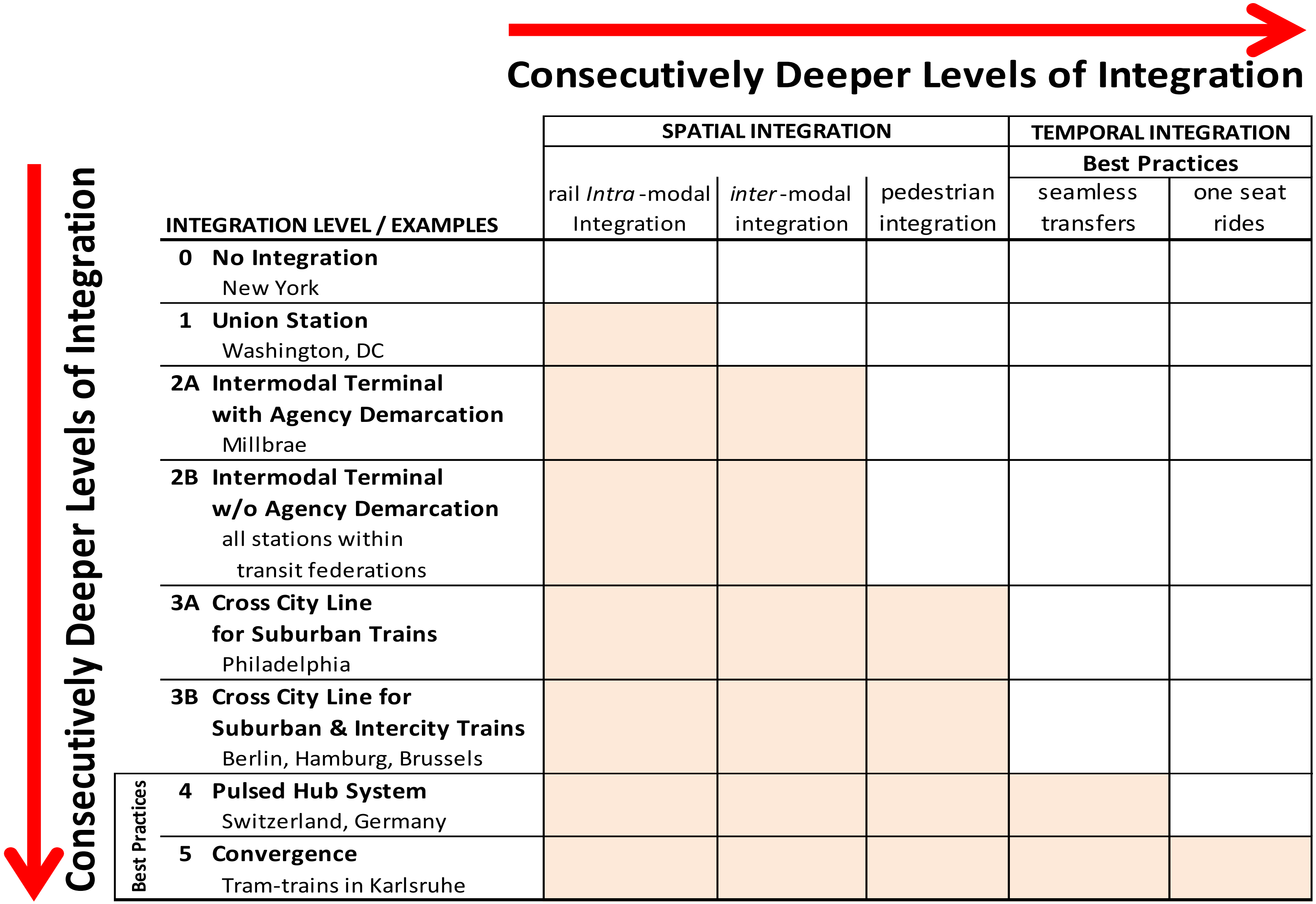


FIGURE 2 The six stages of integration. (b).

Intermodal terminals with agency demarcation lines have in common that they are optimized for operational expediency, not for ease of transfer. By and large Stage 2A Integration appears to be the state of the practice in the United States. There are a few exceptions which are discussed below.

Stage 2B – Intermodal Terminal without Agency Demarcation Lines

Throughout most of the world public transit agencies only receive government subsidies if they agree to a common regional fare system and coordinated schedules. So called transit unions were proposed for the United States as early as 1970, right after its successful implementation in Hamburg (*7*).

Intermodal terminals without agency demarcation lines are optimized for ease of transfer. Stage 2B integration is predicated on transit unions.

Stage 3A – Cross-city Line for Suburban Trains

Intermodal terminals are not necessarily situated at a convenient location for pedestrians. Jack London Square Station in Oakland and Diridon Station in San Jose are two examples. Stage 3A adds a location critical component. It leverages the "quarter mile rule" to achieve pedestrian mode integration. In a typical configuration, **S**uburban Rail (**S**-Bahn, **S**-Linien, linee **S**, or **S**-Tog, among other designations) converge onto a central axis through downtown with stations conveniently located in areas of highest trip end density and then diverge again on the other side of the city. Stage 3A is the state of the practice for most of the First World's larger cities. Metropolis like Paris or Seoul have suburban train lines crisscrossing their urban core. Other major cities with populations exceeding one million usually have a single downtown tunnel through which all or most suburban rail lines are funneled. Smaller cities had to advance to Integration Stage 5 in order to achieve downtown pedestrian integration and resultant high commute travel market shares for public transit.

In addition to maximizing ridership, the cross-city line solution has significant operational advantages. With a 90 s headway (achieved in a few cities) the capacity is 40 trains per track per hour. Even with a more realistic 3 min headway the throughput is still 20 trains per hour in each direction or 40 trains/h for a 2-track station.

Compare this to the proposed Caltrain arrangement at the Transbay stub-end terminal. Each inbound train would occupy a track for 30 min before leaving again for its outbound run. That adds up to 2 trains per hour per track, or, for the two tracks assigned to Caltrain, a total of 4 trains per hour both inbound and outbound. This is merely $1/10^{th}$ of the capacity of a through station. As a result only 4 out of the 10 rush hour trains per hour envisioned for 2025 will be able to serve the Transbay Terminal (*8*, Appendix K).

Cross-city lines also have a significant urban development advantage: high public transport capacity using a small footprint. BART's Market Street Tunnel in San Francisco and Philadelphia's Center City Commuter Tunnel are the only two examples of Stage 3A integration in the United States.

Stage 3B – Cross-city Line for Suburban and Intercity Trains

The earliest implementation of Stage 3B Integration may have been Berlin. In 1882 most of Berlin's eight terminal stations were connected with a 4-track cross-city line (Stadtbahn). Two tracks each are dedicated to suburban and intercity lines.

Brussels and Tokyo are two additional examples of long distance trains making more than one downtown stop, in both cases using underground connections.

Stage 4 – Pulsed Hub System or Seamless Transportation

The genius of a Pulsed Hub System, which was perfected in Switzerland, is the ability to offer timed transfers at many hubs, rather than just at a single hub (*9*). Pulsed Hub Systems, also called Integrated Timed Transfer (ITT), integrate *all* modes of public transport in a large region, not just a single metropolitan area. In the case of Switzerland the large region is the whole country.

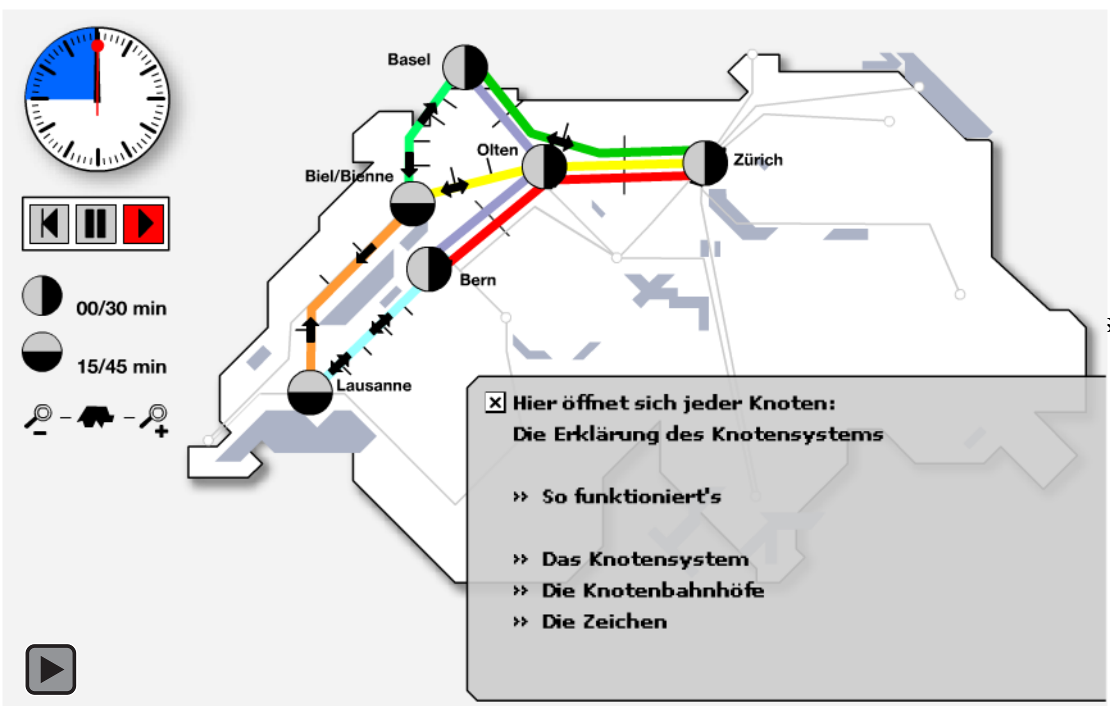
Pulsed hub systems add *temporal* integration to the spatial integration of intermodal terminals. They do not need cross-city lines for either suburban or intercity lines, but they presuppose intermodal terminals specially designed for quick transfers (Integration Stage 2B) and an extreme adherence to schedule.

Pulsed hub systems have not been implemented in the United States as of yet, partly because passenger trains running on freight railroads would probably not be able to maintain the schedule reliability needed to achieve timed transfers at many hubs simultaneously and on a consistent basis. This points to a lack of synergies between heavy freight and passenger movements.

Rail freight infrastructure and rolling stock is optimized for heavy cargo traveling over long distances relatively infrequently. Suburban trains operate with high frequency over short distances with light axle loads. Single versus double track, electric versus diesel, schedule reliability, rate of acceleration, distance between stations, platform heights, etc. are all examples of conflicting needs. The easiest way to distinguish between suburban rail like BART or the Long Island Railroad and traditional American commuter service may be by looking at what rolling stock and infrastructure were optimized for.

Much money has been spent to upgrade freight tracks to passenger standards. This appears to be a "stub-end" investment because it cannot be leveraged to have the service naturally progress to the next logical level of integration, from spatial to temporal integration.

In contrast, investment into dedicated passenger rail infrastructure, like HSR, can easily be guided towards the implementation of temporal integration. This means the time has come to seriously consider pulsed hub systems in the United States.



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Stage 5 – Convergence or "One-Seat-Ride"

The old paradigm has always been to optimize rail systems for one particular application like airport people movers, urban transit like MUNI, regional rapid transit like BART, and intercity transportation like high speed rail. "The right technology should be used with the right corridor." This is akin to saying that people would want to carry a separate cell phone, beeper, PDA, camera, and mobile internet device on their belt, because each gadget is better at what it is specifically designed for than a piece of equipment combining all of the functionality in one unit.

Nobody in the consumer electronics industry questions the new paradigm. But proposals for "one-seat-rides," like the people mover from John F. Kennedy Airport (JFK) to downtown Manhattan, remain very controversial. Convergence adds *modal* integration. JFK's people mover, LIRR's suburban line, and New York City Transit Authority's subway system are merged into a single mode for the proposed connection.

Karlsruhe Model

Probably the best known example of convergence is the Karlsruhe model. Karlsruhe is a medium sized city in Germany with a central station not within walking distance of the downtown business district. Due to the size of the city, building a cross-city line was not an option. The solution was to use specially modified dual system LRT rolling stock for suburban lines. Trains run on main lines outside of the city and then switch to surface streets once they reach the center. The result was a 400% increase in ridership. Interurbans in the United States before World War II operated on the same principle: combining light rail and suburban rail.

Asia has many examples of combining heavy rail suburban electrified commuter service with rapid transit by means of a large number of cross-city lines. In Seoul, Korea the suburban train network is seamlessly integrated with the urban subway system. The only indication of a train crossing the boundary between Korean National Railways and Seoul Metropolitan Transit Authority is that lights go out and the air conditioning stops for a few seconds while the source of power shifts from one agency to the other. Amsterdam is an example of combining light rail and rapid transit (*10*).

There are many more examples of *modal* integration, but the following proposal goes a step further. It would integrate HSR with the suburban train network.

"Hub-on-the-Run"

Consider for example a high speed rail line linking Northern and Southern California including several access branches at both ends (FIGURE 3). If a train was to be split into 4 different pieces, each part serving 4 distinct stations, one single train could connect 16 points in Northern California with 16 points in Southern California for a total of 256 (!) distinct suburb to suburb connections. If a train was only to be split into 2 pieces, which is standard operating procedure today in many countries, a single train could still serve 64 origin and destination pairs. Note that HSR does not need two pointed noses in the middle of the train, nor are pointed noses required for conventional speed operation on existing commuter corridors. An excellent model for the dull-edged end of the high speed train fragment would be the Danish IC3 with hinged cabs designed for quick loading onto ferry boats.

It is not difficult to picture San Jose as the northern hub of this integrated HSR system.

Each branch does not have to follow a different corridor. One branch could represent express and another local, or skip stop service. HSR train sections would not necessarily operate in high speed mode

(V_{MAX} > 200 km/h) on the access branches, but the door to door time for the traveler (the only time that really matters) would still be shorter compared to transfers at each end point. But, most importantly, the trip would be considerably more attractive to the long distance traveler, given the extensive literature on transfer penalties even for commuters without luggage, but especially for travelers with baggage (*1*, pp. 26-32).

If such a system were to be built (sharing right-of-way or tracks with existing commuter rail systems on the access branches wherever possible), opportunities for complimentary land-use development could be substantial. The 16 access points depicted above for both Northern and Southern California (randomly chosen just for illustration purposes) would in a sense become mini-airports without the enormous space requirements of an airport. If transportation planning were to be properly coordinated with land use planning, these access centers could become the seed for a more auto-independent urban form in the Western United States.

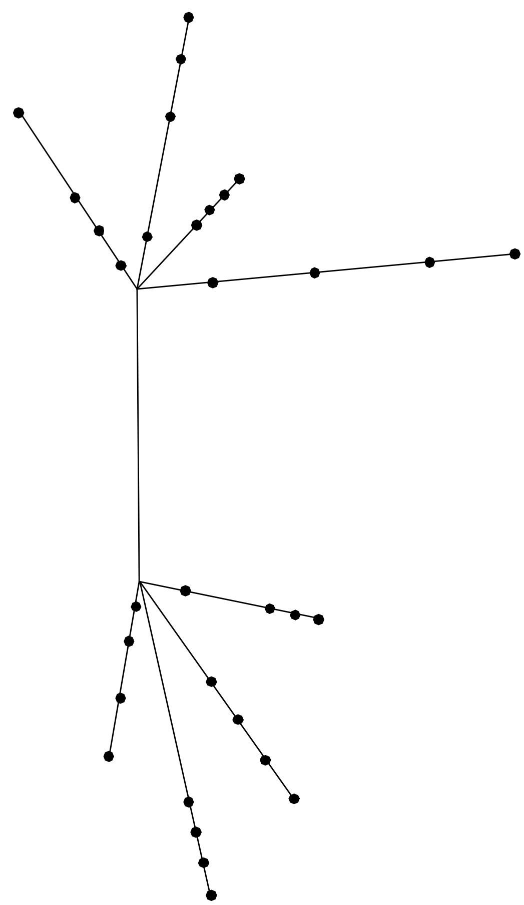

FIGURE 3 California corridor HSR system with access branches – "Hub-on-the-Run."

APPLICATION EXAMPLES OF INTEGRATION ANALYSIS – PRESENT SYSTEMS.

New York

With no Union Station New York is at Integration Level 0. It is however instructive to look beyond this simple categorization.

With 44 platform tracks on two levels Grand Central Terminal (GCT) is the largest railway station in the world. It is only served by Metro North commuter trains. However, the third stub-end terminal in Manhattan for the exclusive use of the Long Island Railroad is presently being constructed underneath GCT.

Pennsylvania Station is an example of a through station operated as two stub-end terminals. Instead of a through train e.g. from Babylon, NY to New Brunswick, NJ taking up a single slot, two separate trains are needed: a LIRR train terminating at Penn Station, and a NJ Transit train originating at Penn Station. This not only severely limits capacity, but it also necessitates midday storage yards to be located in or near the center of the metropolitan area (*11*).

Due to the alleged limited capacity at Penn Station, a fourth stub-end terminal in Manhattan close to Penn Station for the exclusive use of New Jersey Transit was being planned as part of the Access to the Region's Core (ARC) project. The stub end terminal was to be fed by a second Hudson Tunnel with no connection to Penn Station. Plus, the new station would not have been accessible via the original Hudson Tunnel. The project was cancelled in 2010 by the Governor of New Jersey for fears of cost overruns.

It is curious that while the rest of the world is building more and more cross-city lines and expending considerable resources to convert existing stub-end terminals to through stations (e.g. Stuttgart 21), more stub-end terminals for the exclusive use of individual railroad companies / transit agencies are still being built in the United States. That is pre-1882 Integration Stage 0.

New York is an extreme example of how powerful individual transit agencies are able to take advantage of weak metropolitan planning organizations and the lack of federal oversight to each obtain their own station, when a simple cross-city line would have been able to solve capacity problems much more efficiently.

Boston

South Station Boston is connected to the North Station by freeway. Since there is no rail connection Boston remains at Stage 0. As part of the "Big Dig" a cross-city line was proposed. The final compromise was to preserve the option of building the rail connection by driving the side walls of the freeway tunnel deeply into the ground. That would have made later excavation below the freeway level fairly straightforward. In the end this was not done either.

Washington, DC

Washington has a Union Station so it is at least at Stage 1. It also has the beginnings of a cross-city line for both suburban and intercity trains between Union Station and Alexandria via L'Enfant Plaza. With relatively little investment through running of diesel powered commuter trains could be established. However this would presuppose a level of cooperation between two different agencies (MARC and VRE) which may be hard to achieve in the United States. So Washington Union Station remains another through station operated as two stub-end terminals for commuter service.

DERIVING POTENTIAL SOLUTIONS FOR THE SAN FRANCISCO TO SAN JOSE SECTION OF THE CALIFORNIA HIGH SPEED RAIL PROJECT

1. Caltrain With or Without High Speed Rail

1a. Routine Application of a Proven Concept with no Visionary Components

Converting the present heavy rail diesel powered conventional commuter line to Interurban service using tram-trains (FIGURE 4 (b)) would enable Caltrain to firstly use the excess capacity in the SF Market Street Tunnel sharing it with MUNI and secondly take advantage of the underused LRT network in San Jose to directly serve downtown San Jose destinations. Just by making use of surplus capacity in San Francisco and San Jose, Caltrain could use the Quarter Mile Rule to its benefit, rather than let it become its downfall (TABLE 1). As a byproduct, Caltrain would become competitive for the considerable reverse commute traffic of Silicon Valley workers who want to live in San Francisco (*12*) and gain additional ridership at almost no incremental cost. As another byproduct the average speed would increase even if additional stations were added (TABLE 2).

TABLE 2 Performance Parameter Comparison between Conventional Commuter and Tram-trains

	Caltrain Transbay - Diridon	Karlsruhe Tram-train Öhringen - Achern	Tram-train vs Caltrain
Maximum Speed (km/h)	**130**	**100**	**23% lower**
Distance (km)	78	210	
Time (hours)	1.52	3.15	
Average Speed (km/h)	51.7	66.7	**29% higher**
No of Stations	21	71	
Average Distance between Stations (km)	3.7	3.0	**21% shorter**

MUNI operates 5 lines through its Market Street tunnel, 4 of which originate at the Embarcadero station. The minimum weekday peak hour headway is around 7 min. Only 22% of the length of the 213 m platforms in the Market Street tunnel is presently used for a typical consist of two articulated Ansaldo Breda cars (FIGURE 4 (c)). The length of the platform accommodates a consist of nine. Joining all lines into a single train of 9 cars would permit an allocation of two cars per line to four of the five lines Combining all lines into a single consist frees up eight train paths per hour in the Market Street tunnel.

Joining five inbound LRT lines in a very short time period would require a level of schedule adherence that is unrealistic. That is why Caltrain Interurbans would not be able to use the inbound tracks. In the outbound direction, however, only a single coupling operation at the Embarcadero station is required: the KT line from the direction of 4th and Townsend with the four lines that originate at the Embarcadero station, ready for departure before the KT train arrives. In case of delays the spacing between Caltrain Interurbans and the KT line can be adjusted at the 4th and Townsend or the 3rd and King Street Station.

Using a low cost scenario, the only new rail construction needed would be a one mile street level single track connection from Market Street to the existing Caltrain right of way, and one ramp on Market Street out of the MUNI tunnel between Powell Street and Civic Center stations (FIGURE 4 (e)). MUNI's Civic Center station would be available to split nine car consists into five individual trains. There are no high rise buildings at the corner of Seventh and Market Streets, so more complex solutions could also be considered.

The similarities between the above proposal and the Dutch RandstadRail project are striking. It involved the conversion of two heavy rail lines into light rail, in addition to creating connections with Rotterdam's (San Francisco's) metro and The Hague's (San Jose's) LRT network for through running. Heavy rail has effectively been declared obsolete as an option for suburban commuter lines in the Netherlands (*13*).

RandstadRail was completed in August of 2010, and its 2010 ridership is projected to be 300% above 2002, the year construction began (*13*). This is in line with the 475% increase in ridership achieved in Karlsruhe in just a few weeks after the opening of the first dual-system tram-train line (*Stadtbahn*) in 1992 (*14*) .

1b. Opportunity for a State of the Art System

There are no good reasons why passengers have to transfer between airport people mover and local transportation rail vehicles. LRV's with a turn radius of 15 m are able negotiate all people mover alignments. Their operation on airport property could probably as easily be automated as those of other rail vehicles. Those trains continuing on to destinations outside the airport would later switch back to manual mode.

One seat rides from the terminal to stations directly across from downtown hotels would probably negatively impact airport revenues from parking and other fees. How to compensate the airport for the revenue loss may be a bigger obstacle than to retrofit a LR vehicle for driverless operation.

BART is serving San Francisco International Airport from the North. It cannot go beyond the International Terminal. Caltrain would serve the airport from the South via the "ghost track" (FIGURE 4 (d)) between Millbrae and the International Terminal and could then continue on to the other terminals. However losing its "ghost track" would require BART to run separate trains to the airport and to Millbrae during evenings and on weekends as well.

2. Caltrain With High Speed Rail Integration

2a. Routine Applications of a Proven Concept with no Visionary Components

Pulsed Hub System to Achieve HSR-Interurban Synergies and Integration Present Baby Bullet passing tracks will be absorbed by the Peninsula High Speed Rail line (*15*). Caltrain losing its most popular and profitable service presents an opportunity for HSR-Caltrain integration. With both spatial (cross platform transfer without fare barrier) and temporal (pulsed hub system) integration, many connections would actually improve due to the higher speed of the new regional express system.

The beginnings of a Pulsed Hub System are already discernable. HSTs will travel about half an hour from San Francisco to San Jose. The "half way point" (15 min from San Francisco and 15 min from San Jose) may be in Redwood City. With clockface scheduling and a frequency of 4 trains/h, Caltrain could arrive in Redwood City on the hour, and at 15 min, 30 min, and 45 min after the hour. With a run time of either 45 min for all-stop, or 30 min for limited stop service between Redwood City and San Jose, Caltrain would also arrive at San Jose Diridon Station on the hour, and at 15 min, 30 min, and 45 min after the hour. This would only require a single hourly High Speed Train that would be able to meet Caltrain in both Redwood City and San Jose Diridon for a quick cross platform transfer. 30 min or 15 min intervals would of course be preferable.

Synergies, among others, derive from the fact that many HSR passengers will only travel as far as San Jose. This results in empty seats between San Jose and San Francisco available for regional express service.

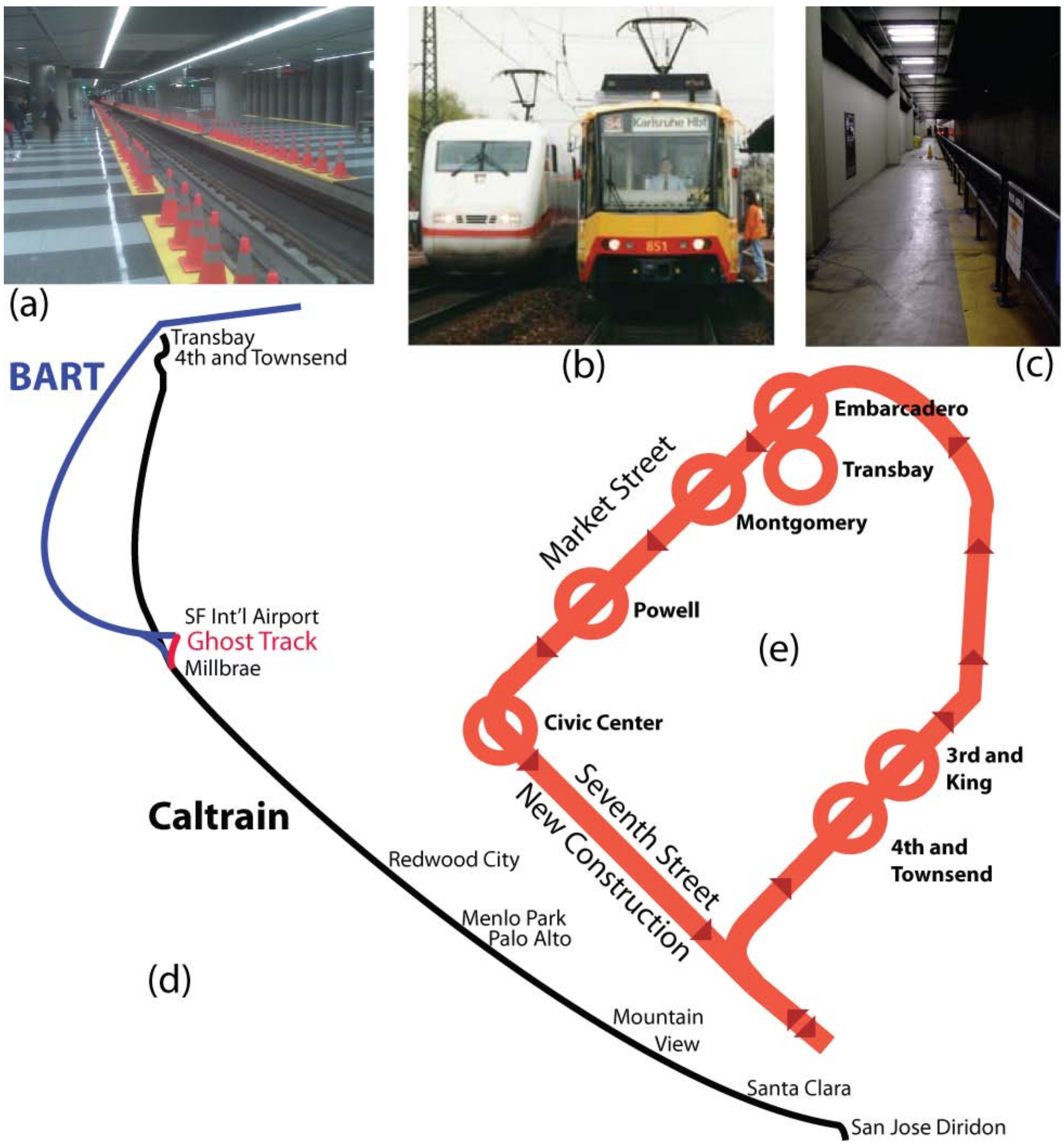

FIGURE 4 Caltrain and BART.

The author has not seen any mention of pulsed hub systems in documents published by or on behalf of the California High Speed Rail Authority. This is particularly unfortunate. If a multi-stop high speed train gets into a regional hub like Fresno 2 min too late, because at one location a curve radius of 2500 m instead of 4000 m was chosen, or the turn off speed of a single switch is too slow, or the bypass of one particular town is 1 mile too long, later modifications to enable temporal integration at that hub would probably be cost prohibitive. If the shortest travel time between SF Transbay and Los Angeles Union station was to be 2:32 hrs instead of 2:29, either one of the two terminals could not be operated as a pulsed hub anymore.

Of all of the European best practices, this one is likely to be the most risky to be ignored by the California High Speed Rail Authority.

Direct Access to San Francisco International Airport to Achieve HSR-Air Transportation Synergies and Integration The competitive advantages of HSR over air are sometimes so compelling that airlines themselves prefer to use trains. Paris – Brussels or Cologne – Frankfurt are but two examples. To achieve a European level of integration between HSR and air transportation, high speed trains need to go *into* the airport and not require another Millbrae type transfer. In this case again, substantial ridership and revenue may be gained using already existing surplus capacity. The "ghost track" (FIGURE 4 (d)) between Millbrae and the International Terminal could be shared with Caltrain. Airport bound high speed trains would then terminate on the one platform track in the BART airport station which has never been used (FIGURE 4 (a)).

International passengers originating in or destined for the Central Valley would be the most likely market segment served by the direct HSR airport connection. The International Terminal BART station is closer to the check in counters than most gates. Additionally, travelers coming from overseas would not have to go through a security check again.

What will give airlines the incentive to use trains? Airports in the United States by and large are not slot controlled as in Europe, where airlines want to use their limited number of slots for more profitable international flights.

An interesting scenario is likely to play out where initial competition will lead to complementarity. As passenger numbers dropped after the introduction of Acela service between New York and Washington, airlines opted to use smaller planes while maintaining the same level of frequency. This strategy will be difficult to follow in Central Valley to San Francisco markets, where very small planes are being used to begin with. Once a market cannot be operated profitably anymore, airlines have a choice to either abandon it or share space on HSTs. If HSR service to the airport was competitive with the automobile, some airlines may well choose the latter. Another point to consider is that SFO is projected to reach the limit of its runway capacity by 2025. Again, if HSR was to be competitive with the automobile, it would be a good substitute in some local markets.

2b. Opportunity for a State of the Art System

All passenger trains operating in the North East Corridor have the same floor height, which means any train can use any platform edge. This was particularly useful at Metropark-Iselin between New York and Philadelphia, which was built as a local station. It proved to be such a high ridership generator of long-distance traffic that many of the fast trains, including the Acela, get off the express track, stop at one of the two outboard platforms, and then merge back onto the express tracks. The Baltimore/Washington

International Airport station is another example. This operational and demand adaptive flexibility is only possible because all trains in the Northeast Corridor use the same platform height.

It is not easy to predict which cities on the Peninsula will generate the highest HSR ridership in the future. This is a good reason for designing the San Francisco to San Jose corridor such that any train can stop at any platform. But an even better reason for a common platform height is that no effort appears to have been made yet to establish which stations on the Peninsula would generate the highest HSR ridership *in the present*. Both the Metropolitan Transportation Commission (MTC) and the Southern California Association of Governments (SCAG) have detailed airport access data which precisely pinpoint the origins and destinations of air travelers in the California Corridor. This data has been used for many airport choice and airport ground access mode choice models (*16*). The author has not seen any mention of this data in documents published by or on behalf of the California High Speed Rail Authority. This is surprising considering that one of the competitive advantages of HSR is that this mode can directly serve areas of highest trip origin and trip end densities.

Unfortunately, decisions about station locations are mostly political in nature (FIGURE 1), which is probably the best reason for retaining all options for future HSR stops. It also gives the HSR operator flexibility in offering tailor made products. A "Silicon Valley Limited" may only stop between San Francisco and Los Angeles in Menlo Park, Palo Alto, Mountain View, and San Jose. As a spin-off, it would present a high quality travel alternative to San Francisco based reverse commuters.

This could make California HSR one of the most successful systems leveraging synergies with local train services, since not only corridors and tracks, but also platform edges would be shared. It would obviate the need for expensive Silicon Valley HSR stations without compromising service levels.

The visionary component is that platform edges would not just be shared between local and intercity heavy rail vehicles as in the Northeast Corridor, but between HSR and Interurban tram-trains, introducing a special set of technical challenges.

On the question of what exactly the common platform height would be, one only needs to look at China, which, following in Japan's footsteps, adopted a standard HSR platform height of 1.25 m. This is probably the future world standard for HST floor height. California's state of the art integrated transportation system could make it the world standard for almost all rail vehicles.

INSTITUTIONAL CHALLENGES

Why does California High Speed Rail planning stop at Stage 2A Integration - Intermodal Terminal with agency demarcation lines? Why are best practices beyond Level 2A Integration being ignored?

Systemic Problems in the Planning of High Speed Rail Projects

Referring back to the beginning of the paper, given the typical triple focus on engineering/capital costs, ridership/operating costs, and environmental impacts, it is not clear where in this process the system would be analyzed as a whole (FIGURE 1). It is unclear at which stage of the process important results published in the mode choice literature of the past 40 years like transfer penalties and the Quarter Mile Rule would be taken into account.

A possible solution would focus on much more powerful metropolitan planning organizations and stricter federal oversight.

Weak Institutions

With individual transit agencies strong enough to each demand and obtain approval for their own stub end terminal in New York City, and none of the properties in the United States being forced to submit to a common regional fare system in spite of heavy Government subsidies, it would be hard to imagine them sharing their infrastructure. The standard response to be expected is “It won’t work.” The standard answer could be “Why does it work where best practices are being applied?”

This would require much more powerful metropolitan planning organizations and stricter oversight by Federal grantors.

Proposition 1A

This voter approved initiative authorized a single HSR line, not an integrated transportation system. An excessive focus on feeder services on the part of the California High Speed Rail Authority could be construed as being unresponsive to the voters’ mandate.

Regulatory Challenges

Federal Railroad Administration (FRA)

With a preponderance of heavy freight traffic, North America has a different approach to railway safety than the rest of the world: passive versus active safety, accident survivability versus accident avoidance, crashworthiness versus positive train control, … But in a giant step forward on 27 May 2010, the FRA granted a waiver allowing Caltrain to operate both FRA compliant and standard European passenger trains without temporal or spatial separation. (A temporal separation of freight trains in the corridor is still required).

In order to run Interurban tram-trains and HSTs in the same corridor at the same time, another waiver would be required, continuing on the path of substituting active safety for passive safety. Tram-trains obtained approval by most European railway authorities to operate concurrently with heavy rail vehicles, because their higher active safety could compensate for their lower passive safety. While tram-trains are designed to lower crashworthiness standards, they have shorter braking distances, in other words better accident avoidance properties. Most European railway authorities does not mean all. In the Netherlands heavy rail equipment is not allowed after a line has been converted to LRT operation (*13*).

The FRA would have to agree with most of their European counterparts.

Transportation Safety Administration (TSA)

HSR stations on the Peninsula are being designed with airport style security screening facilities (*17*). This worldwide unprecedented move seems counterintuitive, since terrorists prefer locations where they can kill the most people, e.g. crowded commuter trains. Spain has one of Europe’s best HSR systems, yet terrorists chose to bomb a commuter train in Madrid on 11 March 2004.

If airport style screening is adopted, HSR would lose almost all of its ability to leverage synergies with local and regional transportation. A special overlay of regional express trains would have to be created in the same corridors which HSR serves. Many passengers would detrain in San Jose, but Caltrain would continue to have to run its Baby Bullet trains, which

1) would be much slower than HSTs

2) would result in six tracks at many locations (due to the speed differential Baby Bullets are unlikely to be able to use HSR tracks), and

3) would need additional equipment to run Baby Bullet trains in spite of surplus capacity on HSTs serving the same corridor.

The waste of public funding would be substantial.

CONCLUSIONS

Without the institutional framework in the United States to even achieve a European level of integration, and at the same time requiring a much deeper level due to the absence of large central stations and the widely dispersed nature of its metropolitan areas, the California High Speed Rail system will almost certainly not reach its full potential.

This does not mean that HSR will not be successful in California. But it does mean that by default it is destined to degrade into a very fast connection between huge parking lots.

Unless grass roots citizen activist groups are able to counteract the official planning process and supply the missing bird's eye perspective, the California High Speed Rail system will only have a limited ability to rebalance the state's transportation system. This in turn would reduce the constituency which benefits from HSR construction, leaving the California High Speed Rail Authority more vulnerable to political attacks in the face of a Republican controlled Congress.

Even though the public at large is not as familiar with best practices overseas as professionals are, the "wisdom of crowds" (*18*) tends to converge on those exact same best practices.

REFERENCES

1. Clever, R., *Airport and Station Accessibility as A Determinant of Mode Choice*, Dissertation in Civil Engineering. 2006, University of California: Berkeley, Calif. pp. XVI, 300. http://thinkMetric.com/diss
2. Central Transportation Planning Staff, *Transfer Penalties in Urban Mode Choice Modeling*, US Department of Transportation, Federal Transit Administration: Washington, D.C.
3. Harvey, G., *Analyzing Airport Access in a Multiple Airport Region*, National Research Council, Transportation Research Board.
4. *2008 BART Station Profile Study*, Bay Area Rapid Transit District: Oakland. http://bart.gov/docs/StationProfileStudy/2008StationProfileReport_web.pdf
5. *Caltrain Annual Passenger Counts*. February 2008, Caltrain: Oakland. http://www.caltrain.com/pdf/annual_ridership_counts/2008_Caltrain_Ridership_Counts.pdf
6. Holstege, S., *BART schedule to change Monday*, in *Oakland Tribune*. 2004: Oakland.
7. Homburger, W.S. and V.R. Vuchic, *Federation of Transit Agencies as a Solution for Service Integration*, Institute of Transportation and Engineering, University of California: Berkeley, Calif.
8. California High Speed Rail Authority, *Preliminary Alternatives Analysis Report for the San Francisco to San Jose Section*. April 2010: Sacramento. http://www.cahighspeedrail.ca.gov/lib_San_Francisco_San_Jose.aspx
9. Clever, R., *Integrated Timed Transfer: a European Perspective*. Transportation Research Record, 1997. **1571**:109-115. http://thinkMetric.com/pubs/itt
10. Geissenheimer, H.H., *New Vehicle Options for Lower-Cost Rail Mobility*. Transportation Research Record, 1997. **1571**:125-133.
11. Haikalis, G. (2008) *Regional Rail and Real Estate*. Trains of Thought. http://www.trainsofthought.com/realestate.pdf

12. Swift, M., *San Francisco gaining computer workers*, in *San Jose Mercury News*. 2010. http://www.mercurynews.com/ci_16460241?IADID=Search-www.mercurynews.com-www.mercurynews.com&nclick_check=1
13. Vosman, Q., *RandstadRail emerges from the shadows.* International Railway Journal, 2010. **50**(10):44-47.
14. *A 2007 Presentation on Valley Rail*. 2007, Last updated: 2009-06-25, Last accessed: 2011-01-20; Available from: http://www.railforthevalley.com/latest-news/zweisystem/a-2007-presentation-on-valley-rail-by-the-light-rail-committee/.
15. *Preliminary Alternatives Analysis Report for the San Francisco to San Jose Section.* April 2010, California High Speed Rail Authority: Sacramento. http://www.cahighspeedrail.ca.gov/lib_San_Francisco_San_Jose.aspx
16. Lunsford, M.E. and G.D. Gosling, *Airport Choice and Ground Access Mode Choice Models: A Review and Analysis of Selected Literature*, Institute of Transportation Studies, University of California: Berkeley, Calif.
17. Tillier, C., *Station Design 101* in *Caltrain HSR Compatibility Blog*, C. Tillier, Editor. 2010. http://caltrain-hsr.blogspot.com/2010/10/station-design-101.html
18. Surowiecki, J., *The Wisdom of Crowds*. 2004, New York: Doubleday. 296.