Integrating HSR into North America's Next Mobility Transition

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Abstract

The American Recovery and Reinvestment Act of 2009 has opened a window for implementing high-speed passenger rail operations in the U.S. by allocating $8 billion to jumpstart both comprehensive and incremental development efforts. Because North America had never pursued high-speed rail as a national transportation priority, the planning framework for designing such services and linking them to the national transportation system was never created. An intermodal integration strategy will thus have to be developed in parallel with the designs for new high-speed train services, if these projects are to achieve their potential.

Connecting these new high-speed passenger rail routes to airport, highway, and transit infrastructure and integrating train operations with aviation, transit and vehicular travel will facilitate future use of high-speed trains and enable high-speed rail supportive land uses to evolve. But designing tomorrow's high-speed rail to fit into today's air and surface transportation network would yield suboptimal results. A successful intermodal integration plan for high-speed rail will need to anticipate evolution in air and surface transportation modes that will adapt to the energy and climate challenges shaping future mobility.

A five-step 'energy first' mobility planning tool is proposed to assess the extent to which energy and environmental factors could spur the redesign of transportation technology and organization. As much of the cheap and accessible oil that fueled mobility has been consumed, transportation modes that rely on oil are expected to decline, while modes that are energy efficient and can shift to other energy sources will increase considerably. Electrically powered passenger trains offer the opportunity to create a new model railroad that moves intercity passenger travel beyond carbon-based fuels more quickly than alternative technologies. Electric trains' post-carbon energy shift is particularly advantageous because it can occur through an incremental adaptation of current passenger services, a comprehensive transformation using high-speed train technology, or a combination of both these trajectories.

Given both higher levels of mobility and more diverse spatial dynamics of settlement and commercial activity in North America, compared to Europe, high-speed rail station designs will need to adapt and expand the European innovation of providing multiple options for air, auto and rail connectivity along a high-speed rail corridor. Four different station types will be needed to implement the full range of intermodal connections in North America. These include the city center and airport stations that are prominent in Europe, as well as stations at suburban business parks and at regional shopping centers.

Three types of policy tools need to be applied to maximize the synergy between high-speed rail, other mobility modes and local land use. First, legal and regulatory innovation could enable high-speed rail projects to overcome current development constraints posed by private railroad ownership. Creating a legal capability to separate infrastructure asset ownership from the title to the railroad right of way that it occupies would open the door for fruitful public-private partnerships. Second, the excise tax regime that has been used

to fund America's airport, highway and transit infrastructure will soon need to be overhauled to accommodate the shift to new energy sources and greater fuel efficiency. When this happens, intercity passenger rail needs to be brought into the circle of infrastructure funding, as both a contributor to and a beneficiary of public finance. Taxing high-carbon transport fuels and low-efficiency vehicles could provide the transitional funds to continue the high-speed rail developments for which the Recovery Act's $8 billion represents just a first stage of support. Third, new organizational structures will need to be created to link the planning, building, and operation of America's future high-speed trains with state and local transportation agencies on an ongoing basis, moving beyond project-specific initiatives.

1. 'Ready, Fire, Aim' – launching America's high-speed rail development outside an established policy framework

America's recent implementation of a federally funded high-speed rail development program has opened a policy window for better connecting intercity travel by rail with driving, flying and local public transportation. These connections will require advancing beyond the longstanding political stalemate over the role that passenger trains should play in American transportation. In the Northeast, passenger trains already carry significant numbers of travelers along the Boston – New York – Washington Northeast Corridor. But beyond the Northeast, passenger trains occupy a much smaller market niche, in part because they operate over privately owned tracks that are designed for, and used primarily by, freight trains. Whether the Northeast's configuration of predominantly passenger rail infrastructure should represent the 'floor' or the 'ceiling' in America's transportation goals has been the subject of protracted and inconclusive debate since the 1970s.

Perennial conflict over whether to preserve or eliminate federal spending on Amtrak has played out in the federal budget making process, since passenger trains are the only transportation mode that does not have a dedicated revenue stream coming from excise taxes (e.g., the federal gas tax, or airline ticket taxes). Amtrak's supporters and skeptics have fought recurrent battles in the halls of Congress that consumed (among other things) the available political capital that might have been devoted to designing a policy framework that integrates passenger trains into the planning and financing institutions that support the rest of America's passenger mobility. (Perl, 2002: 99) Instead, the 1980s and 1990s became lost decades when it came to finding a place for passenger trains in federal transportation policy.

During these two decades, project-specific initiatives to introduce high speed trains beyond the Northeast were pursued by a handful of state governments, without the support that a national policy framework offered in developing airports, roads and transit. Various financial and organizational formulations were created ranging from a publicly led initiative in Ohio (Perl, 2002:158 - 161) to privately led efforts in Texas (Robey, 1994) to joint ventures in which private promoters partnered with the state of Florida to advance high-speed rail projects. Each pursuit of high-speed rail failed to deliver any trains. Among other revelations, these false starts with high-speed rail highlighted the challenge of initiating such projects in the absence of a policy framework that could provide clear 'rules of the game' for building, and rebuilding, rail infrastructure. Without such guidance Washington, state and local governments, as well as the private sector railroads that owned all the relevant rights of way were left to negotiate custom-made financial and operational arrangements. None of these stood the test of time. This paper will examine the challenges and opportunities for (re)developing rail infrastructure and (re)connecting it to established road, air and public transit systems that each occupy an established place in national transportation policy.

The introduction of $8 billion in federal grants for passenger rail development made available through the American Recovery and Reinvestment Act of 2009 has brought a long absent momentum to the question of how to plan, build and operate modern intercity passenger train services. However, still absent is a national policy framework to guide investment in the needed infrastructure, whether incremental upgrades to conventional tracks or stand-alone new high-speed rail corridors. Thus, questions of ownership, control of planning and construction efforts, regulatory oversight and future operating arrangements are all open for deliberation in each of the projects moving forward to implementation. Who will lead these efforts, what the goals will be and who will follow the leader remains to be seen in each project, and the answers are certain to differ from project to project.

Within the Northeast, where publicly owned rail infrastructure predominates, existing tracks are mostly ‘full’ of local trains operated by regional commuter entities like NJ Transit, Metro North Commuter Railroad and the Long Island Railroad. Beyond the Northeast, rail infrastructure is owned by a small number of large freight carriers who see limited economic opportunity, and considerable risk, in expanding their facilities to move more passengers. Figuring out how to build high-speed rail into both kinds of existing railroad infrastructure, and then connect the resulting services with air, road, and transit systems poses a planning challenge of the highest order.

Not only must new physical, fiscal and operational arrangements be reached to connect roads, transit and aviation with intercity passenger trains on an infrastructure that does not yet exist (in the form that would accommodate higher speed trains), but the changing role of each non-rail mode must also be anticipated in order to assure an effective fit. A double dose of prescience will be needed to anticipate a future in which passenger trains are ‘reinvented’ to move many more people than currently occurs, at the same time that new energy sources will be introduced to vehicles using America’s road network (e.g., electric vehicles) and new business models will be applied to adapt the airline industry to the end of cheap oil.

This paper adopts the premise that major transformations in the way that people and freight move are likely to occur within the coming decade. These ‘transport revolutions’ will be driven by energy and environmental factors that impel the redesign of both transport technology and organization in order to sustain today’s levels of mobility (Gilbert and Perl, 2010) In *Transport Revolutions: Moving People and Freight Without Oil*, Richard Gilbert and I have proposed an ‘energy first’ planning framework that can be applied to gauge the magnitude of future changes as well as the trajectory of such changes.

In this framework, the increasing geo-political, economic and environmental risks of fueling mobility with oil are expected to yield a disruption of oil's virtual monopoly as a transport fuel. Currently, oil powers close to 95% of global mobility (Gilbert and Perl, 2010: 112) The U.S. Department of Energy (Davis, *et. al.*, 2009: 1-18) note, 'Transportation accounts for more than two-thirds of the U.S. petroleum use.' This means that when petroleum use becomes more problematic, the impacts and consequent changes in the transportation sector will be proportionately greater than in other economic sectors.

Transportation options that are either energy efficient or adaptable to alternative energy sources can be expected to grow, while those that depend exclusively on oil will decline. In this perspective, use of passenger trains, which offer *both* energy efficiency and a straightforward energy substitution through electric power generated by energy sources other than oil, can expect to grow considerably in future. Table 1 provides an estimate of the energy consumption per passenger-mile of America's main travel modes produced by the Oak Ridge National Laboratory. It highlights the energy advantage for rail, an advantage that is claimed to increase further for electrically powered high-speed trains. An article in *Popular Mechanics* (Quain, 2007) claimed energy consumption of 1,200 BTU per passenger-mile for high speed trains already in operation, suggesting that state of the art electric intercity passenger trains would be at the low end of rail's energy consumption. Section 2 considers two methods of change that could arise as the United States moves ahead with large-scale passenger rail improvements.

Table 1
Energy Use by U.S. Passenger Modes, 2007

	Number of vehicles (thousands)	Vehicle-miles (millions)	Passenger-miles (millions)	Load factor (persons/ vehicle)	Energy intensities (Btu per vehicle-mile)	(Btu per passenger-mile)
Cars	135,932.9	1,670,994.0	2,623,461.0	1.6	5,517.0	3,514.0
Personal trucks [a]	89,286.4	928,755.0	1,597,459.0	1.7	6,788.0	3,946.0
Motorcycles	7,183.5	13,612.0	16,334.0	1.2	2,224.0	1,853.0
Demand response [b]	64.9	1,471	1,502	1	16,771	16,429
Buses	b	b	b	b	b	b
Transit	65.8	2,314	21,132	9.1	39,408	4,315
Intercity [d]	b	b	b	b	b	b
School [d]	677.2	b	b	b	b	b
Air	b	b	b	b	b	b
Certificated route [e]	b	6,122	595,327	97.2	301,684	3,103
General aviation	231.6	b	b	b	b	b
Recreational boats	13,078	b	b	b	b	b
Rail	19.7	1,333	35,007	26.3	67,900	2,586
Intercity (Amtrak)	0.3	267	5,784	21.7	54,585	2,516
Transit (light & heavy)	13	741	18,070	24.4	62,833	2,577
Commuter	6.4	326	11,153	34.2	90,328	2,638

[a] Includes passenger cars, vans, and small buses operating in response to calls from passengers to the transit operator who dispatches the vehicles.
[b] Data are not available.
[c] Energy use is estimated.
[d] Only domestic service and domestic energy use are shown on this table. (Previous editions included half of international energy.) These energy intensities may be inflated because all energy use is attributed to passengers–cargo energy] use is not taken into account.

Source: Davis, *et. al*., 2009

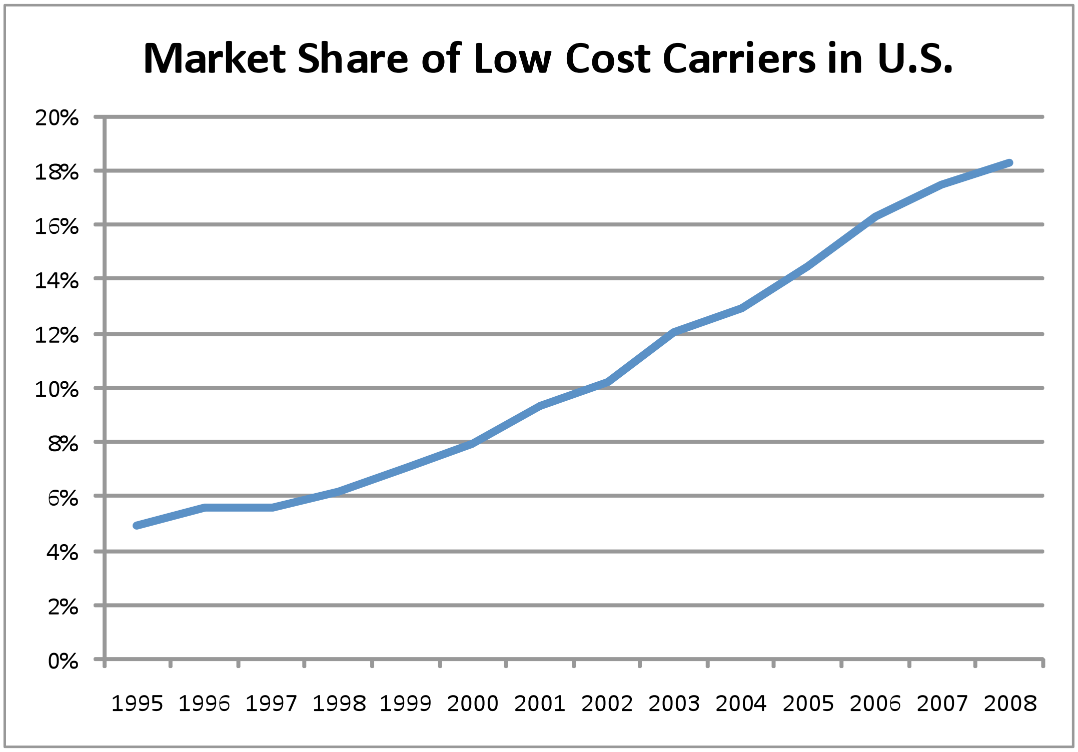
2. Two trajectories toward the 'new model railroad': incremental and comprehensive

Creating a new model railroad that could reorient America's 'fly-drive' intercity travel paradigm to shift a growing volume from road and air to trains will likely proceed along either, or possibly both, of two trajectories. Sketching the broad outline of these trajectories will reveal how they would entail different relationships with local and regional transportation connections. One path to a new model railroad for intercity travel in the United States would be pursued through **incremental adaptation** of the organization, infrastructure and technology that supports current intercity rail passenger services. This transformation would be akin to the reorientation of air travel following arrival of the low cost carrier (LCC) business model.

The LCC business model presented a travel offering (e.g., no-frills flying) that is different in degree, but not in kind, from what was already available to the traveling public from established airlines, which have become known as 'legacy' carriers. LCCs used the same technology and infrastructure that the legacy air carriers operate with, but organized their use of those inputs around a different business model. LCCs did not try to accomplish as much with their aircraft and terminals as legacy carriers do. Southwest Airlines or JetBlue Airways do not offer first class cabins, do not serve hot meals, do not provide airport lounges and do not participate in global alliances with carriers on other continents. Instead, they do focus on providing reliable and comfortable flights which include snacks and checked baggage. Delivering consistent performance on these parameters earns both carriers high customer satisfaction and a considerable following.

As shown in Figure 1 below, LCC traffic in the U.S. has grown steadily from the mid-1990s, having more than tripled in volume from a 5% share of domestic flying in 1995 to surpass 18% in 2008. (MIT Global Airline Industry Program, 2010)

Figure 1 – Market Share of Low Cost Carriers in the United States



The passenger rail analog to LCC's steady rise in air travel market share can be found in the efforts of some state governments to enhance Amtrak operations within, and even beyond, their borders to provide service innovations that draw more riders to the rails. Just as LCC's drew some travel from cars and buses through their enhanced value proposition, as well as inducing demand for trips that had previously been priced beyond discretionary travel budgets, state sponsored passenger rail enhancements sought to grow rail travel through a mix of modal shift and induced demand. A significant difference between the LCC business model and the state-led passenger rail development initiatives was that airport terminals were usually better integrated into local road and transit networks than were passenger rail stations.

State-sponsored passenger rail service enhancements have occurred through increased speeds (though still well below the global understanding of high-speed), increased frequencies, and enhanced connections with buses that bring service closer to travelers' origins and destinations. Providing these local bus connections has usually proven easier than convincing local transit agencies to provide greater access to intercity train stations. Table 2 presents recent ridership for these specialized state services, which have on the whole grown faster than Amtrak's overall ridership.

Table 2
Passenger Volumes on State-Enhanced Amtrak Operations in North Carolina, California and the Pacific Northwest

North Carolina	FY09	FY08	FY07	%change vs. 08	%change vs. 07
Carolinian	277,740	295,427	256,212	-6	8.4
Piedmont	68,427	65,941	50,551	3.8	35.4
California					
Pacific Surfliner	2,592,996	2,898,859	2,707,188	-10.6	-4.2
San Joaquin	929,172	949,611	804,785	-2.2	15.5
Capitol Corridor	1,599,625	1,693,580	1,450,069	-5.5	10.3
Pacific Northwest					
Cascades	740,154	760,323	674,153	-2.7	9.8
Total	27,167,014	28,716,407	25,847,531	-5.4	5.1

This strategy is embodied in the majority of initiatives supported, and dollars allocated, through the Federal Railroad Administration's (FRA) 'High Speed Intercity Passenger Rail (HSIPR) program,' which awarded $8 billion in grants for passenger rail development that had been authorized by the American Recovery and Reinvestment Act of 2009. A majority of these grants, totaling $4.5 billion out of $8 billion, were awarded to incremental upgrades of passenger services that will operate at speeds no higher than

110 miles per hour. Funds will go to upgrade existing track capacity, expand and upgrade stations and acquire new rolling stock. (USDOT, 2010)

If policymakers continue to pursue this approach, these upgraded intercity passenger trains would continue to operate on tracks shared with freight trains, and in some cases with regional and commuter trains. They could serve Amtrak stations that are already in operation, as well as new station facilities. Intermodal connectivity has been a major feature in some of the state enhanced services such as Amtrak California and the Cascades trains in the Pacific Northwest.

A second path to change aims at a more **comprehensive transformation** by introducing specialized high-speed train technology, new infrastructure needed to support it and a reorganized management structure. Working together, these attributes would yield a capacity to move large numbers of people by train, faster and with much less energy per passenger-mile, just as on the Boston – Washington Northeast Corridor today. This approach would require importing key elements of the high-speed revolution that has now swept Asia twice – first in Japan and then in Korea, Taiwan and mainland China, and has also spread across Western Europe. Characteristics of these systems are discussed in detail in Section 4. Table 3 shows the global deployment of such specialized high-speed rail operations. (UIC, 2009)

Table 3
Global High-Speed Rail System Development as of November 2009

	Miles in operation	Miles under construction	Miles planned	Total miles
Japan	1,525	367	363	2,255
China	1,345	5,015	1,804	8,165
France	1,164	186	1,627	2,978
Spain	995	1,380	1,059	3,433
Germany	799	235	417	1,451
Italy	545	0	246	791
USA	225	0	559	784
Taiwan	215	0	0	215
South Korea	205	51	0	256

Turkey	146	317	1,044	1,508
Belgium	130	0	0	130
Netherlands	75	0	0	75
United Kingdom	70	0	0	70
Switzerland	22	45	0	67

The 559 miles of high-speed rail in the United States that are noted as 'planned' include just two entirely new corridors. An 84 mile route between Orlando and Tampa would become the first phase of a Miami – Orlando – Tampa corridor. This project was awarded a $1.25 billion federal grant under the American Recovery and Reinvestment Act. An even more ambitious intrastate corridor aims to link the Bay Area with Southern California. This initiative received the single largest federal grant of $2.344 billion, which is being added to a $9 billion bond authorization that was passed in November 2008. These projects would bring passenger rail operating practices and management models to the United States in short order, because existing technology and established organizational arrangements are not capable of delivering the 186 to 220 mile per hour speeds which are envisioned for these systems.

Both the California and Florida high speed projects would create a new type of rail infrastructure in North America, one dedicated exclusively to intercity passenger rail operations. This new infrastructure would bring with it the need to connect high-speed trains with conventional intercity trains as well as roads, air and local public transit. Perhaps the most relevant U.S. experience with such a combination of newly built infrastructure and reorganized service delivery can be found in the 'high tech' heavy rail transit systems that were launched in the 1970s in the Bay area and the nation's capital. BART and the Washington Metro were developed to change the ways that people moved around their metropolitan regions. It took time for their effective integration with existing transportation options, both local public transit and auto travel through park-and-rides.

The new technology and service delivery models that BART and Metro introduced to their respective regions had to be fine tuned along a learning curve that was both technical and organizational. Both BART and the Washington Metro are now viewed as success stories by all but the most strident proponents of automotive transportation, but their contributions took decades to mature and become recognized as important drivers of change in their respective regions. These comprehensive packages of new technology and organization did not transform mobility trends and spatial dynamics overnight, but their cumulative impact has been considerable.

Plans for integrating passenger rail with other transportation modes must be designed to accommodate the very different dynamics of incremental and comprehensive redesign. The question of how far to go in anticipating progress along each path of change presents a key challenge for transportation planners across the United States. As suggested previously, the impending energy transition from oil to other sources will be a major influence on the pace of change in intercity travel during the creation of America's new model railroad(s). Whatever the actual speed of this transition, the energy-first planning framework presented in the following section will facilitate the adjustments that lie ahead.

3. Anticipating a game change in transportation strategy based on future oil production

Despite an ongoing debate regarding the exact timing of a peak in global oil production, evidence is mounting that we are on the threshold of a substantive change in the ways by which future oil will be extracted. As shown in Table 3, the 'low hanging fruit' of cheap and easily accessible oil has largely been consumed. Ghanta (2009) concludes that:

> Only 14 out of 54 oil producing countries and regions in the world continue to increase production, while 30 are definitely past their production peak, and the remaining 10 appear to have flat or declining production. Put another way, peak oil is real in 61% of the oil producing world when weighted by production.

Producing the world's remaining oil reserves will be both more costly and more risky than obtaining past oil supplies.

Table 3
2008 oil production in nations at or near their peak

Country	Peak Prod.	2008 Prod.	% Off Peak	Peak Year
United States	11297	7337	-35%	1970
Venezuela	3754	2566	-32%	1970
Libya	3357	1846	-45%	1970
Other Middle East	79	33	-58%	1970
Kuwait	3339	2784	-17%	1972
Iran	6060	4325	-29%	1974
Indonesia	1685	1004	-41%	1977
Romania	313	99	-68%	1977
Trinidad & Tobago	230	149	-35%	1978
Iraq	3489	2423	-31%	1979
Brunei	261	175	-33%	1979
Tunisia	118	89	-25%	1980
Peru	196	120	-39%	1982
Cameroon	181	84	-54%	1985
Other Europe & Eurasia	762	427	-44%	1986
Russian Federation	11484	9886	-14%	1987
Egypt	941	722	-23%	1993
Other Asia Pacific	276	237	-14%	1993
India	774	766	-1%	1995
Syria	596	398	-33%	1995
Gabon	365	235	-36%	1996
Argentina	890	682	-23%	1998
Colombia	838	618	-26%	1999
United Kingdom	2909	1544	-47%	1999
Rep. of Congo (Brazzaville)	266	249	-6%	1999
Uzbekistan	191	111	-42%	1999
Australia	809	556	-31%	2000
Norway	3418	2455	-28%	2001

Oman	961	728	-24%	2001
Yemen	457	305	-33%	2002
Other S. & Cent. America	153	138	-10%	2003
Mexico	3824	3157	-17%	2004
Malaysia	793	754	-5%	2004
Vietnam	427	317	-26%	2004
Denmark	390	287	-26%	2004
Other Africa	75	54	-28%	2004
Nigeria	2580	2170	-16%	2005
Chad	173	127	-27%	2005
Italy	127	108	-15%	2005
Ecuador	545	514	-6%	2006
Saudi Arabia	11114	10846	-2%	2005 / Growing
Canada	3320	3238	-2%	2007 / Growing
Algeria	2016	1993	-1%	2007 / Growing
Equatorial Guinea	368	361	-2%	2007 / Growing
China	3795	3795	-	Growing
United Arab Emirates	2980	2980	-	Growing
Brazil	1899	1899	-	Growing
Angola	1875	1875	-	Growing
Kazakhstan	1554	1554	-	Growing
Qatar	1378	1378	-	Growing
Azerbaijan	914	914	-	Growing
Sudan	480	480	-	Growing
Thailand	325	325	-	Growing
Turkmenistan	205	205	-	Growing
Peaked / Flat Countries Total	-	49597	-	**60.6% of world oil production**
Growing Countries Total	-	32223	-	**39.4% of world oil production**

Tapping the world's remaining oil reserves requires new, and substantially different, oil production infrastructure that can operate in extreme environments (e.g., five miles below the seabed or in polar regions). Deploying this new energy infrastructure, and responsibly decommissioning established infrastructure that will no longer be used once conventional oil reserves become depleted will increase the price of transport fuels. Learning how to manage that infrastructure safely presents new risks and challenges, as illustrated by the 'Deepwater Horizon' disaster and subsequent ecological catastrophe in the Gulf of Mexico. (Perl, 2010) There is thus considerable likelihood of future price increases in transport fuels derived from oil.

The effects of this price change will be uneven along at least two dimensions. First, the shift from producing conventional to unconventional oil will not proceed in a linear fashion. There will be price 'spikes', either because large investments need to be raised for this new infrastructure ahead of production, or because the absence of such investment will mean production declines with the depletion of conventional sources. In either case, the effects of higher oil prices across different transport modes will be uneven. The more oil-intensive a mode of travel is, the more it will be affected by future oil production trends. In these circumstances, high speed and conventional trains that are powered by electricity will have a growing competitive advantage over driving and flying.

With such major changes on the horizon for oil fueled transportation, a planning focus on energy can help delineate the trajectories of incremental and comprehensive passenger rail redevelopment. This energy-first scenario planning technique consists of five steps (Gilbert and Perl, 2010: 233). First, the parameters of how much to reduce oil consumed by the transport sector, and what time period to achieve that reduction should be selected. Second, current transport activity and energy use need to be estimated. Third, future transport modes and their energy consumption through the end period of the scenario will need to be anticipated. Fourth, a plausible balance of modes is developed to meet the oil reduction target in each year of the scenario. And fifth, the energy use estimates and proposed transport activity levels are continuously refined as data becomes available on actual performance during the time frame of the scenario. In one demonstration of this scenario technique used to illustrate how the United States could reduce the oil consumed by its transportation sector 40% between 2010 and 2025, the role of intercity passenger rail was projected to increase from the 5.6 billion passenger-miles actually recorded in 2007 to 373 billion passenger-miles in 2025. (Gilbert & Perl, 2010: 230) That growth would entail an exponential rate of development that builds upon the $8 billion recently allocated to incremental and comprehensive rail passenger development projects.

Energy-based scenario planning could be applied to both compare the trajectory between incremental versus comprehensive rail passenger redevelopment and better understand the relationship between these two approaches. Paradoxically, the sooner that oil prices spike and the more volatile they become during the scenario period, the more that an emphasis on incremental rail passenger redevelopment would be justified. This is because the high cost of new high-speed rail infrastructure would become less affordable in an economy that would be burdened, if not crippled, by one or more 'super spikes' in oil prices. The 2008 oil price spike is argued to have triggered the housing and financial sector meltdowns and subsequent global recession. (Cortright, 2008; Rubin, 2009, Hamilton, 2009) And while such an economic crisis did precipitate the public spending that included $8 billion for high-speed rail in the American Recovery and Reinvestment Act of 2009, the escalating economic trauma caused by a 'vicious cycle' of oil price spikes, economic downturns, and partial recovery (Gilbert & Perl, 2010: 290 – 292) would not be conducive to raising the hundreds of billions of dollars needed to develop a national high-speed rail network in the United States. Instead, incremental upgrading of conventional rail travel would serve a likely shrinking demand for intercity travel as wealth and incomes declined along with economic output. In this trajectory, travel would be driven to trains that ran well short of 'bullet train' speeds by the rising cost of driving and flying. Electric trains could leverage a growing fuel cost advantage in their pricing to accelerate such a shift.

Along this incremental trajectory, enhancing the connectivity of existing rail stations and future stations located on **existing** rail infrastructure would be the priority for intermodal integration. Future train travelers would need access to local mobility for the first and last miles of their journeys. In urban areas, such access could be provided by better integration with public transit, as well as walking and bicycle. In suburban and rural areas, motor vehicles (either private or shared) would provide the vast majority of local access.

An anticipatory approach to replacing oil in mobility would provide the most supportive context in which to pursue the comprehensive development of a high speed rail network. Along this trajectory, the significant investment required for new high-speed rail infrastructure could be generated by a healthy economy. This development pattern can now be seen in China's rapid implementation of a national high-speed rail network. China's high-speed rail system will overshadow the rest of the world's high-speed rail combined capacity if current development trends continue. Such a trajectory would point to a greater need to integrate high-speed trains with the road and air transport infrastructure, since an extensive fast train network would be able to take on the 'feeder' role for long-distance flights in many heavily traveled areas like the Northeast, the Midwest, California and the Pacific Northwest.

In pursuing either of these trajectories the U.S. will need to further extend the scope of multi-modal integration that has evolved during HSR development over the past 50 years. The next section draws on that experience to present policy options that could facilitate such efforts in the United States.

4. Strategies for connecting high-speed rail with other modes

The world's high-speed rail development has unfolded over a sufficiently long time frame that two different approaches to integrating with other modes of transportation can be observed. In Japan, the world's first high-speed rail network was designed within the context of an extensive, and heavily used, local rail infrastructure that carried the majority of travel within and around major cities such as Tokyo, Kyoto and Osaka. Japan's local rail transportation was provided by both public and private carriers, and was mostly economic, generating an operating surplus. High-speed trains were first introduced along the Tokaido Shinkansen corridor in 1964, a time when both car and air travel were relatively low.

As a result Shinkansen stations make very little provision for access by automobile. Table 4 presents the public parking capacity at Japan's selected Shinkansen stations where data are available.

Table 4
Public parking at selected Shinkansen stations

Sanyo Shinkansen (Osaka - Hakata)		
	Number of spaces	
Shin-Kobe	17	
Himeji	60	
Aioi	30	
Mihara	24	
Higashi-Hiroshima	36	
Hiroshima	350	
Shin-Iwakuni	10	
Tokuyama	29	
Shin-Yamaguchi	107	
Asa	10	
Shin-Shimonoseki	115	
Kokura	820	
Joetsu Shinkansen (Tokyo - Niigata)		
	Number of spaces	
Echigo-Yuzawa	163	
Urasa	65	
Nagaoka	350	
Tsubame-Sanjo	248	
Niigata	1,071	
Nagano Shinkansen (Tokyo - Nagano)		
	Number of spaces	
Okutani	79	
Ueda	126	
Nagano	96	
Akita Shinkansen (Morioka - Akita)		
	Number of spaces	
Ichinoseki	69	
Mizu-Esashi	74	
Kita Kami	70	
Morioka	61	
Ninohe	26	

With the exception of three stations, there are no parking facilities with capacity for more than 300 vehicles along the Shinkansen network. These are Niigata, terminus of the Joetsu Shinkansen corridor, Kokura a major transfer point between the Sanyo Shinkansen and local transportation on the island of Kyushu, and Hiroshima.

Shinkansen trains have similarly limited connections to Japan's air system. While international airports at Narita (Tokyo) and Kansei (Osaka) do have 'express' train links to the central city, these are not by Shinkansen. There is no direct high-speed train access to Japanese airports. The Shinkansen has operated as a successful competitor to domestic aviation, rather than as a compliment and feeder for international air services. Japan's commercial success in high-speed rail has arisen from maintaining a preferred position in relation to driving between big cities and domestic flights along the busiest travel corridors. The Shinkansen's excellent connectivity with existing local transit and regional rail services would thus offer greater inspiration for incremental high-speed rail development in the United States, because these trains are more likely to share stations and rights of way with established local and regional rail services than the newly built comprehensive high speed trains systems.

European high-speed rail presents a different model of intermodal connectivity that could provide lessons for North America. Both automotive and aviation modes were much more developed in the 1980s, when the first high-speed trains were introduced in Western Europe. A strategy for connecting flying and driving with high-speed train travel became part of Europe's successful high-speed rail business model, given the need to attract travelers who were already accustomed to traveling in cars and planes.

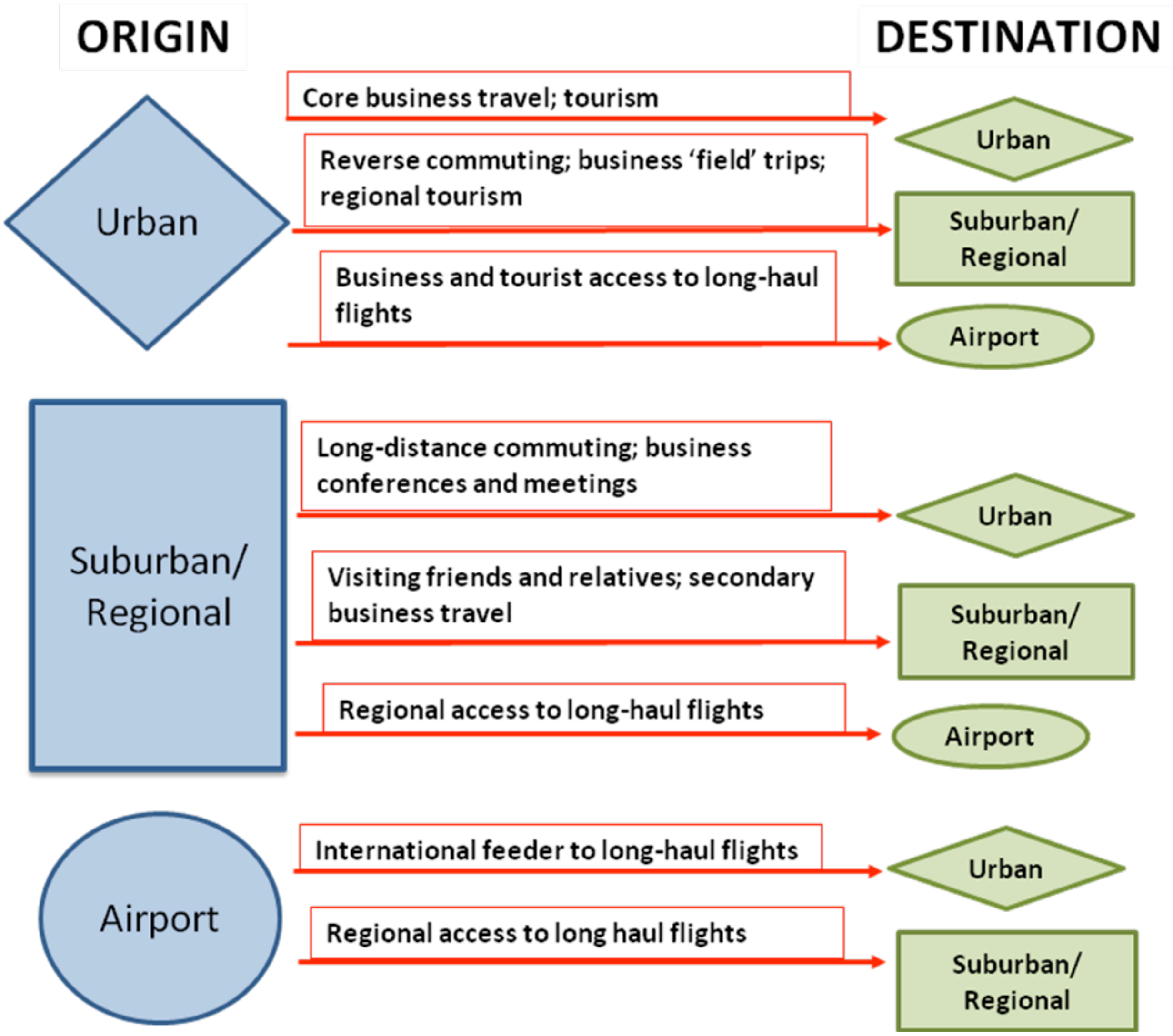
As a result, European high-speed rail systems evolved to complement air and road modes, while also competing with them. Once high-speed train services grew beyond single corridors and as multiple routes and grew into national and then international networks, a system design emerged that allowed both competitive city center – to – city center train services as well as suburban HSR services that were designed to attract many passengers who drove to at least one end of their train journey (and perhaps both) as well as passengers who were connecting to or from air travel. This network design is more elaborate than the Shinkansen model and deserves attention because it can facilitate serving a wider market penetration where driving and flying predominates. The European high-speed train network design thus offers more pertinent lessons for North American services that will be in direct competition with other modes.

Europe's approach to intermodal connectivity is based on a three tiered station design that enables different high-speed train frequencies to serve different markets. High-speed trains' connectivity with public transit and non-motorized transportation is highest in **city center stations**, such as London's St. Pancras, Gare du Nord in Paris and Frankfurt's Hauptbahnhof. Travelers using these stations will arrive and depart by taxi, public transit and their own feet. **Suburban** and **regional stations** have been designed to make high-speed trains easily accessible by private auto. Two examples serving suburban Paris are the 'satellite' TGV stations at Massy-Paliseau, with 1,440 parking spaces[1] and Marne-la Vallee Chessy with 1,636 spaces.[2] **Airport stations** also figure prominently in Europe's high-speed train network. Both international gateways, such as Copenhagen, Frankfurt and Paris, as well as regional airports such as Lyon are served by high-speed trains. Many passengers connect between flights and high-speed trains at these airport stations but some also park their cars at the airport and catch the train, rather than flying.

This mix of stations can be connected to serve a diverse range travel market segments depicted graphically in Figure 2 below.

[1] http://www.parking-public.fr/parking-ville-massy/parking-massy-91-a-598-d-403
[2] http://www.parking-public.fr/parking-ville-chessy/parking-chessy--a-599-d-0

Figure 2
European High Speed Rail Network Structure



This network design expands upon the railroad heritage of operating 'Limiteds,' the fastest tier of traditional intercity trains that stopped at few, if any, intermediate destinations enroute. Usually, these *Limiteds* linked major population centers, leaving it to less prestigious trains to stop at smaller towns and suburbs. While European high-speed trains do make limited stops, they typically mix the types of stations during their journey.

This contrasts with the more traditional network design of Japanese high-speed rail service. Here, faster trains (e.g., Nozomi) make fewer stops in the largest population centers much as the *Limiteds* of yesteryear once did and slower HSR trains (e.g. Kodama) making more frequent stops at smaller population centers along the corridor. The European service design is more diverse, with some high-speed trains originating at airports or suburban centres, or stopping at an airport or suburban or regional centre enroute from one major city to another. When high-speed rail networks reach a critical mass of train service, the total frequency is high enough to provide passengers transferring to cars or planes with sufficient schedule options, even though only a subset of trains stop at their station.

North American designs for high-speed rail are going to have to take the European innovation of providing multiple air, auto and rail connections along a corridor to an even higher level of intermodal integration. North American HSR will need at least four kinds of station types; the city center and airport stations seen in Europe, as well as two types of suburban stations at business parks and at suburban commercial center.

Classic city center stations like New York's Penn Station and Grand Central Terminal or Washington Union Station will remain landmarks of many high-speed rail corridors. As the scope and performance of high-speed passenger trains expands, these classic stations will need to reclaim their intercity travel vocation. In all of these stations today, regional rail travelers outnumber intercity commuters. In past decades, it was easy to fill in much of the spare station capacity that had been created by declining volumes of intercity train travel with commuter rail services which were redeveloped sooner than intercity trains. Finding station space for both growing commuter traffic and intercity travel will require significant new investment in these city center stations. This investment would be synergistic, since many travelers would access high-speed rail by regional rail connections, as well as urban transit and taxis.

Airport high-speed stations will work best if the temptation to locate them outside airports to save costs and avoid organizational challenges is resisted. As European experience demonstrates, the most successful airport train stations are built directly inside the same terminals used by aircraft. Within the Northeast, Newark Liberty Airport, Baltimore-Washington International and Providence among the Northeast airports currently offer the opportunity to turn these facilities into what Hank Dittmar (2002) has called TravelPorts, intermodal terminals where transferring between modes is just as easy and commonplace as making connections within a single mode.

As now occurs at some European airport stations for high-speed rail, such as Lyon-St. Exupery, many U.S. travelers could be expected to access high-speed trains by driving to the airport and parking, just as they do when taking to the skies. This demand for parking should be welcomed by airport operators who are looking to diversify their revenues in an era where air travel will not be growing in the way that it used to. As U.S. aviation will likely see fewer short distance flights in coming decades, there would be a growing share of passengers who make use of both incremental and comprehensive high speed rail networks to connect with long-distance flights. Fully integrating passenger trains into airports would enable the future modal shift from aviation to high-speed rail to make use of terminal infrastructure and road access that would otherwise go underused and could eventually become ‘stranded assets.’

A U.S. high-speed rail network would need to serve two types of regional stations, which would differ spatially from their Asian and European counterparts. **Suburban business park stations** already exist in the New York area, where regional rail services offered a critical mass of mobility to encourage office location around ‘commuter’ stations. Metropark in New Jersey, Stamford in Connecticut and White Plains in New York. Two of these stations, Metropark and Stamford are located along the Northeast Corridor and are served by Amtrak’s Acela Express trains. Office buildings surround these stations, although not with the direct internal access found at stations like Lille-Europe or the magnitude Nagoya’s Shinkansen station, which is over 1,435,000 square feet in size and is topped with both a 59 floor hotel and a 55 floor office building. To achieve similar synergy between surrounding land development and high-speed trains, America’s

suburban business park stations would benefit from additional local mobility to collect and distribute high-speed train passengers to and from the office buildings.
The incremental development of high-speed rail could aim to scale up the capacity of existing suburban train stations like Metropark and Stamford, along with other stations that do not yet have high-speed train service to meet the needs of new travelers, without displacing capacity for local travelers on the trains and connecting public transit that already serve these locations. Most travelers would access high(er) speed trains by driving, and then parking either at their office location and then taking a shuttle bus to the train, or parking at the station's own facility. There would also be connections from commuter trains that serve the stations. Over time, these suburban business park stations could become local transit hubs as the share of single-occupant vehicle commuters declines.

Along the comprehensive high-speed rail development trajectory, suburban business park stations could be good candidates for introducing another electric mobility innovation to the United States. Personal rapid transit (PRT) can combine the attributes of on-demand mobility offered by road based vehicles with the energy efficiency and electric traction now available from light rail systems. (Gilbert & Perl, 2010: 157 – 159) There is an interesting parallel between America's uneven momentum PRT and high-speed rail, with a pioneering PRT system launched in 1975 in Morgantown, West Virginia, followed by a long period of inactivity. Such a 'pod car' system connecting Heathrow Airport's new Terminal 5 with parking and car rental facilities is now in pre-launch testing. (ULTra PRT, 2010)

Another type of regional station that is more likely to emerge with a comprehensive high-speed rail development trajectory is **suburban commercial center stations.** Like their business park counterparts these stations would be located outside cities. But the focus of their surrounding land use would be commercial activity –mega malls and 'power centers' such as the 'Mall of America' or 'Tyson's Corner Center.' These shopping centers have good road access and extensive parking facilities that could offer high-speed train 'park and ride' capacity. High-speed corridor development would need to plan routes to connect into these commercial centers, which is why that such station development is only likely with newly built infrastructure. Over time, high-speed rail access could bring valuable traffic into America's 'malls' in an era where people make fewer car trips. It could also open the door to more intensive transit-oriented development at these commercial centers, a key component of the strategy that some have developed to 'retrofit suburbia' for a transition to more sustainable energy consumption. (Dunham-Jones and Williamson, 2009)

Much work remains to be done in designing the network structure, the station types and the local mobility that will serve America's future high-speed trains. In order to begin this effort, new policy tools will have to be created that enable intercity passenger rail planners and operators to work with local transportation and land use planners and with private developers. The concluding section begins examining what such a tool kit would be comprised of, if the potential for effective development is to be attained.

5. Policy approaches to better connect high-speed rail development with local mobility

If the potential for high-speed rail is to be fully realized, new policy tools will be needed to recapture the synergies between transportation and local land use that once made America's railroad stations invaluable additions to their surrounding cities and communities. Three broad categories of policy tools will need to be brought to this task. The first category of these policy tools will enable high-speed rail developers to overcome the constraints posed by today's rail infrastructure ownership configuration. Today's ownership of rail rights of way gives rise to adversarial dynamics that are sure to bog high-speed train development down in costly conflicts over property rights. Current railroad ownership arrangements will be hard pressed to accommodate the major developments that would be needed to make high-speed trains a significant part of America's intercity transportation future.

What is needed is a means by which public and private ownership could be layered together both along high-speed rail corridors and adjacent to them. Elsewhere, (Gilbert and Perl, 2010; Perl, 2002), I have referred to such arrangements as an '**infrastructure condominium'**. As proposed in *Transport Revolutions*, 'this legal device separates the ownership of land along a transport right of way from what is built upon it.' (Gilbert and Perl, 2010: 253) The same concept could be extended to building alongside the right-of-way at future high-speed train stations.

The infrastructure condominium could allow existing stations like Metropark, or the current single-purpose facility at Newark International Airport, to be turned into a multi-modal developments with integrated commercial and office space, while advancing the interests of the current owners and principal users. Instead of seeing high-speed trains as a threat, the infrastructure condominium could change high-speed train development into an opportunity by enabling public agencies, private railroads, and even private land developers to share the benefits from bring high-speed trains into operation.

A second category of policy tool would address the fiscal needs of high-speed rail development. Here, some form of ongoing funding will be needed to move beyond high-speed rail projects and pursue a high-speed rail development program. Whether the policy instrument turns out to be a new **energy tax** or **carbon tax**, or a fee charged on existing mobility, e.g., a passenger-mile tax, or some other means of raising public revenue for infrastructure investment, some new financial structure awaits invention. The impetus to change America's transportation taxing arrangements is building as the mismatch between current fuel taxes and user fees and the actual use of infrastructure becomes more apparent.

A third category of policy tools will address the organizational dimension of planning, building, and operating America's future high-speed trains. The more ambitious that a post-carbon transition would be, the greater the need to reorganize the federal transportation bureaucracy to shift capacity from planning and building road and air infrastructure to building new electric mobility infrastructure, which includes high-speed trains. A 'Transportation Redevelopment Agency' (TRA) could refashion the existing federal capacity and work with states, local governments, and the private sector much the way that the Reconstruction Finance Corporation and the Tennessee Valley Authority once did to launch major new infrastructure that advanced America's economic redevelopment. (Gilbert and Perl, 2010: 239 – 241) Without some major reorganization of the federal transportation bureaucracy, high-speed rail development is unlikely to move beyond project level initiatives, and these initiatives are likely to fall short of their potential.

Introducing these new tools to advance America's high-speed rail development will require both leadership and experience in entrepreneurship, two attributes in which New York City lays claim to fame. The New York region lies at the heart of America's existing high-speed rail operations. New York City is also the greatest provider of electric mobility in North America, thanks to the considerable volume of riders carried on the New York subway system. And the private sector financial innovations that once produced such transportation masterpieces as Grand Central Terminal were invented in New York City.

New York could thus pursue the goal of becoming America's leading laboratory to test out new arrangements for developing high-speed rail, both close to home at the facilities like Metropark, Stamford and Newark Airport and further afield in the comprehensive project initiatives now unfolding in Florida and California. Or New York could rest on past accomplishments and wait for other initiatives to develop the future solutions that will facilitate high-speed rail's successful integration into America's transportation system. The more that private sector finance can follow Warren Buffet's lead and rediscover the economic rewards of owning railroad assets, the greater that New York's role in America's coming high-speed rail revolution is likely to be. High-speed rail integration into regional transportation could become the single most important regional economic development tool for U.S. metropolitan areas over the coming 25 years. With so much money to be made from doing this integration right, there is hope that New York's financial sector will cash in on America's coming wave of high-speed rail.

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