I-87 Multimodal Corridor Study




HIGH SPEED RAIL PRE-FEASIBILITY STUDY: NEW YORK CITY TO MONTREAL

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New York State Department of Transportation

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A Joint Venture

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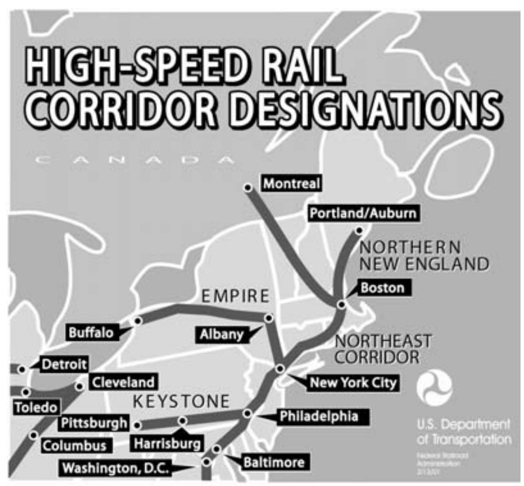
STUDY OVERVIEW

A comprehensive study has been initiated by the New York State Department of Transportation (NYSDOT) to identify improvements to the transportation network in the I-87/Autoroute 15 Corridor in New York State and Quebec. These actions would address past growth in the corridor while allowing the full potential growth in the economy of the corridor and region to be achieved. The I-87 Multimodal Corridor Study ("the Study") will be integrated with the findings and results of the New York and the New World Economy study previously completed for NYSDOT, which focused on major changes in the regional, national and international economies and trade patterns, and the consequences of those changes on future transportation patterns and requirements. The goal of the Study is to identify and analyze recommended transportation initiatives and rank them in terms of their ability to enable New York State to respond to these changing economic forces and trends.

A significant component of the Study is the High-Speed Rail Pre-Feasibility Study, which is assessing the concept of developing high-speed rail (HSR) service in the New York City – Montreal corridor. Passenger train service is presently very limited in that corridor, with only one train per day in each direction that takes over 10 hours. This study, being completed in cooperation with the Quebec Ministry of Transportation (MTQ), includes a preliminary look at the viability of implementing true European-type high-speed service (150+ mph throughout). More modest incremental improvements to the existing New York-to-Montreal passenger rail service are also being investigated. MTQ is looking at similar HSR service over the segment between Montreal and the US-Canadian border. The results of that study are summarized in this report.

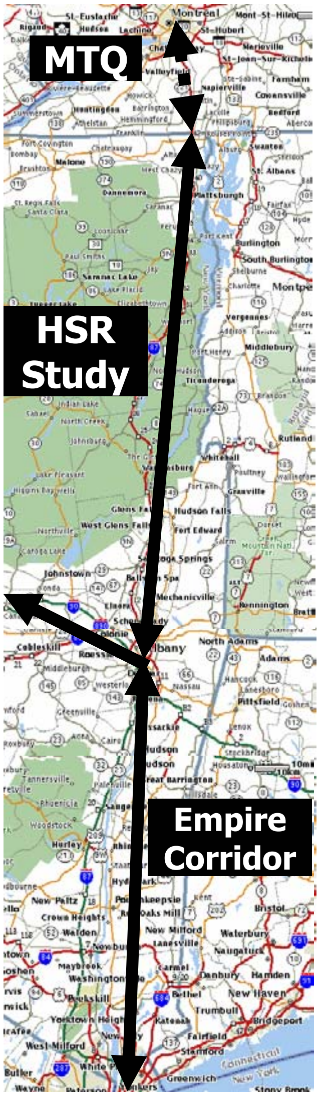
HIGH SPEED RAIL CORRIDORS

The US Department of Transportation's Federal Railroad Administration (FRA) has designated eleven high-speed corridors under the Intermodal Surface Transportation Act of 1991 (ISTEA) and the Transportation Efficiency Act for the 21st Century (TEA-21). This designation allows a corridor to receive earmarked funding for a variety of high-speed rail related projects, including highway-rail grade crossing safety improvements, and recognizes the potential to develop that type of service in that corridor. The presently designated corridors nationwide include:



- California Corridor
- Pacific Northwest Corridor
- South Central Corridor
- Gulf Coast Corridor
- Chicago Hub Network
- Florida Corridor
- Southeast Corridor
- Keystone Corridor
- Northeast Corridor
- Empire Corridor
- Northern New England Corridor

EXECUTIVE SUMMARY



As shown, the Empire Corridor, extending from New York City to Albany and then west to Buffalo, is already one of the nation's 10 designated corridors. This 439-mile corridor has been the subject of a number of previous and on-going studies and projects. Due to improvements in recent years, portions of the Albany-New York section have operations at up to 110 mph, and the growing ridership between New York and Albany make that market one of the strongest in the country. New "RTL" turbine-powered equipment, being re-manufactured in a public/private partnership involving NYSDOT, the FRA and Amtrak, is gradually being introduced to the corridor. NYSDOT and Amtrak are planning further incremental improvements in the 160-mile New York-to-Schenectady corridor to attain speeds of up to 125 MPH. Various upgrades west of Schenectady to Buffalo/Niagara Falls are also planned.

Within the New York-to-Montreal corridor, a primary goal of the existing Empire Corridor effort is to reduce travel time between New York City and Albany to less than two hours from the present scheduled time of 2.5 hours. The new Albany/Rensselaer train station was recently opened, and plans are underway to convert the historic Farley Building Post Office in New York City to the New York City Amtrak station. Parallel programs by NYSDOT and FRA are also ongoing to close or upgrade a number of rail crossings and to test new grade crossing technologies and warning systems in the corridor.

The remaining New York State section of the New York City-to-Montreal corridor – from Albany to the US-Canadian border – is the focus of this High-Speed Rail Pre-Feasibility Study.

Boston-to-Montreal Study. The feasibility of HSR operation in the Boston-to-Montreal portion of the Northern New England HSR corridor is presently being assessed by the States of Vermont, Massachusetts and New Hampshire. Currently, travel from Boston to Montreal requires transferring to a second train in New Haven, Connecticut and to a bus for the final leg from St. Albans, Vermont, with a total travel time of over 12.5 hours. The first phase of that study (*Boston to Montreal High-Speed Rail Planning and Feasibility Study: Phase I*) focused on the potential ridership and passenger revenues under various service scenarios in a 329-mile corridor extending northwest from North Station in Boston, through Concord, NH and Burlington, VT into Quebec and Montreal's Central Station. That study concluded that the best service, in terms of ridership, passenger revenues and likely costs, would

- use existing track alignments, with no electrification;
- provide no service above 110 MPH;
- eliminate the stop at the US-Canada border for Customs; and
- provide a "mid-speed" service at relatively low fares, with 6 round-trips daily.

Annual ridership in the Boston-Montreal corridor was projected at 680,000, of which 220,000 would be traveling between Boston and Montreal. Many of the riders would essentially be making commuter-type trips into the Boston Metropolitan area.

STUDY PURPOSE & APPROACH

The purpose of this study is to assess the issues and impediments associated with implementing high-speed rail service in the corridor between Albany and Montreal. Parallel to this HSR study, an overall review of rail infrastructure in the corridor is being completed as part of the I-87 Multimodal Corridor Study, leading to a list of potential improvements to the rail network that would help both passenger and freight services. The results of the MTQ studies for the portion of the alignment between Montreal and the US/Canadian border are also summarized in this report and used to provide an overview of the likely travel time savings under various high-speed service options.

Two basic approaches are taken in this study to assess the potential for improving the speed of rail passenger travel in the I-87 Corridor:

- **Incremental Improvements to Existing Service** – identify the types of incremental improvements needed to reach maximum corridor speeds of 79 MPH, 90 MPH, 110 MPH, and 125 MPH utilizing, to the extent possible, the existing alignment of the former Delaware & Hudson Railway (D&H) section of the Canadian Pacific Railway system (CP). This approach is addressed in Section 4 of this report.

- **Full High-Speed Rail Service** – assess the improvements needed to achieve a sustained speed of 150 MPH for the full length of the trip, on a primarily new high-speed railway alignment. This new alignment would be exclusively for passenger trains, while the D&H route would be nearly exclusively used as a freight artery, with some local-type passenger service possible as well.

INCREMENTAL IMPROVEMENT SCENARIOS

A total of 19 different "Incremental Improvement" scenarios were analyzed to assess their potential impact on running time. The following factors are varied among scenarios:

- **Superelevation (Ea).** In the same way that race car tracks are banked to allow drivers to safely go at higher speeds, the so-called "superelevation" (Ea) of the outside rail of the track structure can similarly counteract the centrifugal force exerted by a train moving through a curve at a specified speed. For a specific curve, operating speed and train type and weight, the required banking or "equilibrium elevation" can be calculated to place the weight of the train equally on both rails. Ea is stated in inches. Ea on the existing alignment is generally less than 1". Increases of up to 3" were tested under various scenarios. The extent of improvement increased with the projected speed under each alignment (the "MAS" – see below for explanation).

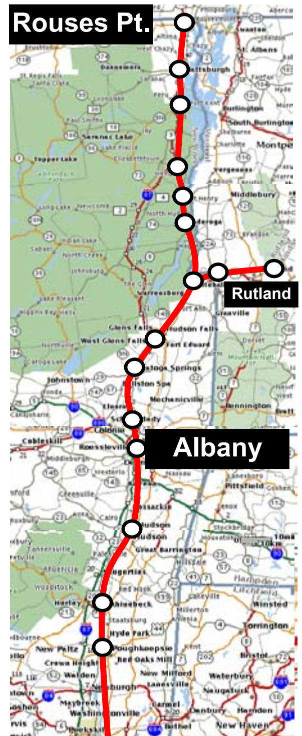


Exhibit S-1: Stops on Adirondack and Ethan Allen Services

- **Underbalance (Eu).** Most rail segments handle both passenger and freight trains, which have considerably different operating speeds. Given this, track is rarely superelevated to the equilibrium elevation due to the different physical and operating characteristics of freight and passenger trains. The difference between the equilibrium elevation and actual superelevation is termed underbalance (Eu) and is stated in inches. Assume, for example, that a particular curved section of track designed for 80 mph operation would be in equilibrium balance with 4 inches of superelevation. If that section in fact had 3 inches of superelevation, it would be said to have 1 inch of underbalance. The Federal Railway Administration (FRA) establishes the amount of underbalance permitted on various segments of track. The FRA generally permits no more than three inches of underbalance for freight equipment and most passenger equipment, with higher amounts possible for passenger equipment after track geometry testing. Changes in Eu are therefore a regulatory matter rather than a change in alignment conditions or equipment. However, those conditions play a role in the amount of Eu that the FRA will permit.

  Increasing the Eu on a track section from 3" to 5" would permit passenger trains to travel faster in that section. Other than a slight worsening of ride quality, this would have no effect on passenger train operations. (At Eu greater than 5", "tilt train" type passenger equipment is required to offset the effect of high speeds around curves.) This Eu increase by itself would have no effect on freight trains, which would simply travel at their normal slower speeds.

Jet Train Locomotive

DMU Train Set

- **Number of Stops between Albany and Rouses Point.** As shown in Exhibit S-1, there are presently 9 stops between Albany and Rouses Point at the Canadian border. Reductions down to 3 stops were considered under various alternatives.

- **Changes in Equipment.** The running speed benefits of new Jet-Train type tilt equipment versus conventional Amtrak train sets were calculated. Any scenario in which underbalance (Eu) of greater than 5" would be permitted requires tilt-train type equipment. The possibility of so-called Diesel Multiple Units (DMU) for use in the Albany-to-Montreal market or in "local service" operation within the Adirondack portion of the corridor was also considered.

- **Maximum Authorized Speed (MAS).** This represents the highest speed that trains can travel over a given length of track. This does not mean that it is acceptable or even possible to go that speed over the alignment's entire length, but rather that no speed greater than the specified MAS is authorized. The MAS between Albany and Rouses Point is presently 70 MPH.

- **Signal Systems.** The FRA, under its current signal and train control regulations (49 CFR Part 236), permits so-called block or manual block signal systems at speeds up to 79 MPH. Above that speed, more sophisticated Automatic Cab Signal or Automatic Train Stop and Automatic Train Control systems are mandated. These provide a warning when the maximum speed on an upcoming track segment is less than the speed at which the train is operating, or automatic enforcement if the engineer fails to respond properly to these speed warnings.

- **Track Crossing Controls.** Regulations generally require that (1) up to 79 MPH, all crossings must be either closed or have up-to-date flasher-gate systems, (2) in the 80-110 MPH range, flasher-gate systems are allowable, but busier crossings may need grade-separation, (3) above 110 MPH, only "positive barrier" controls (which physically restrict crossing the tracks) or grade-separated crossings permitted. The closing of private crossings generally increases as operating speeds exceed 80 MPH, with virtually none permitted above 110 MPH. Under the scenarios considered, increasing levels of improvement in existing crossings would be required as MAS increases.

- **Sidings.** Track sidings are required to allow trains to pull off the main tracks to permit faster trains to pass or, on a single track system, to allow a train in the opposite direction to use a section of track first. As the number of trains and maximum speeds increase on a given track segment, the need for such sidings increases. This is particularly important for the Adirondack service segment between Albany and Rouses Point, which is entirely a single-track system.

- **Maintenance Upgrade (MU).** Based on a review of conditions along the existing alignment and on discussions with CP Rail and others, it was clear that alignment improvements such as changes in superelevation and requests for higher operating speeds could not happen without basic track maintenance upgrade work in critical sections. This work, involving tie replacement, track surfacing and track replacement (continous welded rail – CWR – for jointed rail), would address problems in the alignment's most critical areas. These "MU" improvements are then assumed to be in place, and to be part of the capital costs, under all Existing Alignment HSR scenarios.

Benefit to Rail Freight. CP Rail, NYSDOT and others are carrying out or planning a number of critical improvements (e.g., improved signal systems, removal of low clearances that preclude some "double-stack" container trains from the corridor, etc.) to improve rail freight operations. The "MU" projects noted above to improve the reliability of passenger service are fully consistent with these freight-improvement goals, and as such would further enhance rail freight service in the corridor.

FULL HIGH SPEED RAIL SERVICE SCENARIO

The frequent and closely spaced curves, necessitated by the hilly terrain, are the dominant feature of the existing alignment. Even with the modest goal of increasing the unbalanced superelevation (Eu) to five inches, a maximum continuous speed of 79 MPH is not possible for a majority of the line, particularly where the curves are nearly continuous. For example, in the forty-mile segment between Port Henry and Port Kent, there are 164 curves, an average of 4.1 curves per mile, and about ninety percent of the curves exceed three degrees. Passenger trains presently on this 40-mile line segment are generally restricted to the 35 – 40 MPH range.

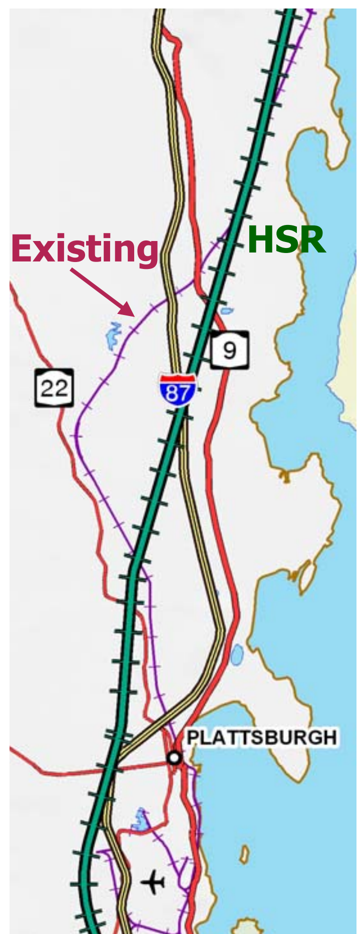


Exhibit S-2: Portion of 150 MPH HSR Alignment

Providing sustained, true high-speed rail operation of 150 MPH would therefore required an almost entirely new alignment. Several assumptions were made in this process:

- Existing alignments would be utilized to access the Albany-Rensselaer station, and the new alignment would match up with the existing alignment at Rouses Point. It was expected that many of the stations on the existing alignment could not be used for the new alignment.
- A number of long bridges and several tunnels would be necessary to provide the generally flat sections that HSR operations require.
- The train would have a tilt-body capability, such as the Jet Train.
- The alignment would not be electrified. This is consistent with assumptions made by MTQ in its assessment of the Montreal-to-Rouses Point alignment.

Exhibits indicating the existing rail alignment used between Albany and Rouses Point and the conceptual 150 HSR alignment are included in this report (see Exhibit S-2, which shown a portion of the HSR alignment and how it would frequently diverge from existing alignment and station locations). The location and length of the required tunnel and bridge segments are also indicated. Much of this would occur within portions of the Adirondack Park.

US/CANADA CUSTOMS DELAYS

Consistent with assumptions made by MTQ in its assessment of the Montreal-to-Rouses Point alignment, and by the Boston-to-Montreal HSR study, this study assumes that the existing stop for Customs would no longer be required, with passengers going through Customs at their destination, in the same manner as airline passengers. This change, which would produce timesavings of up to one hour, is only considered for full HSR scenarios (in both New York State and Canada), although the change could also be considered under any of the Incremental Improvement options.

RESULTS OF MTQ STUDY OF HSR SERVICE IN QUEBEC

The MTQ studies looked at three operating scenarios – 200, 240 and 400 km/hr. (roughly 125, 150 and 186 MPH), for two separate alignments within Quebec:

- The approximately 48-mile **Canadian National (CN)** alignment, on which Adirondack service trains presently travels to Gare Centrale (Central Station) in Montreal, and
- The 41-mile **CP Rail** alignment, which connect to the Lucien-L'Allier Station.

The two existing rail alignments between Rouses Point and Montreal, and the approximate areas where a 150 MPH HSR alignment would have to depart from the existing CP and CN alignments, are shown in Exhibit S-3. As the existing alignments in Quebec are relatively flat and straight compared to the CP alignment between Albany and the border, there are relatively few departures required from the existing alignments to achieve HSR speeds, and considerably lower capital costs.

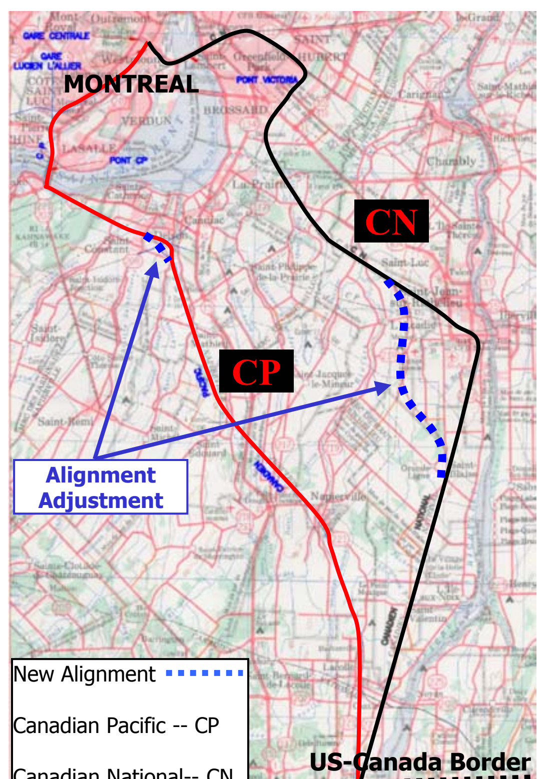


Exhibit S-3: MTQ Study Alignment Options

Studies were performed for both alignments and for all three speed scenarios. The 186 MPH option would require full electrification of the alignment, as 150 MPH is the approximate limit of diesel electric train operating speeds. Based on those studies, the MTQ study indicates that the shorter, faster and less expensive CP alignment, under the 150 MPH operating scheme, appeared the most cost-effective.

Under existing operations, trains cross at Rouses Point, stop at Cantic for Customs and at St. Lambert on the outskirts of Montreal before arriving at Central Station. Under these conditions, it takes trains roughly 175 minutes (2 hrs. 55 minutes) to travel from the US-Canada border to Central Station, including approximately 1 hour for the Customs stop. MTQ projects that this could be reduced by over 80%, to approximately 27 minutes, assuming full 150 MPH service with no station or Customs stops between Montreal and the border.

The approximate capital costs for the 150 MPH CP alignment shown in Exhibit S-3 were estimated by MTQ at $179 million, including rolling stock, or roughly $4.4 million per alignment mile. As discussed later in this summary, the equivalent costs for 150 MPH HSR service on the 190-mile segment from Albany to Rouses Point are considerably higher on a per-mile basis. This difference reflects the relatively flat and straight alignment in Quebec, while the New York State alignment faces considerably greater topographic challenges.

ADDITIONAL TIME SAVINGS IN THE NEW YORK CITY TO ALBANY SEGMENT

A variety of improvements are underway or planned for the New York City-to-Albany portion of the Empire Corridor. These improvements involve changes to tracks, sidings and other elements of the alignment, along with train set upgrades and possible skip-stop express service. Preliminary timesaving estimates of up to 30-35 minutes have been projected, but the full extent of these savings and when they will occur have not been finalized. No travel time credit is taken for these improvements under the scenarios analyzed in this report, although the approximately 35-minute timesaving possible from these improvements was shown under the full 150 MPH HSR scenarios to provide a sense of its relative impact. In addition, under the more extensive "Incremental Improvement scenarios" and under all full HSR options, it was also assumed that the present 15-minute layover in the Albany-Rensselaer Station would be reduced to five minutes.

ESTIMATED PROJECTED TIME IMPROVEMENTS COSTS AND UNDER HSR SCENARIOS

Table S-1 summarizes the various travel time improvements assumed under

(1) Nineteen "Incremental Improvement" scenarios (divided into "Moderate" and "Extensive" as well as two scenarios under which DMU train set equipment would be utilized), and

(2) several 150 MPH Dedicated High Speed Rail Alignment scenarios. The number of stops between Albany and Rouses Point is varied between nine and three stops to highlight the approximate timesaving associated with fewer stops.

TABLE S-1: COMPARISON OF EXISTING NEW YORK TO MONTREAL RAIL SERVICE TO POTENTIAL ALIGNMENT AND SERVICE ENHANCEMENTS LOWER-COST ENHANCEMENTS TO EXISTING ALIGNMENT										
	Changes in Operations, Alignment & Train Equipment					Travel Time & Average Speed				
	# Stops: Albany to Rouses Point [2]	Maximum Authorized Speed (MAS) – Albany to Rouses Pt.	Underbalance (Eu) – Albany to Rouses Pt.	Train Sets	Changes to Rail Crossings	NYC – Albany [3]	Albany – Rouses Point	Rouses Pt. – Montreal [4]	Total Travel Time	Total Capital Cost (Millions)
Existing Adirondack Service	9	70 MPH	< 1"	P40DC Diesel Electric & Amtrak Fleet Cars	No Change	2:45 51 mph	4:35 42 mph	1:55 21 mph	10:15 43 mph	N/A
Moderate Incremental Improvement Scenarios: Existing Alignment & Train Sets										
Maintenance Upgrade (MU): Existing Adirondack Service w/ track Improvements beteween Albany and Border [1]	9	70 MPH	< 1"	P40DC Diesel Electric & Amtrak Fleet Cars	No Change	2:45 51 mph	4:21 44 mph	1:55 21 mph	10:01 44 mph	$20
S1: 70 MAS, No Alignment Changes, 3" Eu, 9 Stops	9	70 MPH	3"	P40DC Diesel Electric & Amtrak Fleet Cars	No Change	2:45 51 mph	3:50 50 mph	1:55 21 mph	9:30 47 mph	$20
S2: 70 MAS, No Alignment Changes, 3" Eu, 3 Stops	3	70 MPH	3"	P40DC Diesel Electric & Amtrak Fleet Cars	No Change	2:45 51 mph	3:37 53 mph	1:55 21 mph	9:17 49 mph	$20
S3: 70 MAS, No Alignment Changes, 5" Eu, 3 Stops	3	70 MPH	5"	P40DC Diesel Electric & Amtrak Fleet Cars	No Change	2:45 51 mph	3:33 54 mph	1:55 21 mph	9:13 49 mph	$20
S4: 79 MAS, Curve Improvements, 5" Eu, 9 Stops	9	79 MPH	5"	P40DC Diesel Electric & Amtrak Fleet Cars	Minor Upgrades	2:45 51 mph	3:32 56 mph	1:55 21 mph	9:04 51 mph	$40
S5: 79 MAS, Curve Improvements, 5" EU, 3 Stops	3	79 MPH	5"	P40DC Diesel Electric & Amtrak Fleet Cars	Minor Upgrades	2:45 51 mph	3:11 60 mph	1:55 21 mph	8:51 52 mph	$40
S6: 79 MAS, Curve Improvements, 7" EU, 3 Stops, Tilt Train	3	79 MPH	7"	Jet Train Locomotive & Tilt Cars	Minor Upgrades	2:45 51 mph	3:02 63 mph	1:55 21 mph	8:42 54 mph	$150
S7: 90 MAS, Curve Improvements. 5" EU, 9 Stops	9	90 MPH	5"	P40DC Diesel Electric & Amtrak Fleet Cars	Moderate Upgrades	2:45 51 mph	3:16 58 mph	1:55 21 mph	8:56 52 mph	$130
S8: 90 MAS, Curve Improvements. 5" EU, 3 Stops	3	90 MPH	5"	P40DC Diesel Electric & Amtrak Fleet Cars	Moderate Upgrades	2:45 51 mph	3:03 62 mph	1:55 21 mph	8:43 54 mph	$130

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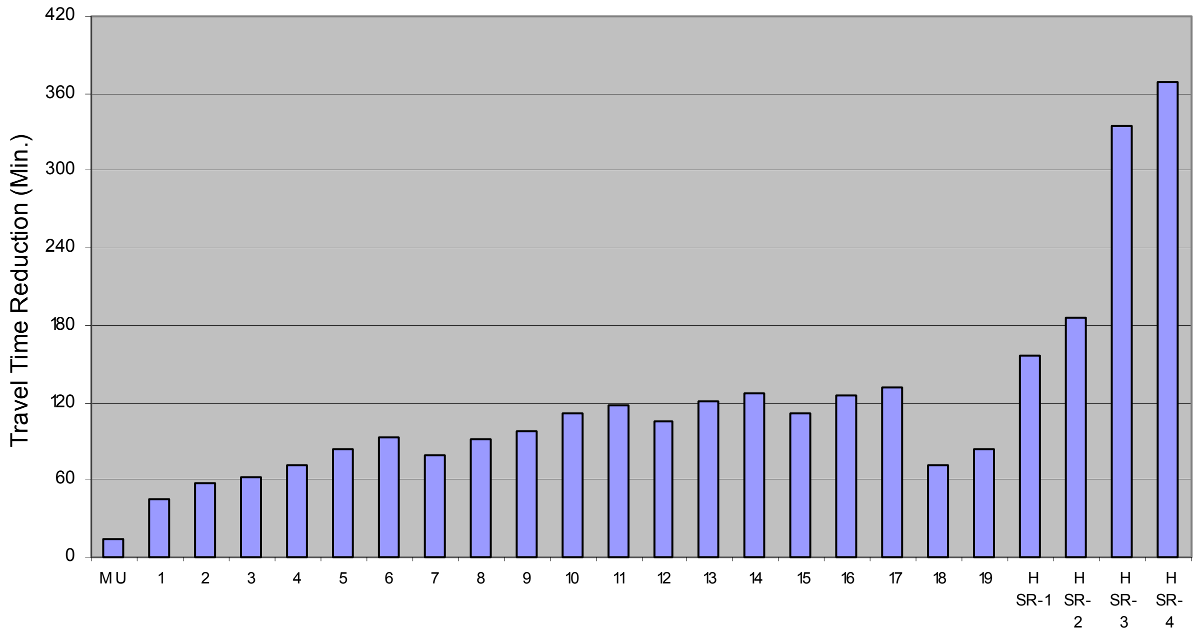
	# Stops: Albany to Rouses Point [2]	Maximum Authorized Speed (MAS) – Albany to Rouses Pt.	Underbalance (Eu) – Albany to Rouses Pt.	Train Sets	Changes to Rail Crossings	NYC – Albany [3]	Albany – Rouses Point	Rouses Pt. – Montreal [4]	Total Travel Time	Total Capital Cost (Millions)
Extensive Incremental Improvement Scenarios: Existing Alignment & New Train Sets										
S9: 90 MAS, Curve Improvements, 7" EU, 9 Stops, Tilt Train	9	90 MPH	7"	Jet Train Locomotive & Tilt Cars	Moderate Upgrades	2:35 55 mph	3:07 61 mph	1:55 21 mph	8:37 54 mph	$240
S10: 90 MAS, Curve Improvements, 7" EU, 3 Stops, Tilt Train	3	90 MPH	7"	Jet Train Locomotive & Tilt Cars	Moderate Upgrades	2:35 55 mph	2:54 66 mph	1:55 21 mph	8:24 57 mph	$240
S11: 90 MAS, Curve Improvements, 9" EU, 3 Stops, Tilt Train	3	90 MPH	9"	Jet Train Locomotive & Tilt Cars	Moderate Upgrades	2:35 55 mph	2:47 68 mph	1:55 21 mph	8:17 58 mph	$240
S12: 110 MAS, Curve Improvements, 7" EU, 9 Stops, Tilt Train	9	110 MPH	7"	Jet Train Locomotive & Tilt Cars	Extensive Upgrades	2:35 55 mph	2:59 64 mph	1:55 21 mph	8:29 56 mph	$270
S13: Curve Improv. 110 MAS, 7" EU, 3 Stops, Tilt Train	3	110 MPH	7"	Jet Train Locomotive & Tilt Cars	Extensive Upgrades	2:35 55 mph	2:44 70 mph	1:55 21 mph	8:14 59 mph	$270
S14: Curve Improv. 110 MAS, 9" EU, 3 Stops, Tilt Train	3	110 MPH	9"	Jet Train Locomotive & Tilt Cars	Extensive Upgrades	2:35 55 mph	2:38 73 mph	1:55 21 mph	8:08 60 mph	$270
S15: Curve Improv. 125 MAS, 7" EU, 9 Stops, Tilt Train	9	125 MPH	7"	Jet Train Locomotive & Tilt Cars	Extensive Upgrades	2:35 55 mph	2:54 66 mph	1:55 21 mph	8:24 57 mph	$270
S16: Curve Improv. 125 MAS, 7" EU, 3 Stops, Tilt Train	3	125 MPH	7"	Jet Train Locomotive & Tilt Cars	Extensive Upgrades	2:35 55 mph	2:39 72 mph	1:55 21 mph	8:09 60 mph	$270
S17: Curve Improv. 125 MAS, 9" EU, 3 Stops, Tilt Train	3	125 MPH	9"	Jet Train Locomotive & Tilt Cars	Extensive Upgrades	2:35 55 mph	2:34 75 mph	1:55 21 mph	8:04 61 mph	$270
Moderate Incremental Improvement Scenarios: Existing Alignment & DMU Train Sets										
S18: 79 MAS, Curve Improvements, 5" EU, 9 Stops, DMU Train	9	79 MPH	5"	DMU Train Set	Minor Upgrades	2:45 51 mph	3:24 56 mph	1:55 21 mph	9:04 51 mph	$110
S19: 79 MAS, Curve Improvements, 5" EU, 3 Stops, DMU Train	3	79 MPH	5"	DMU Train Set	Minor Upgrades	2:45 51 mph	3:11 60 mph	1:55 21 mph	8:51 52 mph	$110

TABLE S-1: COMPARISON OF EXISTING NEW YORK TO MONTREAL RAIL SERVICE TO POTENTIAL ALIGNMENT AND SERVICE ENHANCEMENTS LOWER-COST ENHANCEMENTS TO EXISTING ALIGNMENT										
	Changes in Operations, Alignment & Train Equipment					Travel Time & Average Speed				
	# Stops: Albany to Rouses Point [2]	Maximum Authorized Speed (MAS) – Albany to Rouses Pt.	Underbalance (Eu) – Albany to Rouses Pt.	Train Sets	Changes to Rail Crossings	NYC – Albany [3]	Albany – Rouses Point	Rouses Pt. – Montreal [4]	Total Travel Time	Total Capital Cost (Millions)
Dedicated High-Speed Rail Alignment & Tilt-Train Sets										
HSR-1: HSR Alignment, 150 MAS, 9 Stops, Tilt Train	9	150 MPH	To Be Determined	Jet Train Locomotive & Tilt Cars	Dedicated HSR Alignment	2:35 55 mph	2:08 89 mph	1:55 21 mph	7:38 69 mph	$4000
HSR-2: HSR Alignment, 150 MAS, 3 Stops, Tilt Train	3	150 MPH	To Be Determined	Jet Train Locomotive & Tilt Cars	Dedicated HSR Alignment	2:35 55 mph	1:38 116 mph	1:55 21 mph	7:08 83 mph	$4000
HSR-3: HSR Alignment, 150 MAS, 3 Stops, Tilt Train + Quebec HSR & No Customs	3	150 MPH	To Be Determined	Jet Train Locomotive & Tilt Cars	Dedicated HSR Alignment	2:35 55 mph	1:38 116 mph	0:27 91 mph	4:40 96 mph	$4000
HSR-4: HSR Alignment, 150 MAS, 3 Stops, Tilt Train + Quebec HSR, No Customs + Empire Savings [5]	3	150 MPH	To Be Determined	Jet Train Locomotive & Tilt Cars	Dedicated HSR Alignment	2:00 71 mph	1:38 116 mph	0:27 91 mph	4:05 96 mph	$4000

[1] Maintenance Upgrade (MU) involving tie replacement, track resurfacing and track replacement at critical locations between Albany and Rouses Point, resulting in fewer stop orders, greater reliability and reduced schedule "pad." Costs for this upgrade (approximately $20 million) included in all improvements except "HSR Alignment" schemes, which assume entirely new alignment.
[2] Approximately 4-6 minute reduction in travel time per station removed, depending on improvement scenario and location of station.
[3] Inclues 15 minutes layover time at Albany-Ren. Station, reduced to 5 minutes with investment in Tilt-Train equipment and alignment improvements, and under full HSR operation.
[4] In Quebec, train presently has two stops between Rouses Point and Montreal, including Customs. Under full HSR, assumes no stops in Quebec other than Montreal.
[5] On-going and planned improvements in NYC-Albany portion of Empire Corridor, with preliminary projected savings of up to 35 minutes. Time savings here assume full 35-minute benefit from those programs.

(shaded cell) = Elements changed relative to Existing and Baseline Conditions.

Exhibit S-4: Reduction in Travel Time: New York City to Montreal Under Various Improvement Scenarios (Minutes)



As shown, various combinations of Eu (underbalance), MAS, new versus existing train sets and other alignment improvement factors were assumed under these scenarios. The time benefits associated with full 150 MPH service in the Quebec portion of the corridor, as well as the approximately 1-hour timesavings from elimination of the Customs stop in Canada, are shown under both HSR-3 and HSR-4. HSR-4 also shows the potential impact of on-going improvements in the New York City to Albany rail segment.

Exhibit S-4 summarizes the reduction in travel time between New York City and Albany under the nineteen Incemental Improvement scenarios and the four HSR scenarios.

The present travel time between New York City and Montreal is 615 minutes (10 hrs. 15 minutes). The savings under the HSR options are clearly significantly greater than under the Incremental Improvements, where savings of approximately two hours are possible only under the more extensive improvement options (i.e., S13 through S17). However, none of the Incremental Improvement scenarios reflects the possible benefits of HSR service in Quebec (up to 1 hr. 28 minutes saved), or elimination of the Customs stop (an additional 1 hour savings), both of which were assumed under HSR-3 and HSR-4. Adding these combined 2½ hours savings to the more extensive Incremental Improvement scenarios would bring the total savings under those scenarios to the 4-5 hour range, which starts to approach the time savings under the Dedicated HSR Alignment HSR scenarios.

Table S-2 presents preliminary estimates of additional capital and operating costs under the

TABLE S-2: COMPARISON OF EXISTING NEW YORK TO MONTREAL RAIL SERVICE TO POTENTIAL ALIGNMENT AND SERVICE ENHANCEMENTS CAPITAL AND O&M COSTS, RUNNING TIME SAVINGS & ADDED PASSENGERS VS. CAPITAL COSTS										
	TRAVEL TIME CHANGES				ADDITIONAL ANNUAL RIDERS AND TRAIN AND TRACK MAINTENANCE COSTS + CAPTIAL COSTS					
	NYC – Albany [2]	Albany – Rouses Point	Rouses Pt. – Montreal [3]	Total Travel Time	Additional NYC-Montreal Riders [5]	Additional Operating Costs [6]	Additional Maintenance Costs [7]	Total Capital Cost (Millions)	$ Per Additional Rider	Million $/Minute Saved
Existing Adirondack Service	2:45 51 mph	4:35 42 mph	1:55 21 mph	10:15 43 mph	0	N/A	N/A	N/A	N/A	N/A
<u>Maintenance Upgrade (MU):</u> Existing Adirondack Service w/ track Improvements beteween Albany and Border [1]	2:45 51 mph	4:21 44 mph	1:55 21 mph	10:01 44 mph	25,000	$ -	$ -	$20	$ 800	$ 1.4
S1: 70 MAS, No Alignment Changes, 3" Eu, 9 Stops	2:45 51 mph	3:50 50 mph	1:55 21 mph	9:30 47 mph	50,000	$ 6	$ -	$20	$ 400	$ 0.4
S2: 70 MAS, No Alignment Changes, 3" Eu, 3 Stops	2:45 51 mph	3:37 53 mph	1:55 21 mph	9:17 49 mph	75,000	$ 6	$ -	$20	$ 267	$ 0.3
S3: 70 MAS, No Alignment Changes, 5" Eu, 3 Stops	2:45 51 mph	3:33 54 mph	1:55 21 mph	9:13 49 mph	75,000	$ 13	$ -	$20	$ 267	$ 0.3
S4: 79 MAS, Curve Improvements, 5" Eu, 9 Stops	2:45 51 mph	3:32 56 mph	1:55 21 mph	9:04 51 mph	75,000	$ 13	$ -	$40	$ 533	$ 0.6
S5: 79 MAS, Curve Improvements, 5" EU, 3 Stops	2:45 51 mph	3:11 60 mph	1:55 21 mph	8:51 52 mph	100,000	$ 13	$ 2	$40	$ 400	$ 0.5
S6: 79 MAS, Curve Improvements, 7" EU, 3 Stops, Tilt Train	2:45 51 mph	3:02 63 mph	1:55 21 mph	8:42 54 mph	100,000	$ 13	$ 2	$150	$ 1,500	$ 1.6
S7: 90 MAS, Curve Improvements. 5" EU, 9 Stops	2:45 51 mph	3:16 58 mph	1:55 21 mph	8:56 52 mph	100,000	$ 13	$ 2	$130	$ 1,300	$ 1.7
S8: 90 MAS, Curve Improvements. 5" EU, 3 Stops	2:45 51 mph	3:03 62 mph	1:55 21 mph	8:43 54 mph	125,000	$ 13	$ 5	$130	$ 1,040	$ 1.4
S9: 90 MAS, Curve Improvements, 7" EU, 9 Stops, Tilt Train	2:35 55 mph	3:07 61 mph	1:55 21 mph	8:37 54 mph	125,000	$ 19	$ 5	$240	$ 1,920	$ 2.4
S10: 90 MAS, Curve Improvements, 7" EU, 3 Stops, Tilt Train	2:35 55 mph	2:54 66 mph	1:55 21 mph	8:24 57 mph	150,000	$ 19	$ 5	$240	$ 1,600	$ 2.2
S11: 90 MAS, Curve Improvements, 9" EU, 3 Stops, Tilt Train	2:35 55 mph	2:47 68 mph	1:55 21 mph	8:17 58 mph	150,000	$ 19	$ 5	$240	$ 1,600	$ 2.0
S12: 110 MAS, Curve Improvements, 7" EU, 9 Stops, Tilt Train	2:35 55 mph	2:59 64 mph	1:55 21 mph	8:29 56 mph	150,000	$ 19	$ 5	$270	$ 1,800	$ 2.6
S13: Curve Improv. 110 MAS, 7" EU, 3 Stops, Tilt Train	2:35 55 mph	2:44 70 mph	1:55 21 mph	8:14 59 mph	150,000	$ 19	$ 10	$270	$ 1,800	$ 2.2

TABLE S-2: COMPARISON OF EXISTING NEW YORK TO MONTREAL RAIL SERVICE TO POTENTIAL ALIGNMENT AND SERVICE ENHANCEMENTS CAPITAL AND O&M COSTS, RUNNING TIME SAVINGS & ADDED PASSENGERS VS. CAPITAL COSTS										
	TRAVEL TIME CHANGES				ADDITIONAL ANNUAL RIDERS AND TRAIN AND TRACK MAINTENANCE COSTS + CAPTIAL COSTS					
	NYC – Albany [2]	Albany – Rouses Point	Rouses Pt. – Montreal [3]	Total Travel Time	Additional NYC-Montreal Riders [5]	Additional Operating Costs [6]	Additional Maintenance Costs [7]	Total Capital Cost (Millions)	$ Per Additional Rider	Million $/Minute Saved
S14: Curve Improv. 110 MAS, 9" EU, 3 Stops, Tilt Train	2:35 55 mph	2:38 73 mph	1:55 21 mph	8:08 60 mph	175,000	$ 19	$ 10	$270	$ 1,543	$ 2.1
S15: Curve Improv. 125 MAS, 7" EU, 9 Stops, Tilt Train	2:35 55 mph	2:54 66 mph	1:55 21 mph	8:24 57 mph	150,000	$ 19	$ 12	$270	$ 1,800	$ 2.4
S16: Curve Improv. 125 MAS, 7" EU, 3 Stops, Tilt Train	2:35 55 mph	2:39 72 mph	1:55 21 mph	8:09 60 mph	175,000	$ 19	$ 12	$270	$ 1,543	$ 2.1
S17: Curve Improv. 125 MAS, 9" EU, 3 Stops, Tilt Train	2:35 55 mph	2:34 75 mph	1:55 21 mph	8:04 61 mph	175,000	$ 19	$ 12	$270	$ 1,543	$ 2.1
S18: 79 MAS, Curve Improvements, 5" EU, 9 Stops, DMU Train	2:45 51 mph	3:24 56 mph	1:55 21 mph	9:04 51 mph	75,000	$ 6	$ 2	$110	$ 1,467	$ 1.5
S19: 79 MAS, Curve Improvements, 5" EU, 3 Stops, DMU Train	2:45 51 mph	3:11 60 mph	1:55 21 mph	8:51 52 mph	100,000	$ 6	$ 2	$110	$ 1,100	$ 1.3
HSR-1: HSR Alignment, 150 MAS, 9 Stops, Tilt Train	2:35 55 mph	2:08 89 mph	1:55 21 mph	7:38 69 mph	400,000	$ 38	$ 25	$4000	$ 10,000	$ 25.6
HSR-2: HSR Alignment, 150 MAS, 3 Stops, Tilt Train	2:35 55 mph	1:38 116 mph	1:55 21 mph	7:08 83 mph	400,000	$ 38	$ 25	$4000	$ 10,000	$ 21.5
HSR-3: HSR Alignment, 150 MAS, 3 Stops, Tilt Train + Quebec HSR & No Customs	2:35 55 mph	1:38 116 mph	0:27 91 mph	4:40 96 mph	500,000	$ 38	$ 25	$4000	$ 8,000	$ 12.0
HSR-4: HSR Alignment, 150 MAS, 3 Stops, Tilt Train + Quebec HSR, No Customs + Empire Savings [4]	2:00 71 mph	1:38 116 mph	0:27 91 mph	4:05 96 mph	550,000	$ 38	$ 25	$4000	$ 7,273	$ 10.8

[1] Maintenance Upgrade (MU) involving tie replacement, track resurfacing and track replacement at critical locations between Albany and Rouses Point, resulting in fewer stop orders, greater reliability and reduced schedule "pad." Costs for this upgrade (approximately $20 million) included in all improvements except "HSR Alignment" schemes, which assume entirely new alignment.
[2] Inclues 15 minutes layover time at Albany-Ren. Station, reduced to 5 minutes with investment in Tilt-Train equipment and alignment improvements, and under full HSR operation.
[3] In Quebec, train presently has two stops between Rouses Point and Montreal, including Customs. Under full HSR, assumes no stops in Quebec other than Montreal.
[4] On-going and planned improvements in NYC-Albany portion of Empire Corridor, with preliminary projected savings of up to 35 minutes. Time savings here assume full 35-minute benefit from those programs.
[5] Present annual ridership approximately 90,000. Figures represent preliminary estimates based on ridership growth projected in other HSR studies with comparable time savings. Does not include increases in "local" ridership (e.g., Glens Falls to Albany, Albany to Plattsburgh, etc.).
[6] Reflects need for increased train frequency, with up to 3 additional trains per day in each direction under higher-cost improvements to existing alignments and 5 per day on full HSR scenarios.
[7] Relfects likely "charge" to passenger operator (presently Amtrak) by CP Rail for additional track maintenance expenses associated with operation of higher speed passenger trains on this alignment (Albany to Rouses Point only). Based roughly on present charges to Amtrak for higher-speed portions of Empire line. HSR (150 mph) figure is rough estimate of annual maintenance costs for dedicated HSR alignment.

various improvement scenarios. As shown, capital costs range from $20 million to $40 million for some of the lower-cost Incremental Improvement scenarios (i.e., S1 through S-5), to approximately $4 billion for the full 150 MPH Dedicated HSR alignment. Annual operating and maintenance costs range from $6 million for the lower-level improvements to over $60 million for the 150 MPH HSR options.

As Exhibit S-5 indicates, the capital expenditure per minute saved is considerably higher for the full HSR scenarios than for the more modest-prices Incremental Improvement scenarios. The Incremental Improvement scenarios would appear even more cost-effective if the time savings due to Quebec HSR and elimination of the Customs stop were reflected under those scenarios as well.

Exhibit S-5
Capital Costs ($Mill.) Per Minute Saved

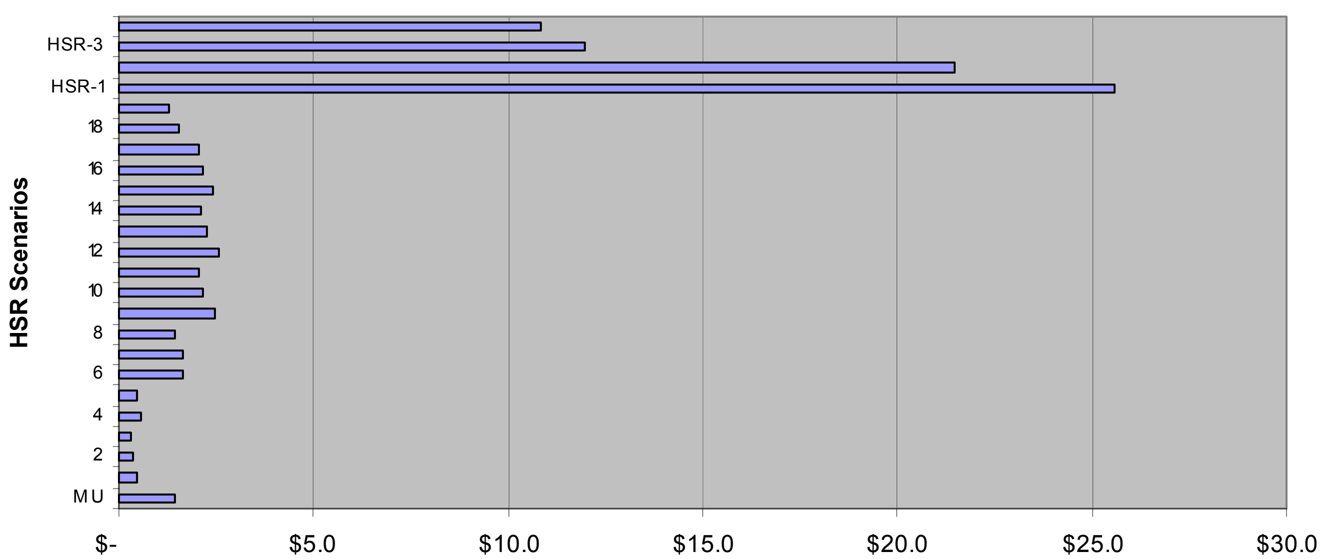


Table S-2 also indicates the approximate ridership projections under each of the improvement scenarios. No detailed marketing studies were completed as part of this study. These projections are based on previous studies of HSR-type service in this and similar corridors, including those made for the Boston-to-Montreal market. For full HSR service, including similar service in Quebec and a total travel time of close to 4 hours, an increase of approximately 550,000 passengers over the present total of approximately 90,000 annual passengers was estimated. Under similar service assumptions, the MTQ study projects annual ridership increases in the New York City to Montreal corridor of approximately 650,000 to 700,000, or slightly higher than this study's estimate. These projections all assume full HSR service service between the two cities, with 5-6 trains per day in each direction. MTQ's projections are primarily based on studies done in the 1980s for higher-speed (180-200 MPH) service in the Montreal to Boston market.

All of these ridership figures are very preliminary estimates. Potential future ridership levels would be substantially impacted by internal factors (e.g., service frequency, fare levels, etc.) and external factors (e.g., growth in discount air service, gasoline prices, etc.). As shown in Table S-2, the capital cost per additional annual rider range from $400 to $1,900 for the Incremental Improvement scenarios to $7,000 to $10,000 for the full HSR scenarios.

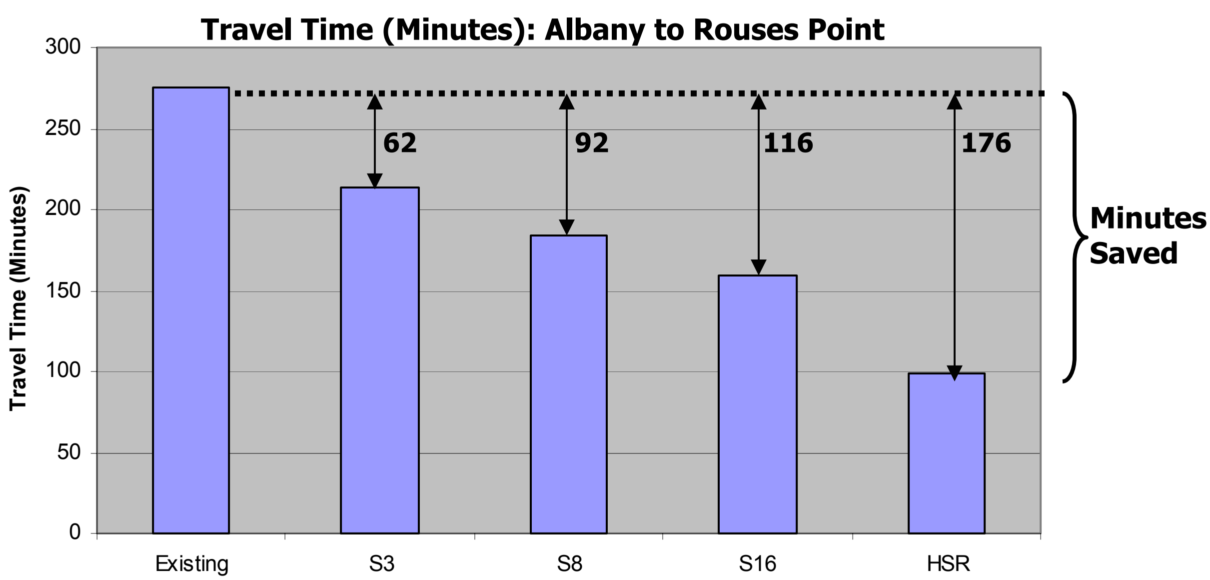
SUMMARY AND RECOMMENDATIONS

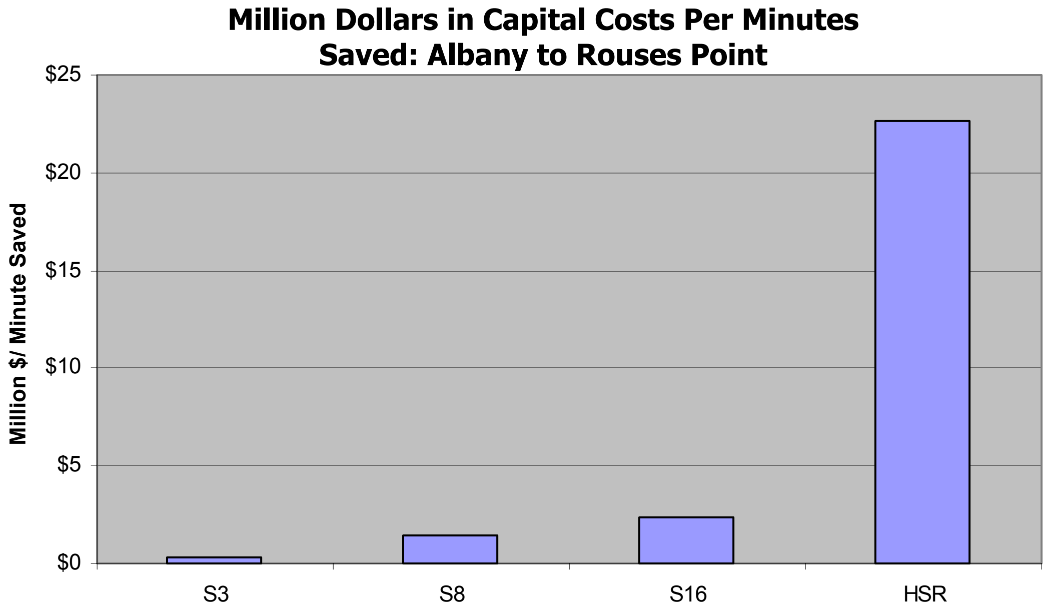
- Full 150 MPH HSR service between New York City and Montreal could reduce rail travel time between these two cities from the present 10 hrs. 15 minutes to 4hrs. 5 minutes. The capital costs for the 190-mile Albany to Rouses Point portion of this alignment would be approximately $4 billion, while the equivalent costs for the 41-mile portion within Quebec would be approximately $179 million.

- Incremental improvements to the existing alignment between Albany and Rouses Point could provide substantial travel time savings at considerably lower costs ($20 to $270 million). The trip from Albany to Rouses presently takes 275 minutes (4 hrs. 35 minutes or 4:35). Full 150 MPH HSR service would cut this to 1:38, while the most extensive incremental options would bring it into the 2:39 to 3:08 range (for the S16 and S8 scenarios shown below). However, in terms of millions of dollars of capital costs per minutes saved, the Incremental Improvement options are far more cost-effective.

- These pre-feasibility studies indicate that development of HSR in this study has merit. The State should seek (a) FRA designation of the Albany-to-Rouses Point corridor as part of the national HSR network, and (b) federal funding to help implement HSR in the corridor.

- Based on the State's current fiscal position and the long implementation time associated with Dedicated HSR Alignment schemes, the State should initially pursue the Incremental Improvement scenarios, which can be implemented more quickly and are the most cost-effective.





- Eliminating the existing Customs stop, which presently required approximately one hour, would be one of the most significant and likely most cost-effective travel time savers. All recent HSR studies involving US-to-Canada routes are assuming that this change could be made, with Customs handled in the same manner as air travel.

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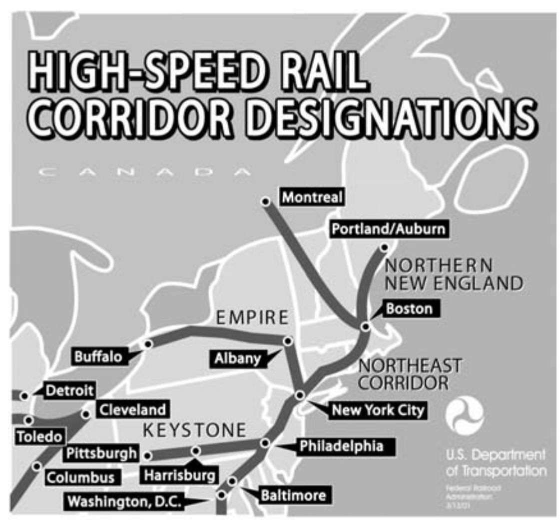
1. INTRODUCTION

1.1. Study Overview

A comprehensive study has been initiated by the New York State Department of Transportation (NYSDOT) to identify improvements to the transportation network in the I-87/Autoroute 15 Corridor in New York State and Quebec. These actions would address past growth in the corridor while allowing the full potential growth in the economy of the corridor and region to be achieved. The I-87 Multimodal Corridor Study ("the Study") will be integrated with the findings and results of the New York and the New World Economy study previously completed for NYSDOT, which focused on major changes in the regional, national and international economies and trade patterns, and the consequences of those changes on future transportation patterns and requirements. The goal of the Study is to identify and analyze recommended transportation initiatives and rank them in terms of their ability to enable New York State to respond to these changing economic forces and trends.

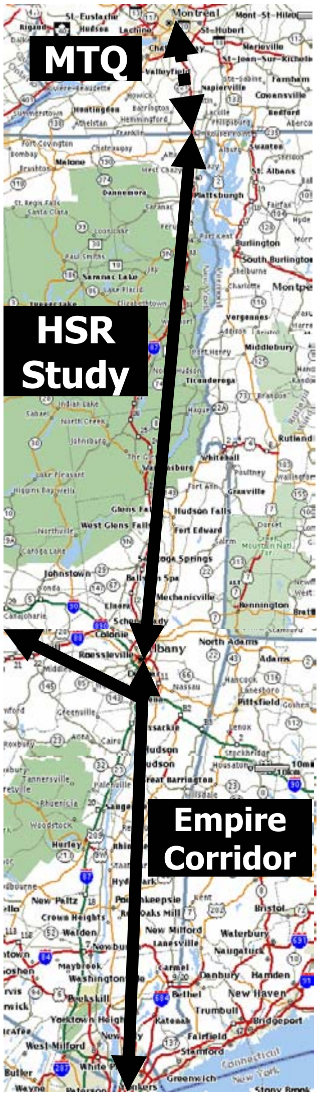
A significant component of the Study is the High-Speed Rail Pre-Feasibility Study, which is assessing the concept of developing high-speed rail (HSR) service in the New York City – Montreal corridor. Passenger train service is presently very limited in that corridor, with only one train per day in each direction that takes over 10 hours. This study, being completed in cooperation with the Quebec Ministry of Transportation (MTQ), includes a preliminary look at the viability of implementing true European-type high-speed service (150+ mph throughout). More modest incremental improvements to the existing New York-to-Montreal passenger rail service are also being investigated. MTQ is looking at similar HSR service over the segment between Montreal and the US-Canadian border.

1.2. High Speed Rail Corridors



The US Department of Transportation's Federal Railroad Administration (FRA) has designated eleven high-speed corridors under the Intermodal Surface Transportation Act of 1991 (ISTEA) and the Transportation Efficiency Act for the 21st Century (TEA-21). This designation allows a corridor to receive earmarked funding for a variety of high-speed rail related projects, including highway-rail grade crossing safety improvements, and recognizes the potential to develop that type of service in that corridor. The presently designated corridors nationwide include:

- California Corridor
- Pacific Northwest Corridor
- South Central Corridor
- Gulf Coast Corridor
- Chicago Hub Network
- Florida Corridor
- Southeast Corridor
- Keystone Corridor
- Northeast Corridor
- Empire Corridor
- Northern New England Corridor



As shown, the Empire Corridor, extending from New York City to Albany and then west to Buffalo, is already one of the nation's 10 designated corridors. This 439-mile corridor has been the subject of a number of previous and on-going studies and projects. Due to improvements in recent years, portions of the Albany-New York section have operations at up to 110 mph, and the growing ridership in that segment of the corridor make it one of the strongest intercity passenger services in the country. New "RTL" turbine-powered equipment, being re-manufactured in a public/private partnership involving NYSDOT, the FRA and Amtrak, is gradually being introduced to the corridor. NYSDOT and Amtrak are looking to make further incremental improvements in the 160-mile New York-to-Schenectady corridor to attain speeds of up to 125 MPH. Various upgrades west of Schenectady to Buffalo/Niagara Falls are also planned.


New Albany-Rensselaer Station

Within the New York-to-Montreal corridor, a primary goal of the existing Empire Corridor effort is to reduce travel time between New York City and Albany to less than two hours versus the present scheduled time of 2.5 hours. The new Albany/Rensselaer train station was recently opened and plans are underway to convert the historic Farley Building Post Office in New York City to the New York City Amtrak station. Parallel programs by NYSDOT and FRA are also ongoing to close or upgrade a number of rail crossings and to test new grade crossing technologies and warning systems in the corridor.

The remaining New York State section of the New York City-to-Montreal corridor – from Albany to the US-Canadian border – is the focus of this High-Speed Rail Pre-Feasibility Study.

Boston-to-Montreal Corridor

The feasibility of HSR operation in the Boston-to-Montreal portion of the Northern New England HSR corridor is presently being assessed by the States of Vermont, Massachusetts and New Hampshire. Currently, travel from Boston to Montreal requires transferring to a second train in New Haven, Connecticut and to a bus for the final leg from St. Albans, Vermont, with a total travel time of over 12.5 hours. The first phase of that study (*Boston to Montreal High-Speed Rail Planning and Feasibility Study: Phase I*) focused on the potential ridership and passenger revenues under various service scenarios in a 329-mile corridor extending northwest from North

Station in Boston, through Concord, NH and Burlington, VT into Quebec and Montreal's Central Station.

The Boston to Montreal study's Phase I results recommend:

- Using the existing track alignments, with no service above 110 MPH due to the higher network costs above that speed;
- The corridor would not be electified;
- Eliminating the stop at the US-Canada border for Customs;
- A "Mid-Speed"service scenario (FRA Class 6, up to 110 MPH but with curve speeds restricted by track geometry); and
- A "low fare" marketing approach and 6 round-trips daily.

As shown in Table 1, total annual ridership of 680,000 passengers in the overall corridor was projected under this Mid-Speed/Low Fare scenario, assuming roughly 5 hrs. 48 min. travel time. Roughly one-third of these passengers would be traveling between Boston and Montreal, with the others making shorter trips, including many that would effectively be commuter-type trips into Boston. By cutting travel time by roughly 40% for the Boston-Montreal trip, ridership is projected to over 15 times higher when compared against the present service. Going to a higher-speed option (110 MPH with no curve restrictions), which would provide another 1 hr. 15 min. in time savings, was not recommended due to the high costs and likely required higher fare. As indicated in the chart, competition with auto travel time would play an important role in travelers' decisions in this market. Under the scenario that produced the highest ridership and passenger revenues, the travel time between train and car were roughly equal.

Table 1. Boston-to-Montreal High-Speed Rail Scenarios

	Low Speed	Mid Speed High Fare	Mid Speed Low Fare	High Speed
Annual Ridership				
Total Corridor	213,276	330,097	683,667	644,232
Boston-Montreal	13,469	84,428	221,227	200,564
Approximate Fare	$53	$99	$66	$119
Travel Time	8:55	5:48	5:48	4:31

1.3. Study Purpose & Approach

The purpose of this study is to assess the issues and impediments associated with implementing high-speed rail service in the corridor between Albany and Montreal, in an effort

to significantly improve the competitiveness of rail service in this corridor. Parallel to this HSR study, an overall review of rail infrastructure in the corridor is being completed as part of the I-87 Multimodal Corridor Study, leading to a list of potential improvements to the rail network that would help both passenger and freight services. As previously noted, MTQ is completing a parallel study of high-speed rail service in the corridor segment between Montreal and the US/Canadian border at Rouses Point. NYSDOT and MTQ HSR study teams have met frequently to insure compatibility of approaches and to compare notes regarding the types of improvements required to achieve HSR service, the approximate related costs, and estimated travel time savings. The results of the MTQ studies are summarized in this report and used to provide an overview of the likely travel time savings under various high-speed service options.

Two basic approaches are taken in this study to assess the potential for improving the speed of rail passenger travel in the I-87 Corridor:

- **Incremental Improvements to Existing Service** – identify the types of incremental improvements needed to reach maximum corridor speeds of 79 MPH, 90 MPH, 110 MPH, and 125 MPH utilizing, to the extent possible, the existing alignment of the former Delaware & Hudson Railway (D&H) section of the Canadian Pacific Railway system (CP). This approach is addressed in Section 4 of this report.

- **Full High-Speed Rail Service** – assess the improvements needed to achieve a sustained speed of 150 MPH for the full length of the trip, on a primarily new high-speed railway alignment. This new alignment would be exclusively for passenger trains, while the D&H route would be nearly exclusively used as a freight artery, with some local-type passenger service possible as well. This approach is addressed in Section 5 of this report.

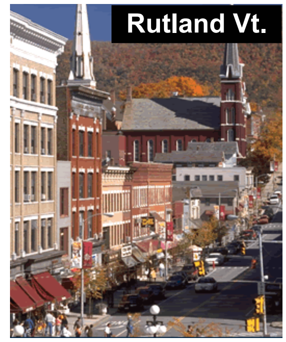
The report discusses existing rail infrastructure conditions and passenger operations in the corridor and compares them against possible improvement scenarios. In these analyses, an initial "Maintenance Upgrade" condition is assumed, reflecting a minimum set of necessary track-related improvements necessary for subsequent improvements to be effective. On-going and planned improvements in the portion of the Empire Corridor between New York City and Albany is projected to produce travel time reductions. These potential time savings are noted in this study but are not assumed to be part of the "baseline" conditions. While other on-going and planned track, signal, yard and related improvements in the corridor north of Albany could result in some incremental time savings, no credit is taken for them in this study.

Sections 2 and 3 review existing passenger and freight traffic in the rail corridor, the status of the corridor's rail infrastructure and its associated shortcomings relative to potential high-speed passenger service. After the Incremental and Full High-Speed analyses are presented in Sections 4 and 5, Section 6 discusses and presents data relating to the construction costs of the various time saving options. The report's appendices provide additional details supporting the data and conclusions presented in this report.

2. EXISTING RAIL TRAFFIC AND INFRASTRUCTURE IN THE CORRIDOR

2.1. Existing Passenger and Freight Train Traffic

Amtrak generally operates four passenger trains on the D&H trackage each day:



- The Adirondack (two trains per day – one in each direction) between New York (Penn Station) and Montreal (Central Station). These trains operate on the Delaware and Hudson line (D&H) between Schenectady and Rouses Point at the U.S./Canada border, and on Canadian National tracks from the border to Central Station in Montreal.

- Ethan Allen Express (two trains per day – one in each direction) between New York (Penn Station) and Rutland, VT (Rutland Plaza). This train utilizes the D&H line between Schenectady and Whitehall, and the Vermont Railway system to Rutland.

Stops on Adirondack and Ethan Allen Services

There are presently nine intermediate station stops on the Adirondack service between Albany/Rensselaer and Rouses Point -- Schenectady, Saratoga Springs, Fort Edward-Glens Falls, Whitehall, Ticonderoga, Port Henry, Westport, Port Kent (seasonal), and Plattsburgh. After Rouses Point the train stops in Quebec at Cantic (customs) and St. Lambert before arriving at Central Station in Montreal. The estimated annual ridership (FY 2001 – 2002) was 91,000 between Albany/Rensselaer and Montreal on the Adirondack and 69,000 for the Ethan Allen Express (at stations in N.Y. State).

The number of line haul freight trains operated in the corridor each day is highly variable, depending upon day of the week, traffic received from connecting carriers, and traffic volume at terminals on-line. The present freight operating plan for the D&H between Schenectady and Rouses Point is primarily focused on the Saratoga Springs Yard. The greatest freight train density occurs on the southernmost portion of the Schenectady/Rouses Point line of the D&H, with an average of roughly 8.2 line haul freight trains per day on the 19-mile line segment between Schenectady and Saratoga Springs. Between Saratoga Springs and Whitehall (40 miles), an average of 5.2 trains per day includes two trains operated by the Vermont Railway on trackage rights between Whitehall and Albany (D&H's Kenwood Yard) for interchange. From Whitehall to Rouses Point/Montreal, the average drops to 3.2 line haul freight trains each day.

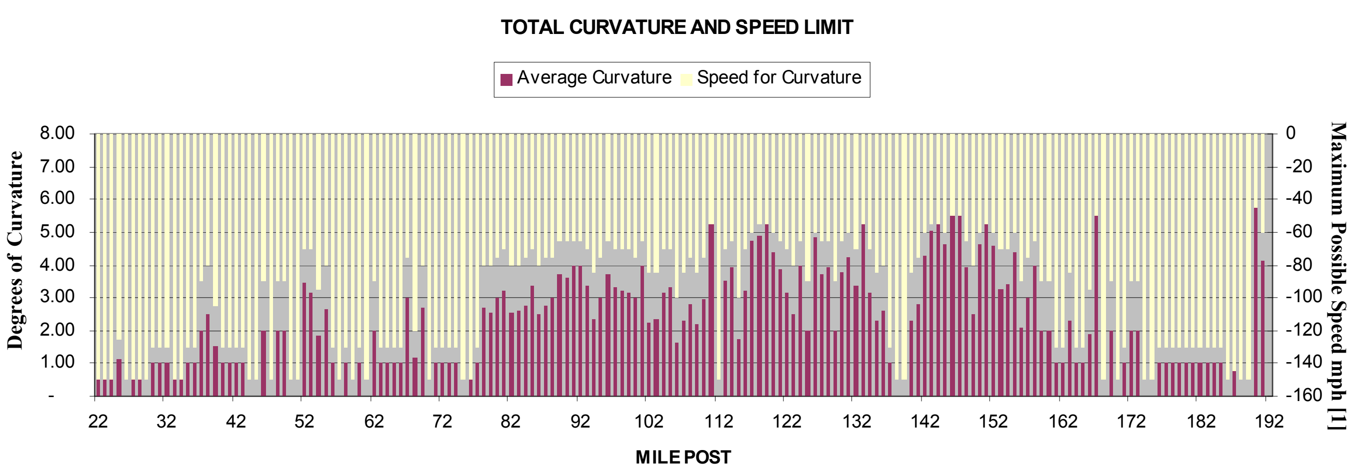
The majority of commodities handled by CP on the D&H route between Montreal and Albany/Schenectady area consist of paper, lumber, plastics, chemicals, and intermodal containers. Much of the freight revenue generated by the D&H is overhead or bridge traffic that neither originates nor terminates on the CP/D&H system. A significant amount of this traffic moves between the Norfolk Southern and the Guilford systems in New England via the CP/D&H at Mechanicville, N.Y. This traffic tends to have relatively low profit margins for CP Rail.

By U.S. mainline railroad standards, the D&H is very lightly used. The CP recently disclosed that it is reviewing strategic options toward improving the financial performance of the D&H unit. Reportedly one option under consideration is a lease of the D&H to a non-Class I railroad who may be able to generate more traffic, short haul in all probability, and to operate the property with a more favorable cost structure.

2.2. Existing Railway Alignment

As noted above, CP Rail owns and operates the D&H line between Montreal and Albany/Schenectady, generally paralleling the I-87 Corridor. For purposes of this report, the D&H alignment is the 178-mile line between the D&H connection with the CSX/Amtrak Chicago Line in Schenectady and the Canadian border at Rouses Point, NY, where the D&H connects to both the CP and Canadian National Railway (CN) systems.

The existing D&H alignment, as a continuous through route to the Canadian border, is 130 years old. In its present configuration, this single-track alignment largely reflects the construction technology and financial limitations of the mid-19th century. Because of this, the average speed of Amtrak's Adirondack service between Schenectady and Rouses Point is 41 MPH, including the eight station stops in between. The nearly constant curvature of the alignment is the constraint on average speed, particularly in the 85-mile line segment between Whitehall and Bluff Point (south of Plattsburgh).



[1] Maximum possible speed on a given curve in isolation. Does not reflect the interaction of the grouping of curves or actual train performance (acceleration, deceleration).

As the chart matching curvature and speed limits indicates, train speed is fundamentally limited by frequent curves in the alignment, regardless of the available horsepower, the method of propulsion, or the general speed capability of the equipment utilized. In the 178 miles between Schenectady and Rouses Point, there are 366 curves. In the 85-mile segment between Whitehall and Bluff Point, there are 289 curves of which 46 curves exceed 3 degrees. In terms of grades, there are no sustained grades that exceed 1% over the entire Albany-Rouses Point alignment (1% is commonly found along most heavy-duty mainline railroads throughout the United States). The only exception is a westbound grade of 1.5% in the West Albany area, as trains crossing the Hudson River must gradually climb out of the river valley. The curve chart appears to indicate that trains could operate at 80-100 MPH or more over long segments of this alignment. However, as the following section will discuss, the theoretical speed around a given curve in isolation does not reflect how the combination of the bunching of curves, their location relative to station stops, train performance capabilities and other factors determine the maximum allowable speed.

2.3. Track Configuration

Exhibit 1 presents the existing D&H alignment between Rouses Point and Albany. The D&H is a single main track railroad with nine remote-controlled sidings of varying length, ranging between 4,900 feet and 16,900 feet, as shown in Table 2.

Table 2. Controlled Siding Locations Between Albany-Rensselaer and Rouses Point

Mile Post	Location	Length (feet)
156.5 –159.9	CSX Carman/Schenectady	15,750
482.57 – 480.36	Mohawk Yard	West- 6,800 East -10,600
30.76 – 32.91	Ballston Spa	10,600
34.97 – 37.51	Saratoga Springs	12,300
55.87 – 57.98	Fort Edward	9,700
73.92 – 77.29	Whitehall	16,900
99.00 – 100.02	Fort Ticonderoga	4,900
123.0 – 124.5	Westport	7,800
130.58 – 131.90	Wadhams	5,800
162.50 – 165.20	Bluff Point	13,350
189.39 – 190.58	Rouses Point	5,800

Train movements along the line are controlled by wayside automatic block signal systems (ABS). South of Whitehall, the D&H had previously been a double-track main line with manually controlled interlockings. However, declining train traffic beginning in the 1950s warranted a reduction in both plant capacity and in the expense of operating and maintaining the plant.

The D&H Line (Canadian Main Line) has a maximum authorized speed (MAS) of 40 MPH for freight and 70 MPH for passenger trains (Amtrak). However much of the line has speed restrictions well below the MAS, mostly related to extreme curvature of the alignment.

CP has an on-going capital improvement agreement, with some assistance from New York State Department of Transportation, to maintain the line in the best possible condition, consistent with available capital program funds. In addition to correcting temporary slow order conditions, the focus of the capital program is the rehabilitation of interlockings and the signal system, as well as replacing jointed rail with welded rail, which provides both improved ride quality and lower maintenance expenses. This $18 million program of short-term capital improvements focuses on the segment between Schenectady and Rouses Point. The intent is to complete these track and signal improvements, primarily on the Canadian Main Line, by the end of 2005. These include track improvements (e.g., installation of relay rail, new crossties and switch ties, etc.), improvements to bridges, culverts and grade crossings, and a rail grinding program along the corridor. The goals are to:

- Reduce long-term speed restrictions at a minimum of 10 locations along the corridor;
- Improve passenger & freight train safety and on-time performance;
- Reduce passenger train delays by increasing track speeds to over 65mph on the passenger corridor, where permissible; and
- Reduce passenger train delays caused by freight trains.

I-87 Multimodal Corridor Study

Exhibit 1a
Existing Rail Alignment

Existing Alignment

I-87 Multimodal Corridor Study

Exhibit 1b
Existing Rail Alignment

Existing Alignment

I-87 Multimodal Corridor Study

N

0 2 Miles

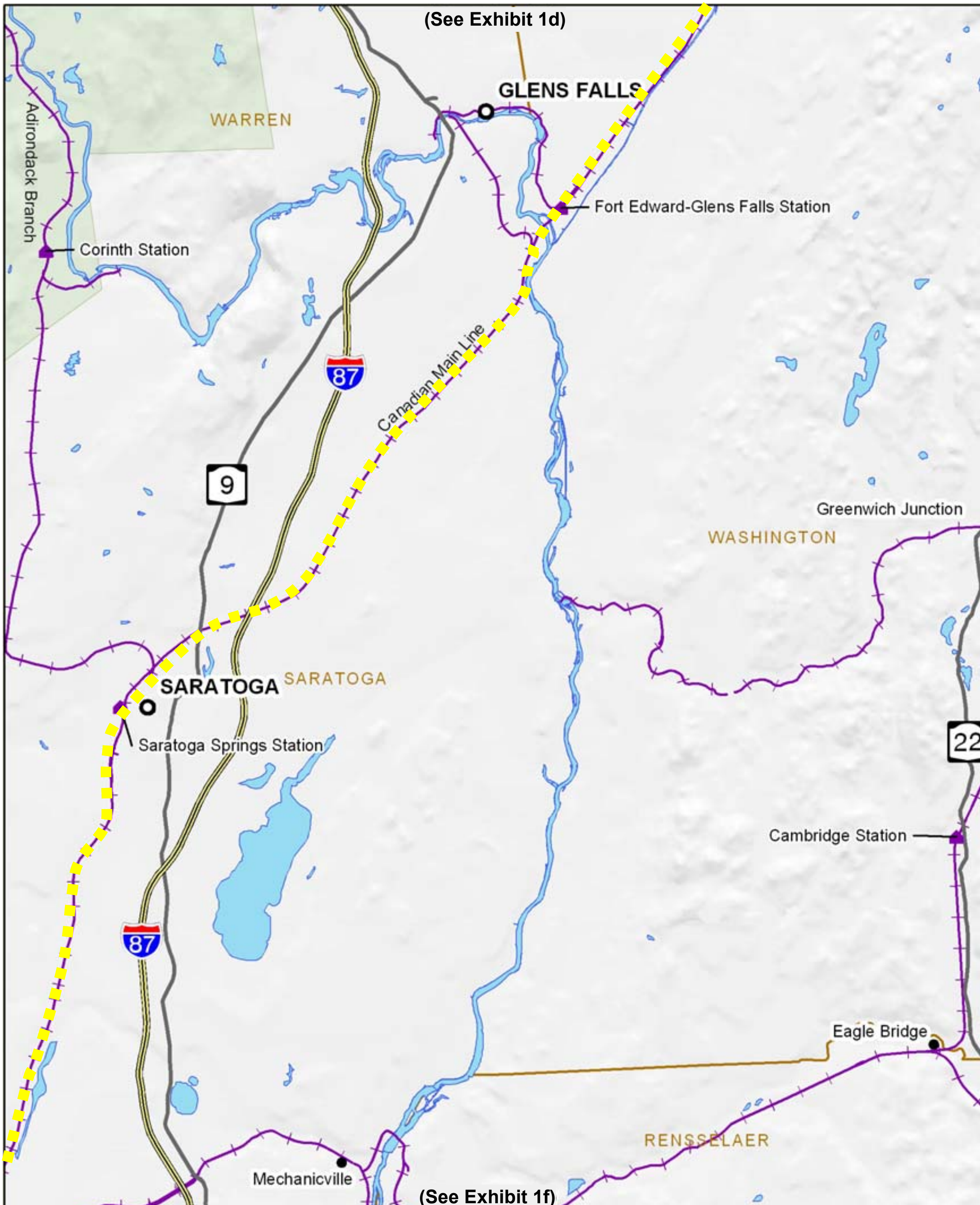
Exhibit 1c
Existing Rail Alignment

Existing Alignment

I-87 Multimodal Corridor Study

Exhibit 1d
Existing Rail Alignment

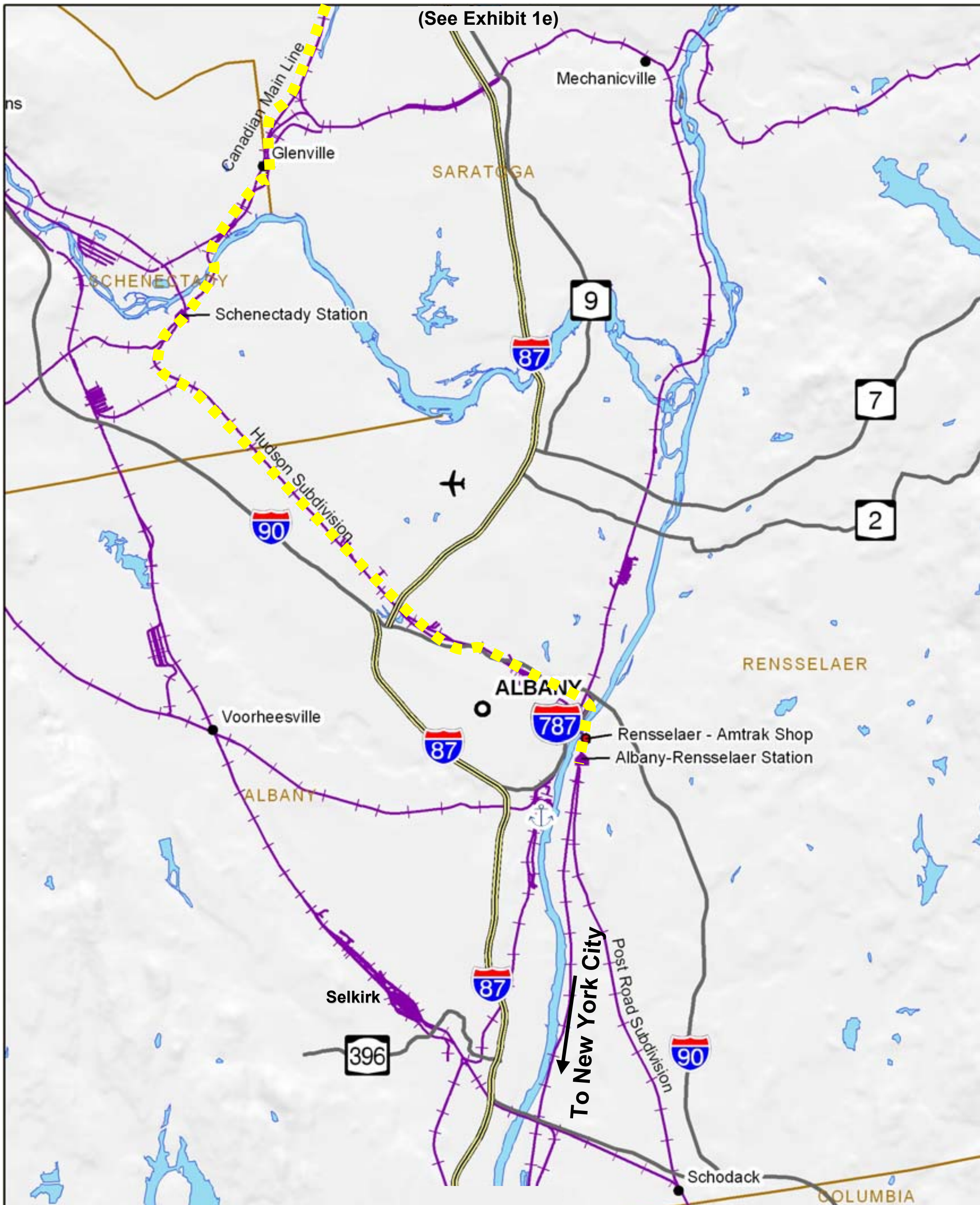
Existing Alignment



I-87 Multimodal Corridor Study

Exhibit 1e
Existing Rail Alignment

Existing Alignment



I-87 Multimodal Corridor Study

N

0 2 Miles

Exhibit 1f
Existing Rail Alignment

Existing Alignment

3. EQUIPMENT: ROLLING STOCK & TRAIN CONTROL SYSTEMS

3.1. Existing Passenger Train Service Equipment

P40DC Locomotive

Presently, Amtrak operates the Adirondack and Ethan Allen Express with a diesel-electric engine (P40DC model 4,250 h.p. or occasionally a P32), normally four Amfleet cars, including a lounge car serving snacks and beverages, as well as a baggage car. The Amfleet equipment is nearly 30 years old and has been the mainstay of Amtrak's single-level coach equipment, including the high-speed Metroliner service fleet on the Northeast Corridor. Overhauls and rebuilds can be expected to extend the life of the Amfleet equipment into the foreseeable future.

New York State, as part of its overall investment in improved rail passenger service, has ordered the re-manufacturing of existing train sets by SuperSteel Schenectady, Inc., to increase their high-speed operating capabilities. The improved high-speed train sets, known as RTL Turboliners, can reach speeds of 125 mph in non-electrified areas. The train sets are dual-powered, capable of running at high speeds using diesel fuel, as well as operating under 100 percent electrical power in the tunnels of New York City. They also reduce travel time because of faster acceleration and better curve speed. A total of 6 train sets have been ordered and several are already in operation between New York City and Albany. The use of these new train sets, along with a variety of track improvements, are projected to reduce running times between New York City and Albany to under two hours. However, these trains are not scheduled to be used for the Adirondack service to Montreal.

3.2. Other Potential Equipment

Tilt-body Equipment

Given the extraordinary horizontal curvature of the majority of the line along Lake Champlain, tilt-body equipment is an important consideration in reducing the capital investment needed to improve running time. Tilt-body equipment is presently in revenue service in the United States in the electrified Northeast Corridor and on a 309-mile mixed passenger and freight corridor in the Pacific Northwest between Seattle, Washington, and Portland and Eugene, Oregon.

Tilt-body equipment can provide the necessary passenger comfort while moving through curves at a higher speed. This equipment combines tilt-body technology with reduced train weight and a lower unsprung weight per axle in the locomotive/power cars compared with the weight of components below the primary suspension system. The centrifugal (g) force generated as a train goes around a curve is a function of the train's velocity entering a curve, and the radius of the curve. Tilt-body equipment provides a means to counter the increase in centrifugal force while moving through a curve at a higher speed.

JetTrain Technology

Developed in a partnership with the U.S. Federal Railroad Administration's research and development funding, Bombardier Transportation, Inc. introduced its JetTrain in 2001, utilizing gas turbine power and a computer-controlled and hydraulically activated tilting system assuring full stability and passenger comfort when negotiating curves at higher speeds.

Jet Train Locomotive

JetTrain's operating speed is 150 miles per hour and fully complies with all FRA Passenger Safety Standards. The locomotive's low unsprung mass permits high-speed travel on the existing North American network without producing damaging track forces. Weighing only 1,200 pounds, the Pratt & Whitney engine is one-tenth the size and 38,000 pounds lighter than a conventional diesel engine. JetTrain coaches are equipped with an advance tilting system that allows the train to take curves at higher speeds on existing railway alignments. The tilting system reduces centrifugal forces by almost 60 percent, compared with trains without tilting mechanisms.

3.3. Technology Assumptions used in this Report

Signal and Train Control Assumptions

This study assumes the regulations and guidance presently promulgated by the Federal Railroad Administration for the planning and operation of high-speed rail lines that may or may not be owned or jointly used by freight service operators. In this case, CP owns the D&H but the Vermont Railway has trackage rights on the D&H between Whitehall, NY and Albany via Mechanicville.

Under the current signal and train control regulations (49 CFR Part 236), signal systems are mandated based on train speed as follows:

Signal System	Speed (MPH)	
	Freight	**Passenger**
None required	To 49	To 59
Block Signals or manual block	50-79	60-79
Automatic cab signal, train stop or train control	80-110	80-110

Automatic Cab Signals provide a warning when the maximum speed on an upcoming track segment is less than the train is presently operating. Automatic Train Stop and Automatic Train Control provide automatic enforcement if the engineer fails to respond properly to these speed warnings. Under the FRA Track Safety Standards (49 CFR Part 213), train operations are permitted up to 110 MPH. Subpart G of those regulations applies to all track used for the operation of trains at a speed greater than 90 MPH. A railroad seeking to operate at greater speeds must receive special approval from the FRA. The following maximum allowable operating speeds apply:

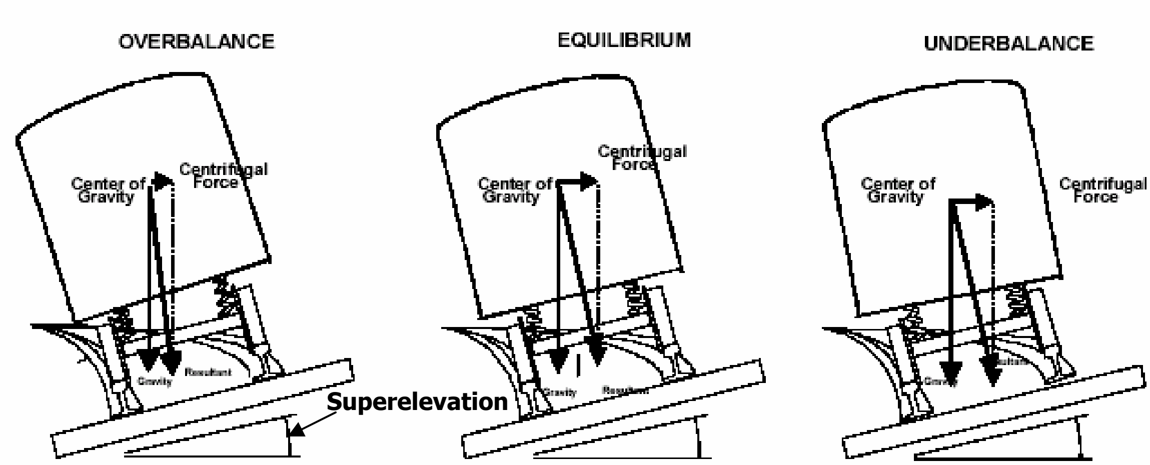
Class 6 track	110 MPH
Class 7 track	125 MPH
Class 8 track	160 MPH
Class 9 track	200 MPH

Operating speeds in excess of 150 MPH are authorized only in conjunction with an FRA ruling addressing a variety of safety issues presented by the system in question. Subpart G of 49 CFR Part 238 applies to Tier II passenger equipment. Tier II applies to operating at speeds between 125 and 150 MPH, while Tier I passenger safety standards apply to equipment operating at speeds up to 125 MPH.

Curvature, Superelevation & Underbalance

In the same way that race car tracks are banked to allow drivers to safely go at higher speeds, the so-called "superelevation" (Ea) of the outside rail of the track structure can similarly counteract the centrifugal force exerted by a train moving through a curve at a specified speed. For a specific curve, operating speed and train type and weight, the required banking or "equilibrium elevation" can be calculated to place the weight of the train equally on both rails.

Most rail segments, including the D&H alignment, handle both passenger and freight trains, which have considerably different operating speeds. Given this, track is rarely superelevated to the equilibrium elevation. The difference between the equilibrium elevation and actual superelevation is termed underbalance (Eu) and is stated in inches. Assume, for example, that a particular curved section of track designed for 80 mph operation would be in equilibrium balance with 4 inches of superelevation. If that section in fact had 3 inches of superelevation, it would be said to have 1 inch of underbalance. Trains operating at slower speeds (e.g., 40 MPH) would be operating in an overbalance condition, with weight disproportionately shifted to the inner wheels and track (see diagram). A section of track on which trains continuously operate in an overbalance condition would require more regular maintenance and rail replacement for the inside rail than would otherwise be required.



Source: AREMA, *Practical Guide to Railway Engineering*. Landover, MD (2003)

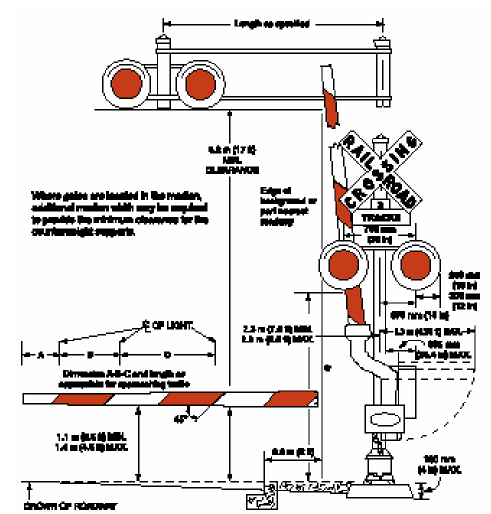
On the safety side, the FRA, which is most concerned about safety and particularly higher-speed derailments in this instance, is most concerned about underbalance, where trains going faster than allowable speeds could potentially derail. The FRA generally permits no more than three inches of underbalance for freight equipment and most passenger equipment, with higher amounts possible for passenger equipment after track geometry testing.

A railroad which owns and maintains a segment of track and operates freight trains over it will therefore resist plans to raise passenger operating speeds by increasing the superelevation and underbalance. Increases in superelevation will mean that the railroad's slower and heavier freight trains will put more pressure on the inner rail, requiring greater maintenance. These two forces – higher maximum authorized speeds (MAS) and higher maintenance expenses – must somehow be balanced.

The transition from level track on tangents to curves can be accomplished in two ways. For low speed tracks with minimal banking (e.g., near or within terminal areas), transition sections are relatively standard based on the amount of superelevation. On higher-speed mainline tracks, the transition from tangent track to superelevated curved track is made by means of a "spiral" section that in essence gradually "introduces" the curve and helps control the forces at work when a higher-speed train enters a banked curved section of track.

Grade Crossings

Every two hours, a vehicle or a pedestrian is struck by a train somewhere in the United States. As train speeds increase, the level of separation and degree of safety at crossings must increase as well. Many systems include both public and private crossings, both of which pose substantial safety problems. FRA guidance for the establishment of a high-speed rail corridor (*High-Speed Ground Transportation for America*, September 1997) assumes the following:



Source: USDOT, FHWA, *Manual of Uniform Traffic Control Devices* (2001).

- At train speeds of up to 79 MPH, all crossings must be either closed or have up-to-date flasher-gate systems.
- At speeds in the 80-110 MPH range, flasher-gate systems are still allowable, but some busier crossings may need to be grade-separated.
- Above 110 MPH, flasher-gate crossings are no longer accepted, with only "positive barrier" controls (which physically restrict crossing the tracks) or grade-separated crossings permitted.
- The closing of private crossings generally increases as operating speeds exceed 80 MPH, with virtually none permitted above 110 MPH.

Beyond these guidelines, the only applicable FRA regulations regarding grade crossings for HSR operations are found in FRA's October 2002 regulations (49 *CFR* 213.347), "Automotive or Railroad Crossings at Grade." However, as confirmed in discussions with FRA staff, those regulations (a) only address requirements for Class 7 (> 125 MPH) and Class 8 (> 160 MPH)

operations, and (b) for operations above 110 MPH, the regulations indicate only that "the track owner shall submit for FRA's approval a complete description of the proposed warning/barrier system…" However, while the regulations do not specifically preclude schemes other than grade separation or positive barrier controls, the FRA generally looks for those types of crossings under higher speed operations.

Electrification

Due to the limits of diesel-electric locomotive technologies, train speeds above approximately 150 MPH require all-electric propulsion systems. However, based on discussions with NYSDOT, as well as MTQ for the section in Quebec, the use of electric traction was not assumed in this report because of the very high initial capital costs (estimated at roughly $1 billion additional costs for the 150 MPH dedicated HSR alignment). Therefore, the top speed considered in this analysis was 150 MPH. The Boston-to-Montreal HSR study discussed in Section 1 of this report similarly recommended no electrification for that alignment. However, the construction design and basic assumptions otherwise used in this New York-to-Mondreal study do not preclude the installation of electrification if warranted in the future.

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4. RUNNING TIMES ON EXISTING CORRIDOR ALIGNMENT

4.1. Train Performance Calculator Runs

Analyses were performed to assess the impact of assumed train consists (number of cars, types of locomotives, etc.), train stopping patterns, and track standards on rail operations between Rouses Point, Schenectady, and Albany. The model that was used was the Train Performance Calculator (TPC), which assesses the performance of a single train over the route. These TPC simulations allow operating conditions and travel times under existing "Baseline" track alignments and train equipment to be compared against those under possible scenarios involving changes to the alignment and/or equipment. A variety of train consists, including conventional intercity and freight trains, can be compared in this way. As discussed in Section 2 of this report, NYSDOT and CP Rail are implementing a number of track, signal, yard and related improvements, primarily along the Canadian Mainline portion of the alignment. While these improvements, scheduled for completion in the next 2-3 years, would have some incremental benfits that could reduce train running times and reliability, no credit was taken for them in these TPC simulations. The main factors that limit passenger train speeds in the corridor would not be significantly changed by these planned improvements.

An alignment analysis also was performed interactively with the TPC throughout the trip time analysis process. The alignment analyzer developed the speed assumptions for individual curves and segments of the rail line that were tested in the TPC process. Analyses of existing track conditions assume up to 4 inches of superelevation. All other scenarios analyzed in this section use a maximum of six inches superelevation, with various levels of underbalance, as specified, from 5 to 9 inches.

The results of the TPC simulations are discussed below. They are organized to present the overall running times and time savings (compared with a Baseline TPC run) between Albany and Rouses Point for different train consists and track configuration assumptions. The following factors should be understood when interpreting the train simulation tables:

- **Northbound vs. Southbound Trip Times Rouses Point to Albany**. Initial runs comparing northbound and southbound trip times were made. The TPC runs assumed existing speeds and nine stops between Rouses Point and Albany. The results were reasonably similar. Based on these preliminary results, it was determined that subsequent runs would be made in the southbound (Rouses Point to Albany) direction.

- **Miscellaneous TPC Assumptions**. Conditions used in the TPC simulations, including maximum authorized speeds, speeds through curves, and unbalanced superelevation, are all a function of track structures and equipment structural capacity, and represent the collective best judgment of experienced rail operators. Before high-speed operations are introduced, however, many of these conditions will have to be analyzed in greater detail, and tested to ensure the safety of the total system.

- **TPC Running Times, Schedule Times, and "Pad."** The TPC-simulated running time is the best achievable time that may be expected of a given train operated over a railroad line with given physical characteristics. The TPC times are therefore the most optimistic running times for each given train consist. When train schedules are prepared using TPC simulated times as a basis for the train running times, it is necessary to add an allowance for minor operating irregularities en route, which may be expected to occur on a daily basis, while maintaining a high probability of on-time performance. Several terms are used for this allowance, the most common of which are "pad," "cushion time," or "slop." A discussion of the issue of the amount of pad that should be added to the TPC times is presented in a later section.

The addition of this allowance to the TPC running time will enable trains to perform reliably on a day-to-day basis. Pad enables trains to regain any lost time resulting from minor delays (i.e., temporary speed restrictions, diversions around maintenance work, time lost at a station when passenger boardings are slow or heavy, etc.). It also provides for two additional components: the probability that not all of the configuration and alignment improvements incorporated into the model will prove physically feasible; and the realization that the model assumes that the train engineer operates the train in a consistent and precise manner in response to speed changes.

- **Station Stops, Existing Nine-Stop Schedule Compared to a Three-Stop Schedule**. As noted in Tables 1 through 4, some simulations assume the nine station stops made under present Adirondack service and other simulations assume a three-station stop schedule. This approach can test the effect of reducing the overall train running time by eliminating station stops. For simulation proposes, it was assumed that the modified schedule would have stops at Schenectady, Saratoga Springs and Plattsburg. These station locations are initial assumptions based on regional population density. They are not to be considered as recommendations of this Report, and adjustments in the location of stops would not have a significant effect on train running times as long as the number of stops remained constant.

- **Superelevation (Ea)**. In a number of simulations (Tables 2-4), a maximum of six inches of superelevation is used on selected curves. Typically, freight railroads are opposed to high superelevation because freight trains usually do not operate around the curves at the speed of passenger trains, and as a result, wear on the inner rail is high. High superelevation also increases maintenance costs because of having to maintain the longer spirals and superelevation runoff. Six inches of superelevation was used here to test the effects in terms of time savings to the overall passenger train trip times, and does not imply agreement by the CP railroad to this change in track elevation. Use of six inches of superelevation would have to be agreed to by the host railroad. This would probably include a reimbursement to the freight railroad for the added track maintenance costs.

It should be understood that not all curves under each case are raised to six inches. The curve analyzer within the simulation program evaluates each curve under the specific parameters of each case to determine the applicability, and subsequently the amount (up to six inches) of superelevation for each curve.

4.2. Description of the Train Performance Output Tables

TPC simulations of Montreal to New York City Service between Rouses Point and Albany with a variety of curve, speed, and stop assumptions were based upon the specific conditions described in the following subsections and on the general simulation assumptions noted above.

- **"Baseline" TPC Runs. (Table 3).** Baseline TPC runs were performed with a trainset consisting of four coaches powered by one P40 locomotive upon the existing (unchanged) track configurations. The runs serve as a point of reference for subsequent TPC runs - a baseline TPC run. These Baseline conditions included:

  - The existing track configuration (curves and interlockings) between Rouses Point and Albany; superelevation on the existing alignment is generally 4 inches or less;
  - Existing passenger train Maximum Authorized Speeds (MAS) between Rouses Point and Albany;
  - Maximum unbalanced superelevation = 2 inches [CP's present criteria];
  - Curve-related speed restrictions as shown in employee timetables;
  - Other non-alignment-based civil speed restrictions, i.e., for grade crossings, local restrictions, etc., were not assumed;
  - The nine existing intermediate stops were assumed: Plattsburgh, Port Kent (seasonal), Westport, Port Henry, Ticonderoga, Whitehall, Fort Edward-Glens Falls, Saratoga Springs, and Schenectady; and
  - Lacking detailed data on the length of dwell at each station, two-minute dwell at Plattsburgh, Port Kent, Ticonderoga, Fort Edward-Glens Falls, Saratoga Springs, and Schenectady and one-minute dwell at Westport, Port Henry, and Whitehall were assumed.

Table 3
COMPARATIVE SIMULATED RUNNING TIMES
With Conventional Trainset Consist - Existing MAS Timetable Speeds
Nine Intermediate Stops
Times Do Not Included Include Schedule Pad
Varying Levels of Unbalanced Superelevation from Rouses Point to Albany

	Rouses Point to Schenectady	*Difference From Baseline- Rouses Point to Schenectady*	*Difference from Previous Time*	*Rouses Point to Albany*	*Difference From Baseline- Rouses Point to Albany*	*Difference from Previous Time*
Base Case - Existing Speeds (70 MPH), Nine Station-Stops	3:44:14	n/a	n/a	4:06:20	n/a	n/a
3" Eu (Underbalance)	3:17:44	0:26:30	0:26:30	3:37:39	0:28:41	0:28:41
4" Eu	3:16:12	0:28:02	0:01:32	3:35:29	0:30:51	0:02:10
5" Eu	3:13:46	0:30:28	0:02:26	3:32:50	0:33:30	0:02:39

Train consist: 1 P42 Locomotive, 4 cars

As noted earlier, increases in superelevation beyond the levels presently permitted by CP as owner of the bulk of the alignment's trackage are assumed in these analyses. For such changes to occur, the trade-off between faster passenger service and increased track maintenance costs would have to be addressed.

Additional TPC runs with increased unbalanced superelevation were made with the amount of permitted imbalance increased in one-inch increments to a maximum of five inches, e.g., three-, four-, and five-inches of unbalanced superelevation. Jerk rate (the lateral movement experienced when entering a curve) was restricted to a maximum of 0.04 g/sec. All other conditions remained the same as the base case.

TPC Calibration. The P40 train information used for the existing speed runs was provided by the Amtrak Planning Department. These locomotive and car data have been used in various combinations for the last two years, and the TPC used is specifically preferred by Amtrak and the FRA for all high-speed work. The plan and profile information was loaded from paper sources into the database and was checked by a reviewer in accordance with QA/QC procedures. CAD data provided for the green-field alignment were brought into the simulation system programmatically.

Train performance simulation results for the existing case were compared to the present schedule. The resultant simulation time of 3:44 is significantly shorter than the current Amtrak runtime of 4:35 northbound and 4:50 southbound. The simulation time represents the optimum train performance and operating parameters; and has no allowance for pad. In essence, Amtrak adds an additional 30-60 minutes pad to the optimum performance runtime to allow for delays between Albany and Montreal caused by such factors as meeting freight and passenger trains, maintenance slow orders, prolonged customs clearance, train handling, and other factors. (Custom delays are not relevant for the Albany-to-Rouses Point simulations.)

- **TPC Runs - MAS Increased to 79 and 90 MPH for Conventional Three-Stop Trains (Table 4).** TPC runs to determine the amount of time savings to be realized after increasing the maximum allowable speed (MAS) to 90 mph between Rouses Point and Albany were performed. A five-inch level of unbalanced superelevation, the maximum allowed by FRA without a variance, was assumed. The runs determined the time savings resulting from an increase from the existing CP/Amtrak Timetable speed to a 79 mph MAS and then to a 90 mph MAS. The following conditions were used:

  - MAS was increased to 79 and 90 mph; speeds on individual curves were calculated using a previously developed technique.
  - Positive stops and curve speeds were enforced. (The positive stops in the run time simulations are for station stops only. No other stops were assumed.)
  - Spiral length and superelevation of curves were calculated using the curve spreadsheet.
  - Three Intermediate stops: two-minute dwell at Plattsburgh, Saratoga Springs, and Schenectady.
  - Up to 6 inches of superelevation on applicable curves.

Table 4
COMPARATIVE SIMULATED RUNNING TIMES
With Conventional Trainset
Three Intermediate Stops
Times Do Not Include Schedule Pad
Varying Levels of Unbalanced Superelevation from Rouses Point to Albany

	Rouses Point to Schenectady	*Difference From Baseline- Rouses Point to Schenectady*	*Difference from Previous Time*	*Rouses Point to Albany*	*Difference From Baseline- Rouses Point to Albany*	*Difference from Previous Time*
Base Case - Existing Speeds (70 MPH), Nine Station-Stops	3:44:14	n/a	n/a	4:06:20	n/a	n/a
Existing Speeds (70 MPH), Three Stops	3:01:41	0:42:33	0:42:33	3:20:16	0:46:04	0:46:04
5" Eu,Three stops, 79 mph	2:42:01	1:02:13	0:19:40	3:00:36	1:05:44	0:19:40
5" Eu Three stops, 90 mph	2:35:35	1:08:39	0:06:26	2:53:12	1:13:08	0:07:24

Ea - 6 ", Consist - 1 P42 Locomotive, 4 cars

TPC Runs - MAS Increased to 79, 90, 110, and 125 MPH for Tilt-Vehicle, Three-Stop Trains (Tables 5 and 6). Another set of TPC runs were performed to determine the amount of time savings resulting from using tilt-vehicle technology (Jet Train) after increasing MAS in stages up to 125 mph between Rouses Point and Albany. Seven and nine-inch levels of unbalanced superelevation were assumed. One and two locomotive consists were assumed (Tables 5 and 6, respectively). The runs determined the time savings resulting from an increase from a 79 MPH MAS to 90, 110, and 125 MPH for the assumed conditions. The following conditions were used:

- MAS was increased to 90, 110, and 125 MPH.
- Positive stops and curve speeds were enforced.
- Spiral length and superelevation of curves were calculated using the curve spreadsheet.
- Tilt cut out under 45 mph and gradually ramped in to maximum at 60 mph;
- Three intermediate stops: two-minute dwell at Plattsburgh, Saratoga Springs, and Schenectady.
- 6 inches of superelevation on applicable curves.
- Speeds were set assuming two levels of unbalanced superelevation:
  - 7 inches (Table 5)
  - 9 inches (Table 6)

Table 5
COMPARATIVE SIMULATED RUNNING TIMES
With Tilt Trainset Consist - 79 to 125 MPH MAS
Three Intermediate Stops
Times Do Not Include Schedule Pad
Varying Levels of MAS from Rouses Point to Albany

	Rouses Point to Schenectady	*Difference From Baseline- Rouses Point to Schenectady*	*Difference from Previous Time*	*Rouses Point to Albany*	*Difference From Baseline- Rouses Point to Albany*	*Difference from Previous Time*
Base Case - Existing Speeds, Nine Stops	3:44:14	n/a	n/a	4:06:20	n/a	n/a
7" Eu - 79 mph	2:34:42	1:09:32	1:09:32	2:52:36	1:13:44	1:13:44
7" Eu - 90 mph	2:26:59	1:17:15	0:07:43	2:43:47	1:22:33	0:08:49
2 Locomotives 7" Eu - 90 mph	2:24:32	1:19:42	0:02:27	2:41:02	1:25:18	0:02:45
7" Eu - 110 mph	2:19:57	1:24:17	0:04:35	2:35:36	1:30:44	0:05:26
7" Eu - 125 mph	2:15:22	1:28:52	0:04:35	2:30:35	1:35:45	0:05:01

Train consist: JetTrain - 1 Locomotive, 4 Tilt cars

Table 6
COMPARATIVE SIMULATED RUNNING TIMES
With Tilt Trainset Consist - 79 to 110 MPH MAS
Three Intermediate Stops
Times Do Not Include Schedule Pad
Varying Levels of MAS from Rouses Point to Albany

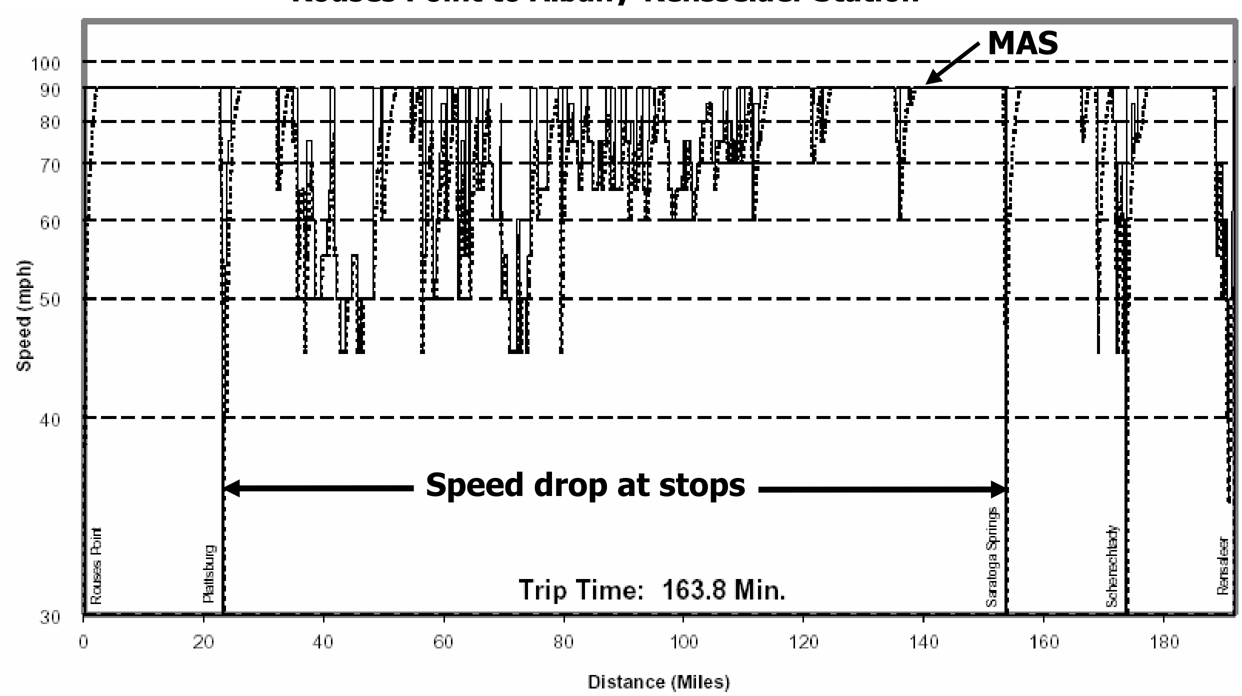
	Rouses Point to Schenectady	*Difference From Baseline- Rouses Point to Schenectady*	*Difference from Previous Time*	*Rouses Point to Albany*	*Difference From Baseline- Rouses Point to Albany*	*Difference from Previous Time*
Base Case - Conventional trainset, Existing Speeds, Nine Stops	3:44:14	n/a	n/a	4:06:20	n/a	n/a
9" Eu - 79 mph	2:30:34	1:13:40	1:13:40	2:48:14	1:18:06	1:18:06
9" Eu - 90 mph	2:22:15	1:21:59	0:08:19	2:38:47	1:27:33	0:09:27
9" Eu - 110 mph	2:14:29	1:29:45	0:07:46	2:29:48	1:36:32	0:08:59
9" Eu - 125 mph	2:10:03	1:34:11	0:04:26	2:24:54	1:41:26	0:04:54

Train consist: JetTrain - 1 locomotive, 4 tilt cars

Note on One- Vs. Two-Locomotive Consist. As noted in Table 5, the effect of using two locomotives under 7" Eu and 90 MPH MAS was tested, primarily to evaluate the ability of two locomotives to improve travel time. As shown, the running time savings were under 3 minutes for the Rouses Point to Albany run. Similar reductions could be expected in the other speed regimes. When the two-locomotive set was tested for 125 MPH under 7" and 9" Eu (results not shown), there was virtually no change in running time, primarily due to the number and close proximity of curves. Given these findings, and the substantial costs of purchasing and maintaining twice the number of locomotives, all runs beyond this point assumed a one-locomotive consist.

MAS Compared to Actual Speed Attainment. A speed profile graph showing the performance of the Rouses Point to Albany JetTrain trainset operating southbound with seven inches of unbalanced superelevation, and a 90 MPH MAS, is included as Exhibit 2, below. Since the scale between 0 and 25 MPH would dominate the display and the distance traveled at speeds in that range is minimal, that speed range is not plotted.

Exhibit 2
Train Speed Profile Graph: 90 MPH
Rouses Point to Albany-Rensselaer Station



The following table indicates the approximate percentage (based on mileage) that the trains would be able to operate at the designated MAS under various scenarios:

Scenario	Albany-Rouses Point Running Time	Percent Miles at MAS
79 MPH MAS, 5"Eu, conventional	3:00	47
90 MPH MAS, 5"Eu, conventional	2:52	34
110 MPH MAS, 7"Eu, Tilt JetTrain	2:36	31

These results indicated that significant further speed improvement along the existing alignment would require costly realignments in difficult terrain.

4.3. Summary of TPC Results

The relative merits of a variety of options to reduce trip time were systematically evaluated. A great variation in benefits and costs in the range of alternatives evaluated was identified. Some of the options created significant benefits at relatively low costs. Other options resulted in relatively minor benefits at relatively high costs. The following description provides an indication of the projected benefits of the options considered.

- **Time Savings Resulting From Optimizing Curves and Curve Speeds, and Reducing Number of Stops from Nine to Three (Tables 3 and 4 above).** Several scenarios, each with several options, were examined. The most basic scenario, optimizing the existing alignment, gave the largest increment of improvement. Relatively minor physical adjustments to the alignment's superelevation and spiral length to optimize the speed through curves to enable three inches of unbalanced superelevation would result in a 28-minute 41-second savings (see Table 3), or roughly a 12 percent reduction in trip time as compared with the existing MAS of 70 MPH. Reducing the number of stops from nine to three (Plattsburg, Saratoga Springs, and Schenectady shown as the examples) results in an additional 12 minute time savings (derived from station stop benefits shown in Table 4), a 5 percent reduction in trip time at the existing MAS of 70 MPH. These two changes -- optimized curves with an Eu of up to 3" and a reduction from nine to three stops -- provide a time savings of just under 41 minutes, or approximately 17 percent.

- **Time Savings from Increasing MAS above 70 MPH Using Conventional Amtrak Equipment (Table 4).** The FRA allows Amtrak conventional train sets to operate at a maximum unbalanced superelevation (Eu) of five inches on the Northeast Corridor. Increasing the MAS north of Schenectady to 79 MPH and increasing the Eu from three to five inches results in an additional 19-minute 40-second, or roughly 10 percent reduction in trip time for a conventional trainset on a three stop schedule. These two improvements – optimized curves with an Eu of up to 5" and a reduction to three stops – provide a total time savings of 1:05:44 compared to the base case. Increasing the MAS north of Schenectady to 90 MPH would provide an overall savings of 1:13:08 compared to the base case.

- **Time Savings from Increasing MAS above 70 MPH and Utilizing Tilt Equipment (Tables 5 and 6).** These tables tested the effects of using tilt body equipment as opposed to the conventional Amtrak equipment assumed under Tables 3 and 4. Increasing unbalanced superelevation, raising the MAS, and substituting tilting equipment produced varying levels of improvement; i.e.:

  - Increasing Eu to 7" with a 79 MPH MAS and a train set similar to the Jet Train with tilting equipment reduces trip time by 1:13:44 as compared to the base case.

- Same assumptions except increasing the MAS to 90 MPH reduces the trip time by 1:22:33 as compared to the base case. Operating at 110 MAS saves 1:30:44 and at 125 MAS saves 1:35:45.

- **Increasing MAS to 150 MPH on Improved Existing Alignment.** Another test run was conducted increasing the MAS to 150 between Rouses Point and Albany. Two locomotives were assumed in this case because of the high horsepower required in this speed regime. The higher MAS had no effect on the trip time. The characteristics of the route and the train set prevented any further reduction over that of the 125 MAS.

- **Increasing Eu to 9 Inches.** Increasing the Eu to nine inches (Table 6) resulted in trip time reduction at 125 MAS of 1 hour and 42 minutes as compared to the base case. The resultant overall trip time under this most ambitious set of improvements on the existing alignment between Rouses Point and Albany would be approximately 2 hours and 25 minutes, compared with over 4 hours and 6 minutes under existing operations (excluding pad under both figures).

- **Trip Time Loss Resulting from Station Stops.** The amount of time loss to be experienced if a Montreal to New York City trainset makes a stop at various stations was calculated by comparing non-stop TPC runs with all-stop TPC runs. The time lost stopping at each station is summarized in Table 7. The time includes deceleration, acceleration and dwell. Under existing "Baseline" conditions, the 9 stops presently require about 19 minutes (19:14). It was assumed for analysis purposes that only three stops would remain – Schenectady, Saratoga Springs and Plattsburgh. The time required to stop at the six eliminated stations is approximately 12 minutes under present operating speeds, with the remaining three stations accounting for roughly 7 minutes. As the speeds being considered increase, the amount of time required for each stop increases due to the longer time required to accelerate and decelerate to or from the higher speed. Under existing speeds, for example, stopping at Saratoga Springs takes approximately 2 minutes 35 seconds. Under full 150 MPH high speed operation, this stop takes up 4 minutes 38 seconds. For the various scenarios comparing the time savings of having only three stops between Albany and Rouses Point vs. nine, it was roughly assumed that 12 minutes would be gained by dropping these stops with an MAS of 79 – 90 MPH, and 14 minutes when the MAS rose to 110-125 MPH. The figure under full 150 HSR operation, as shown later in this report, is considerably higher.

Table 7
Impact of Removing Intermediate Station Stops
On Running Time (Times Shown in Minutes:Seconds)

	9-Stops	3-Stops: Tilt-Train Operation											
Station	*Baseline*	*79 Mph*		*90 Mph*		*110 mph*		*125 mph*		*150 mph*		*150 mph*	
	Eu >>>	*7 inch*	*9 inch*	*7 inch*	*9 inch*	*7 inch*	*9 inch*	*7 inch*	*9 inch*	*7 inch*	*9 inch*	*9 inch*	*9 inch*
Rouses Point	0:00:17												
Plattsburg	0:02:16	02:29	02:33	02:30	02:33	02:30	02:34	02:49	02:57	03:03	03:18	03:03	03:18
Port Kent	0:02:23												
Westport	0:01:27												
Port Henry	0:01:23												
Ticonderoga	0:02:37												
Whitehall	0:01:21												
Ft Edward-G.Falls	0:02:35												
Saratoga Springs	0:02:35	02:58	02:57	03:10	03:09	03:28	03:34	03:54	04:07	04:13	04:38	04:13	04:38
Schenectady	0:02:20	03:03	03:09	03:14	03:21	03:32	03:39	03:44	03:56	04:08	04:22	04:08	04:22
Total	0:19:14	08:30	08:39	08:54	09:03	09:30	09:47	10:27	11:00	11:24	12:18	11:24	12:18

4.4. Analyzing Trip Time Attainment Utilizing Pad

- **Components of Pad.** Whether a given trip time is reliably met is determined by additional factors, most importantly the capacity of the rail line to adequately handle the levels of intercity passenger and freight traffic that are projected to be operated in the corridor. Capacity considerations are not addressed in this stage of the analysis.

A TPC run only assesses the time required to move a train over the railroad and reflect perfect running under ideal conditions. As noted earlier, actual scheduled run times between two points will be longer than TPC-projected trip times due to the uncertainties (realities) of everyday operation. This difference, or "pad," was not included in the run time figures presented above. The goal of adding "pad" to a train schedule is to produce a schedule that can be reliably operated with a high degree of confidence. This is essential to the riding public, which needs to know when to arrive at a given station, and to the train operator, who needs to plan equipment cycles and service frequency.

The FRA and Amtrak have historically used a "7 percent" planning schedule pad to evaluate train schedules for multiple-track high-speed corridors, and this pad was the starting point in the development of the schedule pad to be used to analyze train schedules for the Montreal to New York City Corridor between Albany and Rouses Point. The planning pad comprises two main components that account for:

- Operator/vehicle variability, and
- Rail system performance.

The amount of pad also provides allowance for the reality that:

- Train operations are never precise, things just never go quite according to plan, station stops are slower, bad weather slows operations, equipment failures do occur, etc.,
- Vehicle performance is never uniform,

- Train operators do not consistently and instantaneously adhere to all changes in speeds along the route, and
- Trains incur small increments of delay en route, and overtake and meet other freight and passenger/commuter trains.

Realizing that typical day operations introduce periodic train delays and fluctuations in train speeds along the route, pad takes into account variables that occur in ″typical″ as opposed to "ideal day" operating conditions. Accounting for rail system performance may account for between 2 and 3 percent of the 7 percent pad.

- **Accounting for Anticipated Albany to Rouses Point Train Operations.** Typical daily variations also include the likelihood that passenger trains would have to divert from one track to a second track to avoid slower moving trains. Additional schedule allowances also must be made for the occurrence of meets involving two passenger trains on the single-track segments, situations that will always result in delaying one of the passenger trains. Each time a passenger train is required to slow down, enter a siding, and wait for the passenger train coming in the opposite direction to go past, the train adds an average of 9.5 minutes of delay to its trip time.

The likelihood of train diversions and meets occurring is significantly greater in the Albany to Rouses Point corridor than in the New York City to Albany segment of the Montreal to New York City Corridor. Although plans to double-track portions on this alignment are in various stages of planning or design, more than likely, a significant portion of the corridor between Rouses Point and Saratoga Springs still would be operated as a single-track railroad with sidings. The extent to which these conditions continue to exist will tend to increase the amount of schedule pad necessary for any passenger or freight operation in this corridor.

4.5. Summary of Travel Time Benefits of Improvement Scenarios

Table 8 presents a summary of travel times and average speeds for Albany to Rouses Point under a number of the scenarios discussed above. The following factors are varied among scenarios:

- Superelevation (Ea)
- Underbalance (Eu)
- Number of Stops between Albany and Rouses Point (9 existing vs. 3)
- Train type (existing Amtrak train sets vs. Jet-Train type tilt equipment)
- MAS

A total of 19 scenarios involving improvements to the existing alignment are defined in Table 8 in terms of the improvement components included in each. Operations under each scenario are then compared against existing conditions and against a "Maintenance Upgrade" (MU) condition. Based on review of conditions along the alignment and on discussions with CP Rail and others, it was clear that alignment improvements such as changes in superelevation and requests for higher operating speeds could not happen unless certain basic track maintenance upgrade work was completed in critical sections. This work would involve tie replacement, track surfacing and track replacement (continous welded rail – CWR – for jointed rail). These improvements would not take care of all problem areas (e.g., only 20 of the 80 miles of jointed rail sections in the alignment would be replaced with CWR), but they would address the most critical area. These MU improvements are then assumed to be in place, and to be part of the capital costs, under all Existing Alignment Improvement scenarios.

The existing schedule has an approximately 12% scheduling pad. Much of this is to account for trains going well below possible speeds due to poor track conditions. The MU improvements, by addressing many of these problems, were projected to reduce scheduled running time by approximately 14-15 minutes – i.e., reducing the schedule pad on that section from 12% to 6%. This travel time benefit relative to existing conditions is shown in Table 8 as a reduction in running time from 4 hrs. 35 minutes to 4 hrs. 21 minutes. The projected 6% pad on the Albany to Rouses Point section was assumed to remain constant under all 19 scenarios discussed below, even though this percentage would decrease with the number of stops and further corridor track, crossing and signal improvements.

Table 8
Improvements in Travel Time and Average Speed Under Alternative Improvement Scenarios: Albany to Rouses Point

Scenario	MAS	Eu	Curve Improv. [1]	Train Equip. [2]	Stops [3] Albany to Rouses Pt	Time (Hr:Min)	Average Speed MPH	% Time Savings
Existing	70	1	Existing	Existing	9	4:35	43	-
MU	70	1	Existing	Existing	9	4:21	44	5%
1	70	3	Existing	Existing	9	3:50	50	16%
2	70	3	Existing	Existing	3	3:37	53	21%
3	70	5	Existing	Existing	3	3:33	54	22%
4	79	5	Improved	Existing	9	3:24	56	26%
5	79	5	Improved	Existing	3	3:11	60	31%
6	79	7	Improved	Tilt Train	3	3:02	63	34%
7	90	5	Improved	Existing	9	3:16	58	29%
8	90	5	Improved	Existing	3	3:03	62	33%
9	90	7	Improved	Tilt Train	9	3:07	61	32%
10	90	7	Improved	Tilt Train	3	2:54	66	37%
11	90	9	Improved	Tilt Train	3	2:47	68	39%
12	110	7	Improved	Tilt Train	9	2:59	64	35%
13	110	7	Improved	Tilt Train	3	2:44	70	40%
14	110	9	Improved	Tilt Train	3	2:38	73	43%
15	125	7	Improved	Tilt Train	9	2:54	66	37%
16	125	7	Improved	Tilt Train	3	2:39	72	42%
17	125	9	Improved	Tilt Train	3	2:34	75	44%
18	79	5	Improved	DMU	9	3:24	56	26%
19	79	5	Improved	DMU	3	3:11	60	31%

[1] Also includes increasing levels of cost for grade crossing improvements and increass in sidings.
[2] Existing = P40DC Diesel-Electric & Amtrak Fleet Cars; Tilt Train = Jet Train type locomotive and tilt cars. See below for discussion of DMU train sets.
[3] Assumes approximately 12 minutes lost time for 9 station stops vs. 3 stops

4.6. Potential for DMU Train Sets in Corridor

In various public transportation markets around the United States, the possibility of using so-called Diesel Multiple Unit (DMU) is being investigated. The most commonly mentioned DMU system, produced by Colorado Railcar, includes 1,200 horsepower power cars capable of traveling alone or pulling up to 2 passenger carriages. The DMU was the first to pass the FRA's 49 CFR Part 238 Test, clearing it to operate jointly on tracks with heavy rail passenger and freight trains. While capable of traveling over 100 MPH, they are designed to operate on alignments with up to 90 MAS. As such, it is not generally considered for any corridor considering higher-speed operations. The typical market for which they are viewed is commuter service in smaller urban areas that don't already have such service. Not needing electrification and able to run in many combinations, they provide a generally lower-cost option for areas looking into that type of service.

For the New York to Montreal corridor, this type of equipment would not be appropriate for the Empire Corridor portion, which already has sections that operate over 110 MPH. However, they could possibly be used in the Adirondack portion of the corridor, between Albany and Montreal, under scenarios with MAS of 90 MPH or lower, and with underbalance no greater than 5". Under local/express schemes, DMU train sets could provide local service between, say, Albany and Plattsburgh, with other trains providing express service from Albany to Montreal. DMUs would generally have the same performance characteristics of present Amtrak equipment, with running times similar to those shown above with that type of equipment. The costs of this equipment is roughly $2.8 to $3.0 million for the power cars and $1.5 million for the carriage cars, or approximately $11 million for the likely mix of 3 power cars and 2 carriage cars in this type of service corridor.


DMU-Type Equipment in Germany

Potential Role in New York City – Montreal Rail Corridor

The two characteristics of DMUs that make them attractive in many existing or potential rail markets are:

- Their flexibility – the ability to operate from single cars to full train sets equivalent to more traditional equipment.
- The diesel-electric power – no need for electrification.

These factors make this type of equipment very popular in Europe, primarily for smaller intercity and commuter markets that don't warrant a higher-capacity investment. In considering various HSR scenarios for service between New York City and Montreal, this type of equipment would not be appropriate (1) for the Empire Corridor portion of the corridor, as DMUs would not be able to meet the MAS goal of 110 MPH for much of that corridor; or (2) for any of the higher-speed (>90 MPH) scenarios for the Adironkack portion of the corridor, including the portion within Quebec. They could, however, be used in the Adirondack service portion under lower-speed options, or to handle "local" service within New York State (and into Vermont) while higher-speed equipment handles limited stop "express" service to Montreal.

5.0 HIGH-SPEED ALIGNMENT (150 MPH, SUSTAINED OPERATING)

For sustained operating at 150 MPH, the existing alignment is unsuitable because of the constancy of horizontal curvature, particularly in the 90-mile line segment between Whitehall and Plattsburgh, along Lake Champlain. Developing true high-speed rail service will require these problematic elements of the alignment to be comprehensively addressed.

5.1. Limitations of the Existing Alignment

The frequent and closely spaced curves, necessitated by the hilly terrain, are the dominant feature of the existing alignment. Even with the modest goal of increasing the unbalanced superelevation (Eu) to five inches (with an accompanying lengthening of spirals into and out of the curve), a maximum continuous authorized speed (MAS) of 79 MPH is not possible for a majority of the line, particularly where the curves are nearly continuous. The MAS specified for each of the respective scenarios in the previous section of this report is not sustainable for significant line segments or distances. For example, in a forty-mile segment between Port Henry and Port Kent, there are 164 curves, an average of 4.1 curves per mile, and about ninety percent of the curves exceed three degrees. Passenger trains presently on this 40-mile line segment are generally restricted to the 35 – 40 MPH range.

5.2. Conceptual Design of a Potential New High Speed Alignment

To provide sustained, true high-speed rail operation of 150 MPH, most of the operation would have to be run on an entirely new alignment. Existing track chart information, digitized USGS maps (to provide topography) and other elements of the study's Geographic Information System (GIS) base were used to determine a potentially suitable alignment. Several assumptions were made in this process:

- Existing alignments would be utilized to access the Albany-Rensselaer Station and the new alignment would match up with the existing alignment at Rouses Point. It was expected that many of the stations on the existing alignment could not be used for the new alignment.
- Design assumptions described in Appendix 1 would be utilized.
- It was expected that large "fills" and a number of long bridges and several tunnels would be necessary to provide generally flat sections.
- Trains would consist of two turbine-powered locomotives (one at each end) and six cars. The train would have a tilt-body capability, such as the Jet Train.
- Consistent with assumptions made by MTQ in its assessment of the Montreal-to-Rouses Point alignment, these analyses assume that the existing stop for Customs would no longer be required, with passengers going through Customs at their destination, in the same manner done by airline passengers. This would only be relevant when considering the combined running time in New York and Quebec, as there is presently no Customs stop in New York. (See Section 5.5) The Boston-to-Montreal HSR study discussed in Section 1 of this report also assumed in its future running time projections that the Customs function at the border would be handled at the train's origin/destination stations. Time savings associated with the elimination of a Customs stop, which are only considered here under the 150 MPH HSR scenarios, could be considered under any of the more limited Existing Alignment improvement scenarios discussed in Section 4. A map of the proposed high-speed conceptual alignment is provided as Exhibit 3.

The following are some of the details of the high-speed conceptual alignment established for this corridor.

- **Bridges and Tunnels**

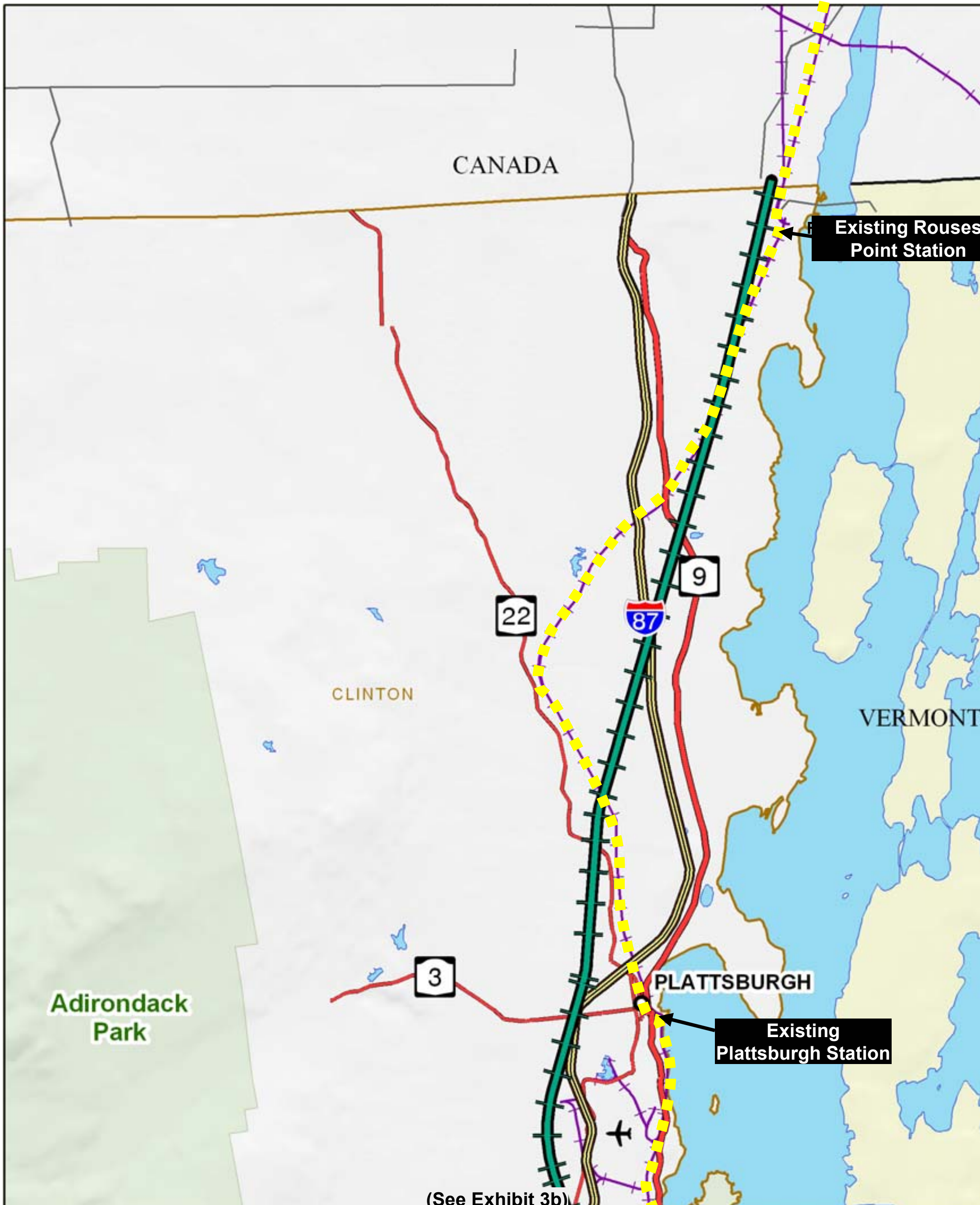
The conceptual high-speed alignment between Albany-Rensselaer and Rouses Point is 186.7 miles long, with the new alignments between Schenectady and Rouses Point. The alignment would have 14 major bridges and 6 tunnels, summarized as follows:

Structure	Number	<1000 Meters	> 1000 Meters	Longest (meters)
Bridges (major)	14	6	8	4,690
Tunnels	6	3	3	1,345

The location of the two longest bridges on the conceptualized alignment would be in the vicinity of Wadhams (4,690 meters) and Willsboro (3,616 meters), both in Essex County. The two longest tunnels are in the vicinity of Fort Ticonderoga in Essex County and Putnam Station in Warren County. The locations of these bridge and tunnels sections are noted in Tables 9A and 9B respectively and shown in Figure 3.

Table 9A: Projected Alignment Bridge Locations & Lengths

Map # (See Exhibit 3)	Length Meters	Length Feet
B-1	1,000	3,280
B-2	1,200	3,936
B-3	1,200	3,936
B-4	262	859
B-5	924	3,031
B-6	1,132	3,713
B-7	700	2,296
B-8	850	2,788
B-9	1,700	5,576
B-10	195	640
B-11	4,690	15,383
B-12	3,614	11,854
B-13	1,185	3,887
B-14	700	2,296



I-87 Multimodal Corridor Study

Exhibit 3a: HSR Alignment

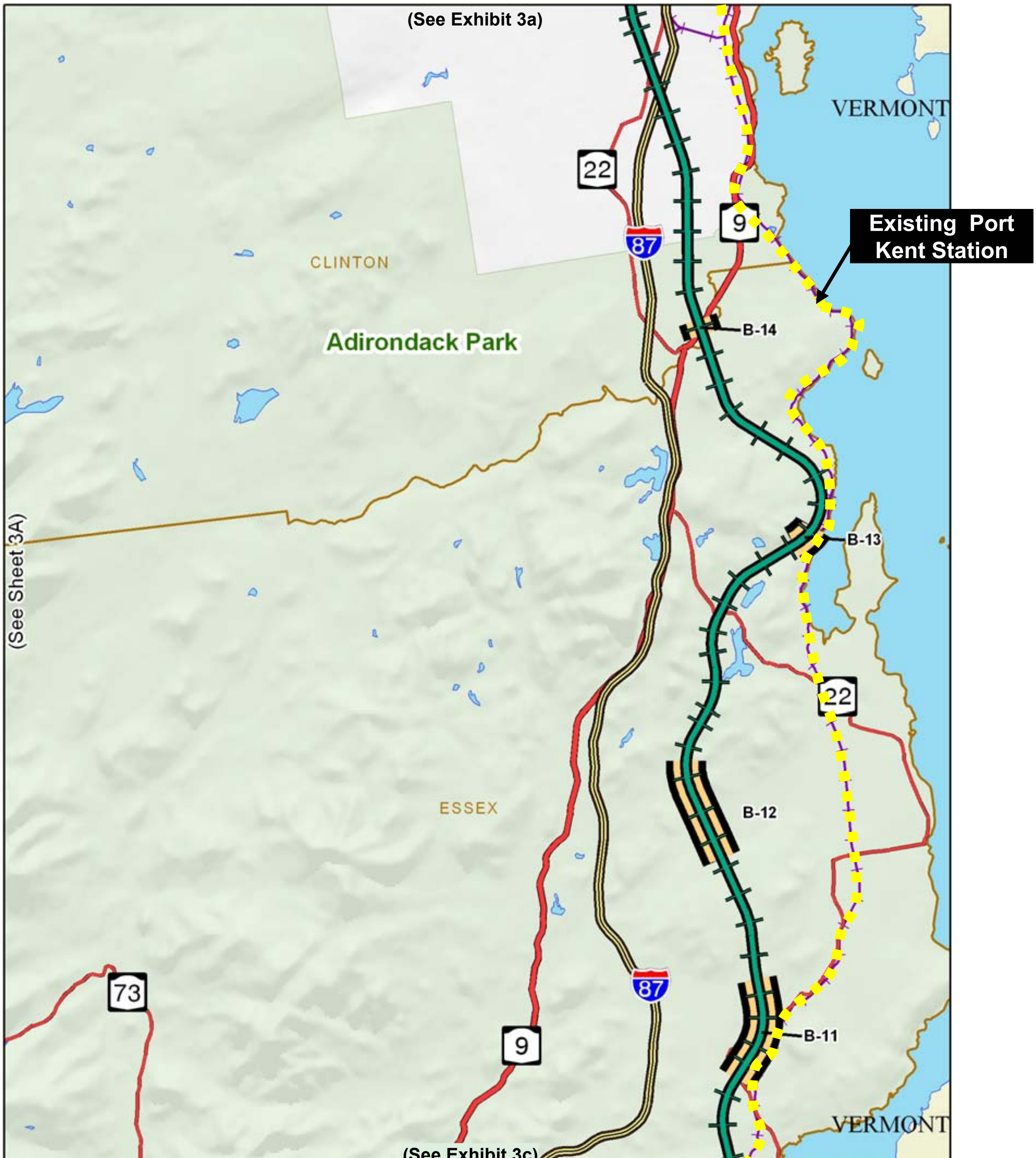
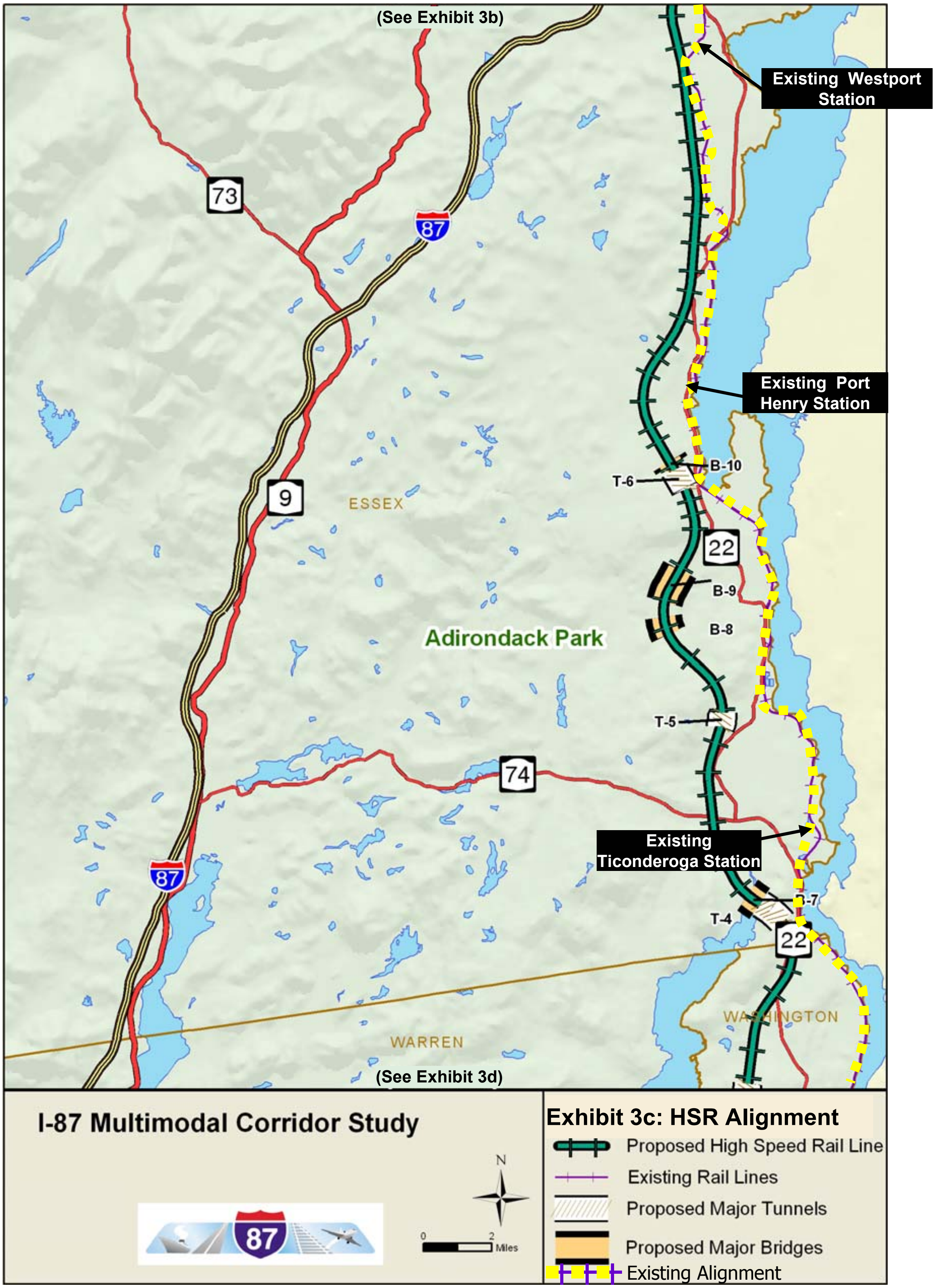


Exhibit 3b: HSR Alignment

- Proposed High Speed Rail Line
- Existing Rail Lines
- Proposed Major Tunnels
- Proposed Major Bridges
- Existing Alignment



(See Exhibit 3b)
Existing Westport Station
Existing Port Henry Station
B-10
T-6
22
B-9
B-8
T-5
74
73
87
9
ESSEX
Adirondack Park
Existing Ticonderoga Station
B-7
T-4
WASHINGTON
WARREN
(See Exhibit 3d)
I-87 Multimodal Corridor Study
N
0
2
Miles
Exhibit 3c: HSR Alignment
Proposed High Speed Rail Line
Existing Rail Lines
Proposed Major Tunnels
Proposed Major Bridges
Existing Alignment

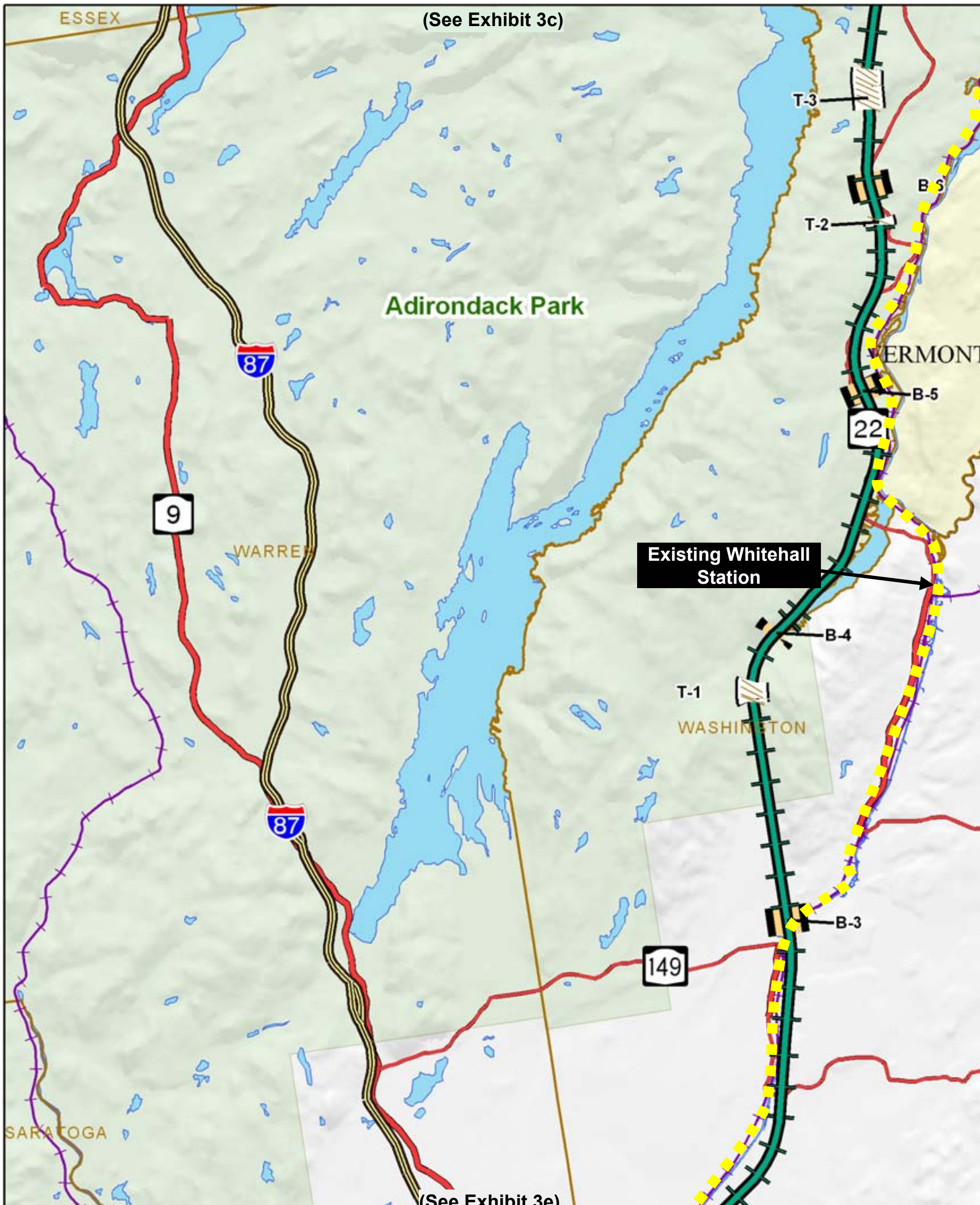


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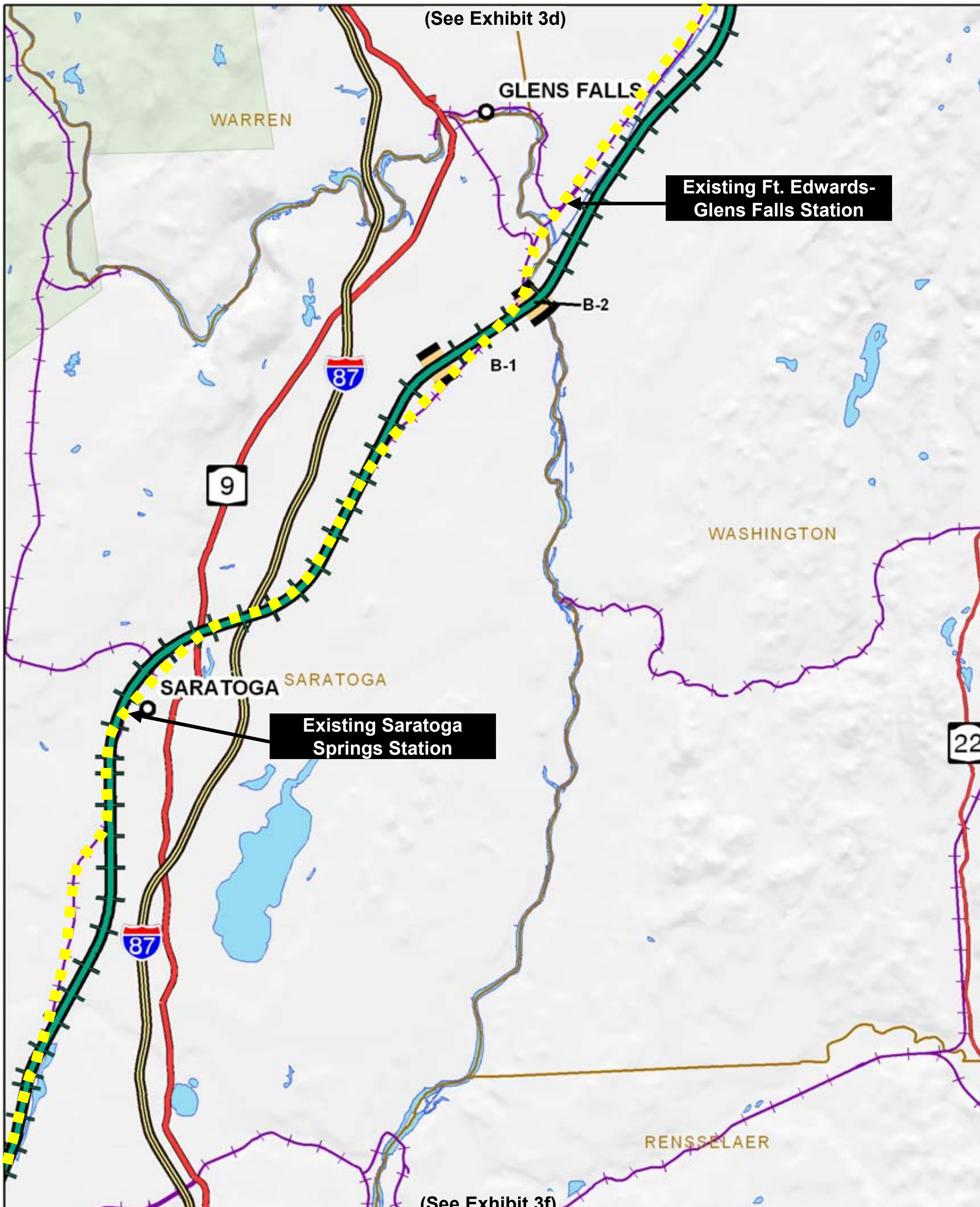
Exhibit 3d: HSR Alignment

- Proposed High Speed Rail Line
- Existing Rail Lines
- Proposed Major Tunnels
- Proposed Major Bridges
- Existing Alignment



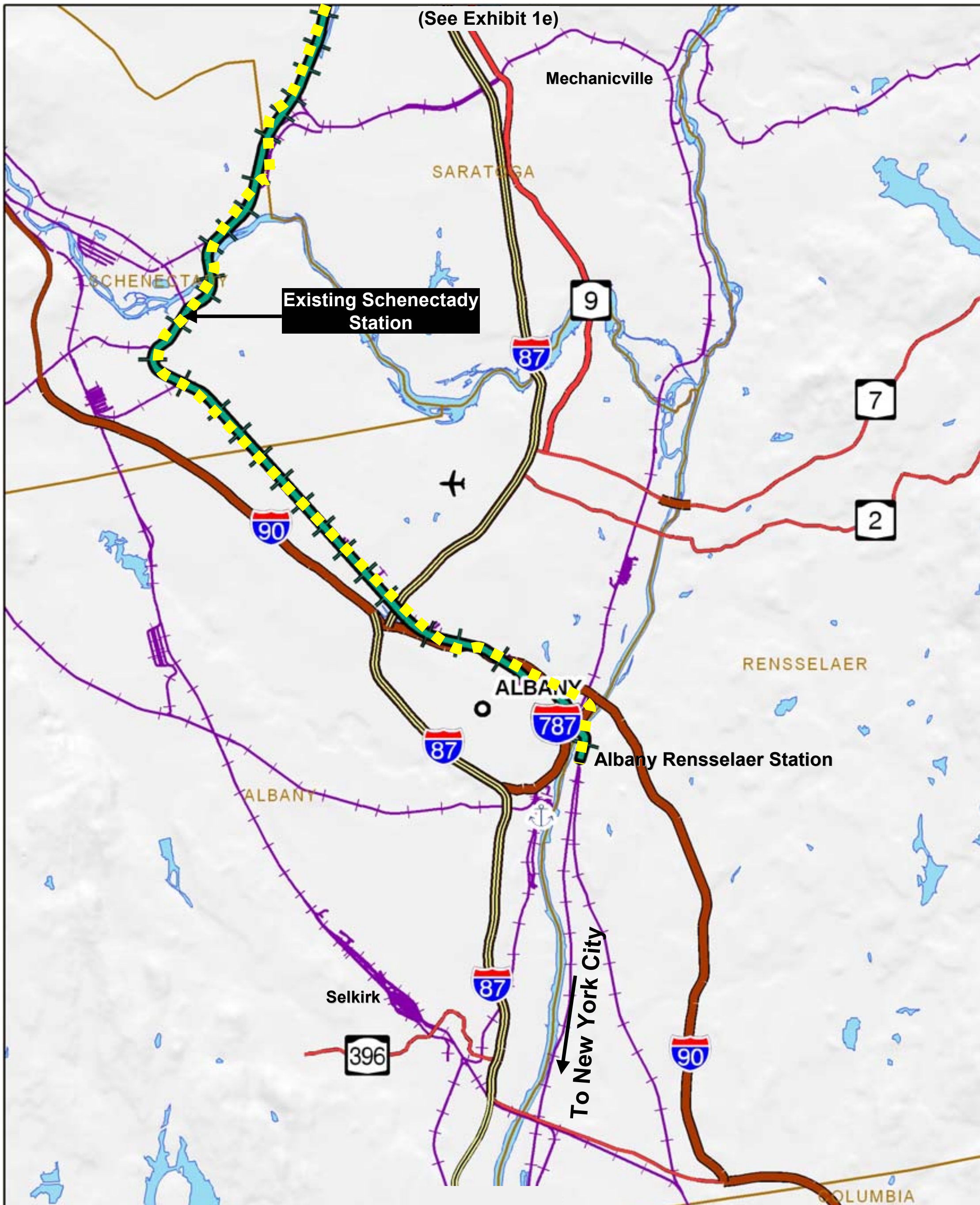
I-87 Multimodal Corridor Study

Exhibit 3e: HSR Alignment

- Proposed High Speed Rail Line
- Existing Rail Lines
- Proposed Major Tunnels
- Proposed Major Bridges
- Existing Alignment

N

0 2 Miles



I-87 Multimodal Corridor Study

N

0 2 Miles

Exhibit 3f: HSR Alignment

- Proposed High Speed Rail Line
- Existing Rail Lines
- Proposed Major Tunnels
- Proposed Major Bridges
- Existing Alignment

Table 9B: Projected Alignment Tunnel Locations & Lengths

Map # (See Exhibit 3)	Length meters	Length Feet
T-1	890	2,920
T-2	224	735
T-3	1,715	5,627
T-4	1,323	4,341
T-5	650	2,133
T-6	1,038	3,406

- **Grades**

The extensive structural work required for this alignment is mandated by the need to reduce curves and maintain a maximum grade suitable for high-speed rail operation. The maximum grades that resulted from the conceptual engineering process for this alignment are 1.0 percent, with one grade at 1.5 percent.

Design assumptions for the JetTrain were used in laying out the 150 MPH alignment. JetTrain does not perform as well on steeper grades as electrified trains. The profile for the150 mph alignment includes 13 segments totaling about 35 miles with a 1% gradient – roughly 7% of the total route. The longest continuous 1% gradient is about 13 miles long. Although assuming steeper grades results in a shorter route length, it does not automatically translate to lower construction costs. For example, a steeper shorter gradient may require tunneling through a large hill where as a longer shallower gradient may simply go around the hill. Considering the total length of the route and the relatively small percentage of 1% grade, it was projected that whatever variations in construction costs might result by using steeper gradients would not materially affect the magnitude of the construction cost at this pre-feasibility stage. Further, additional grades would also increase run times.

Note: Use of the I-87 Highway Corridor for High-Speed Rail. A new alignment using the existing I-87 as a potential high-speed railway route was evaluated. The general problem is that the geometry (especially grades and curves) that is suitable for a highway is not suitable for rail operations in general, and even more so for high-speed operations. Using the I-87 corridor would force the rail alignment to run either immediately adjacent to or in the median of the highway. The alignment, to maintain its straight configuration relative to the highway and deal with its often-steep grades would need constant bridgework to "criss-cross" the highway. In general, it would provide no appreciable benefits to offset the very high costs of creating a rail alignment in that area. Because of these problems, use of the I-87 highway corridor as a HSR alignment was dropped from consideration.

5.3. Impact of New Alignment on Running Times

Based on the conceptual alignment's design, including distance, curvature, and grade, train performance calculation (TPC) simulations were run and the alignment's curvature further refined until an approximately 2-hour running time between Albany-Rensselaer and Rouses

Point was achieved, assuming nine station stops. Table 10 presents the projected running times (without pad) from Rouses Point to Albany-Rensselaer under some of the key existing alignment scenarios presented in the previous section of this report, and the equivalent times under 150 MPH service on the conceptual high-speed alignment defined above. As indicated, starting under Baseline conditions with a run time for Albany-to-Rouses Point of 4 hours 6 minutes (4:06), the maximum reduction in running time possible would be as follows:

- Improve curves in the existing alignment, reduce stops (from 9 to 3), but keep existing MAS (70 MPH) and Eu -- approximately 46 minutes (0:46) savings over Baseline.
- Improving curves in the existing alignment, reduce stops (from 9 to 3), and maximize MAS (90 MAS) and Eu -- approximately 1:13 savings over Baseline.
- Improve curves in the existing alignment, reduce stops (from 9 to 3), use tilt-train technology and maximize MAS (125 MAS) and Eu – approximately 1:41 savings over Baseline.
- Construct dedicated 150 MPH alignment, reduce stops (from 9 to 3), use tilt-train technology with dual locomotives and maximize Eu – approximately 2:06 savings over Baseline.

As noted above, the running time savings all assume a reduction in the number of stops between Albany and Rouses Point from 9 to 3. This assumes that given the nature of high-speed service and the associated high cost to establish and operate it, some type of skip-stop operation relative to the existing Adirondack service would be more appropriate.

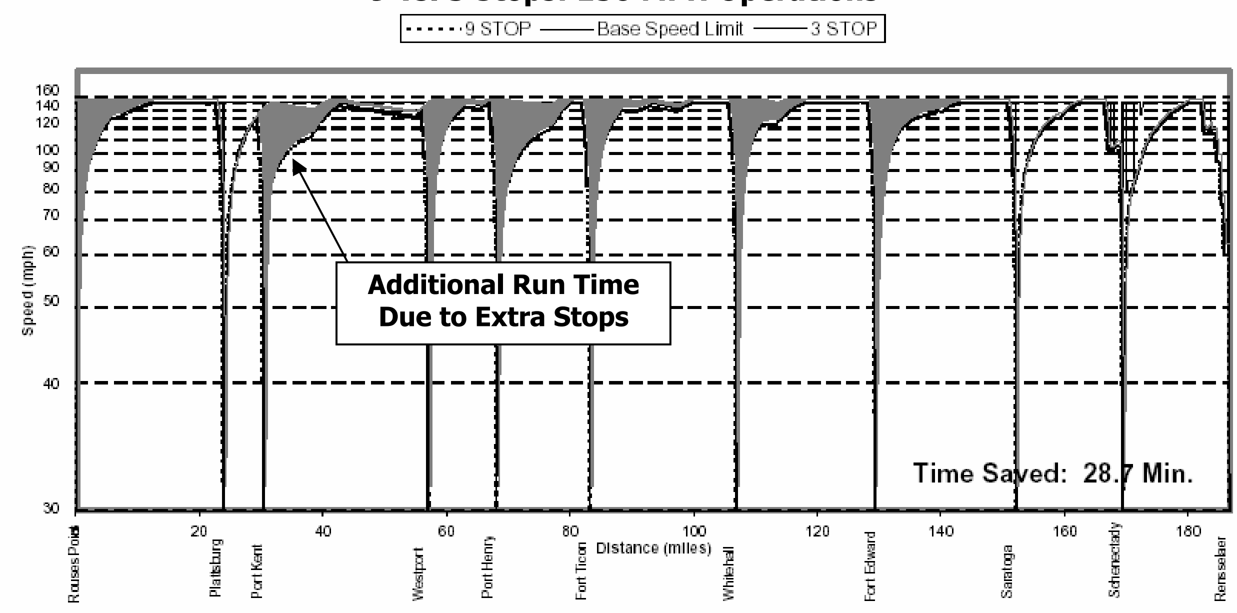
Table 10: Total Running Time: Rouses Point to Albany-Rensselaer Existing Conditions, with Improvements to Existing Alignment and with New HSR Alignment (Hours: Minutes)							
Scenario	**MAS**	**Eu**	**Curve Improv.**	**Train Equip.**	**Stops: Albany to Rouses Pt.**	**Running Time With PAD [2]**	**Time Savings**
Existing Alignment With Existing Equipment							
Existing	70	1	Existing	Existing	9	4:35	-
MU [1]	70	1	Existing	Existing	9	4:21	0.14
4	79	5	Improved	Existing	9	3:24	1.11
5	79	5	Improved	Existing	3	3:11	1.24
Existing Alignment with Jet-Train Tilt Train Sets							
10	90	7	Improved	Tilt Train	3	2:54	1.41
11	90	9	Improved	Tilt Train	3	2:47	1.47
16	125	7	Improved	Tilt Train	3	2:39	1.56
17	125	9	Improved	Tilt Train	3	2:34	2.01
New HSR Alignment with 150 MPH Sustained Running							
HSR-1	150	9	New Align.	Tilt Train	9	2:08	2.26
HSR-2	150	9	New Align.	Tilt Train	3	1:38	2.56

[1] MU = Maintenance Upgrade – repairs to critical sections of existing track.
[2] PAD = time added to straight running time to account for delays at stations, stop orders and related factors that are generally encountered during a typical run. Overall, optimal running time + PAD time = schedule time.

As shown in Exhibit 4, the overall run time savings provided by eliminating 6 stops would be approximately 29 minutes, or an average of slightly less than 5 minutes per stop. Trade-off analyses would be required to determine the best number of stops along this alignment. Factors to be considered would include:

- The cost of constructing and staffing stations along this new alignment.
- The status of service along the existing alignment.
- The potential need for seasonal stops only (e.g., racing season at Saratoga, skiing season in the High Peaks area, etc.).
- The potential for commuter-type operation to expand the "commuter shed" in the Capital District.
- Overall impact on ridership, fare revenues vs. operating costs.

Exhibit 4: Travel Time Losses:
9 vs. 3 Stops: 150 MPH Operations



5.4. Projected Time Savings: Montreal to US/Canada Border

The MTQ studies looked at three operating scenarios – 200, 240 and 300 km/hr. (roughly 125, 150 and 186 MPH), for two separate alignments within Quebec:

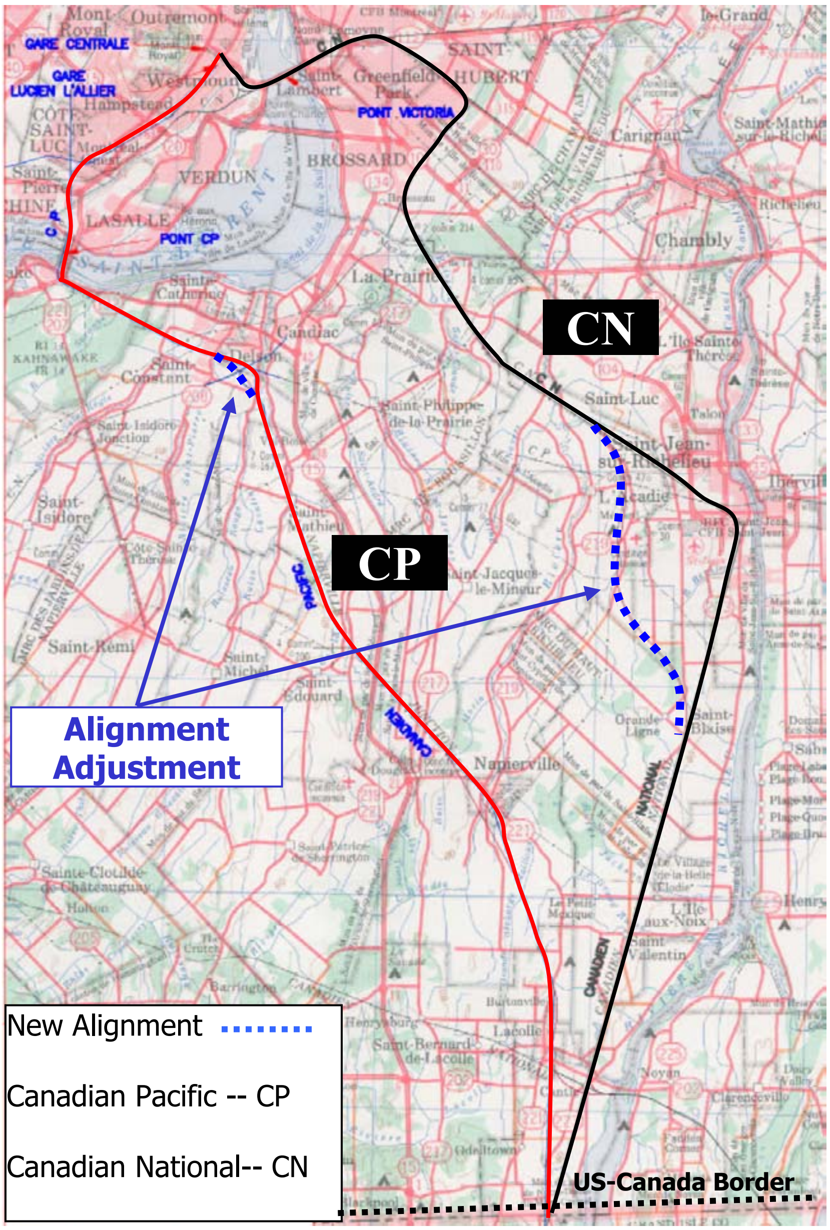
- The approximately 48-mile **Canadian National (CN)** alignment, on which Adirondack service trains presently travel to Gare Centrale (Central Station) in Montreal, and
- The 41-mile **CP Rail** alignment, which connect to the Lucien-L'Allier Station.

Exhibit 5 presents the two alignments and the approximate areas where a 150 MPH HSR alignment would have to depart from the existing CP and CN alignments. As the existing alignments in Quebec are relatively flat and straight compared to the CP aligment between Albany and the border, there are relatively few departures required from the existing alignments to achieve HSR speeds, and considerably lower capital costs.

Studies were performed for both alingments and for all three speed scenarios. The 186 MPH option would require full electrification of the alignment, as 150 MPH is the approximate limit of diesel-electric train operating speeds. Based on those studies, preliminary indications of the MTQ study were that the shorter, faster and less expensive CP alignment, under the 150 MPH operating scheme, showed the greatest promise.

Under existing operations, trains cross at Rouses Point, stop at Cantic for Customs and at St. Lambert on the outskirts of Montreal before arriving at Central Station. Under these conditions, it takes trains roughly 175 minutes (2 hrs. 55 minutes) to travel from the US-Canada border to Central Station, including approximately 1 hour for the Customs stop. MTQ projects that this could be reduced by over 80% to approximately 27 minutes, assuming full 150 MPH service, wth no station or Customs stops between Montreal and the border.

EXHIBIT 5
HSR ALIGNMENTS BETWEEN MONTREAL AND ROUSES POINT



Source: Transports Quebec (September 2003).

5.5. Overall Change in Running Time: New York City to Montreal

The previous section indicated that the conceptual improvements in the Albany to Rouses Point portion of the overall corridor could reduce overall running time by as little as 46 minutes (19%) to over two hours (63%). At the same time, modest but important time savings are projected in the New York to Albany portion of the Empire Corridor while significant savings are projected by MTQ for the Quebec portion of the alignment. Table 11 shows the existing travel times in each of these segments, the projected travel times in each, and the cumulative running time.

Table 11. Travel Time Savings: 150 MPH HSR Rail Service: NYC to Montreal [1]

Origin	Destination	Existing (Min)	HSR (Min)[4]
NYC	Albany [2]	150	115
Albany	*Layover*	15	5
Albany	Rouses Pt. [3]	275	98
Rouses Pt.	Montreal	115	27
Customs	[5]	60	0
	Total - Minutes	615	245
	Total - Hrs. & Min.	**10 hrs. 15 min.**	**4 hrs, 5 min.**

[1] Assumes planned HSR-type improvements in Empire Corridor from NYC to Albany
[2] Based on discussions of Joint Users Study's 2007-2022 operating scenario. The 30-35 minute reduction has not yet been officially released.
[3] Assumes no stop at Rouses Point and only three stops between Albany and the US-Canadian Border.
[4] Approximately pad of 7% above run time assumed.
[5] Custom time approximated. For HSR, assumes Customs would be handled at destination point, similar to procedures used for airline service.

As indicated, the New York – to – Montreal run, which presently takes 10 hours and 15 minutes (and usually longer) would take slightly more than 4 hours, under the following conditions:

- NYC to Albany: 30-35 minute reduction
- Albany: a 5-minute vs. 15-minute layover
- Albany to Rouses Point: a new 150-MPH alignment, with service stopping at 3 vs. 9 stops in that section
- No Customs stop in either direction
- A partially new alignment between Rouses Point and Montreal, with running time cut from almost 2 hours (with over 30-minute pad) to 27 minutes.

6. CONSTRUCTION COSTS, RIDERSHIP AND COMMUNITY BENEFITS

6.1. Construction Costs Associated with the Existing Alignment

The construction costs associated with the existing alignment represent the cost to modify superelevation and adjust spirals. These costs were developed as a function of the curve analysis program. The initial calculations defined the highest speeds for each of the existing curves that could be reached without realigning or adjusting the actual superelevation, while satisfying safety and comfort criteria. Then, an iterative process was followed to identify the maximum speed attainable on each curve (limited by the assumed MAS). An analysis was then performed to determine the magnitude of changes to superelevation, spiral length and unit costs applied to account for ballast, labor, surfacing, lining, and other miscellaneous costs. A 30 per cent contingency was then applied to the resultant costs. No costs for possible land acquisition are included in these estimates, although under these "Existing Alignment" scenarios, most work would likely fall within the existing right-of-way.

In general, the impacts of spiral adjustments on overhead or undergrade bridges and grade crossings are of concern. Although each bridge located on the body of a curve would ultimately have to be individually evaluated to determine the impact of the assumed spiral adjustment, for purposes herein, an individual assessment of each bridge and grade crossing for each option was not possible. Therefore, an additional 10 percent contingency was added to the construction costs. Further, the options assuming speeds above 79 MPH do not include the cost of a positive stop train signal system.

Table 12 presents the projected time savings and the estimated construction costs for the alternative improvement scenarios discussed in Section 4 involving improvements to the existing alignment. As noted, these costs include estimates for track improvements, additional sidings, changes to grade crossings, rolling stock, and signal systems.

Table 12: Estimated Time Savings and Track Shift Capital Cost Estimates: Improvements to Existing Alignment

Scenario	MAS	Eu	Curve Improv.	Train Equip.	Stops: Albany to Rouses Pt.	Running Time With PAD [1]	Time Savings Hrs.:Min.	Capital Costs $Mill.
Existing	70	1	Existing	Existing	9	4:35	-	-
MU	70	1	Existing	Existing	9	4:21	0:14	$ 20
1	70	3	Existing	Existing	9	3:50	0:45	$ 20
2	70	3	Existing	Existing	3	3:37	0:57	$ 20
3	70	5	Existing	Existing	3	3:33	1:02	$ 20
4	79	5	Improved	Existing	9	3:24	1:11	$ 40
5	79	5	Improved	Existing	3	3:11	1:24	$ 40
6	79	7	Improved	Tilt Train	3	3:02	1:32	$ 150
7	90	5	Improved	Existing	9	3:16	1:19	$ 130
8	90	5	Improved	Existing	3	3:03	1:31	$ 130
9	90	7	Improved	Tilt Train	9	3:07	1:28	$ 240

Table 12: Estimated Time Savings and Track Shift Capital Cost Estimates: Improvements to Existing Alignment

Scenario	MAS	Eu	Curve Improv.	Train Equip.	Stops: Albany to Rouses Pt.	Running Time With PAD [1]	Time Savings Hrs.:Min.	Capital Costs $Mill.
10	90	7	Improved	Tilt Train	3	2:54	1:41	$ 240
11	90	9	Improved	Tilt Train	3	2:47	1:47	$ 240
12	110	7	Improved	Tilt Train	9	2:59	1:36	$ 270
13	110	7	Improved	Tilt Train	3	2:44	1:50	$ 270
14	110	9	Improved	Tilt Train	3	2:38	1:57	$ 270
15	125	7	Improved	Tilt Train	9	2:54	1:41	$ 270
16	125	7	Improved	Tilt Train	3	2:39	1:56	$ 270
17	125	9	Improved	Tilt Train	3	2:34	2:01	$ 270
18	79	5	Improved	DMU	9	3:24	1:11	$ 110
19	79	5	Improved	DMU	3	3:11	1:24	$ 110

[1] PAD = time added to straight running time to account for delays at stations, stop orders and related factors that are generally encountered during a typical run. Overall, optimal running time + PAD time = schedule time.

Table 13 shows the factors used to estimate the costs shown in Table 12 for the various scenarios:

Table 13. Capital Cost Factors for Improvements to Existing Alignment

			Capital Costs ($Millions)						
Scenario	MAS	EU	Track Maint.	Track Curves	Sidings Enhance.	Grade Crossings	CAB Signals	Train Sets	Total [1]
MU	70	<1"	$ 20	$ -	$ -	$ -	$ -	$ -	$ 20
1	70	3"	$ 20	$ -	$ -	$ -	$ -	$ -	$ 20
2	70	3"	$ 20	$ -	$ -	$ -	$ -	$ -	$ 20
3	70	3"	$ 20	$ -	$ -	$ -	$ -	$ -	$ 20
4	70	5"	$ 20	$ 8	$ 3	$ 11	$ -	$ -	$ 40
5	79	5"	$ 20	$ 8	$ 3	$ 11	$ -	$ -	$ 40
6	79	7"	$ 20	$ 8	$ 3	$ 11	$ -	$ 110	$ 150
7	79	5"	$ 20	$ 14	$ 3	$ 14	$ 80	$ -	$ 130
8	90	5"	$ 20	$ 14	$ 3	$ 14	$ 80	$ -	$ 130
9	90	5"	$ 20	$ 14	$ 3	$ 14	$ 80	$ 110	$ 240
10	90	7"	$ 20	$ 14	$ 3	$ 14	$ 80	$ 110	$ 240
11	90	7"	$ 20	$ 14	$ 3	$ 14	$ 80	$ 110	$ 240
12	90	9"	$ 20	$ 28	$ 3	$ 33	$ 80	$ 110	$ 270
13	110	7"	$ 20	$ 28	$ 3	$ 33	$ 80	$ 110	$ 270
14	110	7"	$ 20	$ 28	$ 3	$ 33	$ 80	$ 110	$ 270
15	110	9"	$ 20	$ 28	$ 3	$ 33	$ 80	$ 110	$ 270
16	125	7"	$ 20	$ 28	$ 3	$ 33	$ 80	$ 110	$ 270
17	125	7"	$ 20	$ 28	$ 3	$ 33	$ 80	$ 110	$ 270
18	79	5"	$ 20	$ 8	$ 3	$ 11	$ -	$ 66	$ 110
19	79	5"	$ 20	$ 8	$ 3	$ 11	$ -	$ 66	$ 110

[1] Rounded to the nearest $10 million.

For scenarios that would require purchase of new train sets (either tilt train equipment or DMUs), it was assumed under each scenario that a sufficient number of train sets would be purchased to provide an expanded (4-5 trains/day) level of service in the corridor. Possible capital costs associated with providing additional conventional equipment to expand service under "Existing Equipment" scenarios are not reflected in the costs shown above. The exact number and mix of equipment required would depend both on service levels for the New York to Montreal run, as well as possible local service in the Adirondack service area, which will require further assessment. Further discussion regarding the number of additional train sets required under various scenarios is presented later in this section.

6.2. Construction Costs Associated with the New High Speed Alignment

Table 14 presents the conceptual cost estimate for the new high-speed rail alignment. The estimate is based on the alignment presented in Section 5, with an approximate profile prepared to remain below 1% grade. (See section 5.2 above for a discussion of the trade-offs associated with assuming steeper grades in HSR alignments.) Since the mapping is not suitably accurate to support precise quantity take-off, this estimate must be considered as an initial approximation. The preliminary quantity take-offs that were performed indicated more alignment cut than fill. However, since disposing of excess excavation would be difficult, it is clear that the actual design would have to be a balance of cut and fill. Since no additional adjustment of the alignment is appropriate at this early stage, no adjustment was made and the quantity shown is the total amount of excavated material. The price includes an allowance for relatively long haul distances. The estimate is in 2003 US dollars.

Table 14: Conceptual Capital Cost
High Speed Rail Alignment

Item	Unit	Quantity	Unit Cost	Total Cost (millions)
Earthwork	cubic meter	91,540,000	$5.00	$ 458
Double Track	meter	300,000	$600.00	$ 180
Misc. civil	meter	300,000	$500.00	$ 150
Major Bridge	meter	19,352	$20,000.00	$ 387
Tunnel	meter	5,840	$131,000.00	$ 765
Small Bridge	each	125	$650,000.00	$ 81
Station	each	3	$5,000,000.00	$ 15
Maint. Facility	LS			$ 50
Signal & Com	km	300	$650,000.00	$ 195
Subtotal				**$ 2,281**
Administrative	15%			$ 342
Design/Environmental	20%			$ 456
Contingencies	35%			$ 798
Grand Total				**$ 3,878**

Factors and assumptions made in preparing the cost estimates include the following.

- The cost for track construction includes all track material and ballast.
- The cost includes cost for double track.

- The anticipated speed of trains will be high enough that there will be no wayside signals, only a cab signal system.
- Miscellaneous civil expenses include drainage, road relocation, site restoration, utility work, and other similar items.
- Major bridges are those that cross major streams and span deep valleys. They include elements such as long viaducts, long span river crossings, and high piers.
- The cost for tunnels includes two parallel bores with one track each.
- Land acquisition costs are not included. As much of the full HSR alignment would be considerably removed from the existing rail alignment, land acquisition costs could be considerable. The fact that much of this would fall within the Adirondack Park would pose further regulatory complications that any scenarios of this magnitude would have to face.

Prelimiinary Costs for MTQ Segment in Quebec.

The costs estimated for the various HSR scenarios that MTQ analyzed are shown in Table 15.

Table 15. Projected Capital Costs for MTQ HSR Scenarios

Alignment	Distance	MAS (MPH)	Alignment Costs [1] ($Mill. US)	Equipment Costs ($Mill. US)	Total	$/Mile ($Mill. US)
CP	41	125	$ 27	$ 100	$ 127	$ 3.1
		150	$ 79	$ 100	$ 179	$ 4.4
		186	$ 146	$ 100	$ 246	$ 6.0
CN	48	125	$ 34	$ 100	$ 134	$ 2.8
		150	$ 109	$ 100	$ 209	$ 4.4
		186	$ 175	$ 100	$ 275	$ 5.7

[1] 186 MPH options include $60-62 million for electrification of the alignment.
Source: Transports Québec, September 2003.

As shown, the costs per mile (including rolling stock) for the various MTQ options fall into the $3 to $6 million per alignment mile. By comparison, the approximately $4 billion in capital costs projected for the 190-mile Albany-to-Rouses Point HSR alignment translates to approximately $21 million per mile, reflecting the difficulties presented by the considerably greater topographic challenges in that area.

6.3. Increased Operating and Maintenance Costs

As noted in Section 3.3. of this report, there are a number of factors that would increase the amount of on-going track maintenance costs required under the various scenarios discussed in this report. Most of the scenarios discussed above include increases in the banking or superelevation on curved sections to permit higher speeds in those sections. While faster passenger trains can take advantage of these increases in the superelevation, the "overbalance" condition caused by slower and heavier freight trains traveling over the same tracks will increase the amount of track maintenance required in those sections. In addition, track segments with higher operating speeds require a higher level of maintenance in general due to the tighter tolerances necessary for high-speed operations. For existing HSR corridors (e.g., Northeast Corridor, Empire Corridor), there are cost-sharing maintenance agreements between companies that own or maintain segments of track and the operators (Amtrak) that run higher-speed passenger trains over those tracks. This type of arrangement would be required under the various improvement scenarios under consideration in this report.

Present Adirondack passenger service is limited to one train per day in each direction. It is assumed that a major capital investment to improve train operations in the corridor would also require an equivalent increase in train service to take advantage of these improvements. The number of train runs to be added in the New York City to Montreal market would likely increase with the level of investment and associated time savings and the resultant increase in passenger demand for that service. Based on these very preliminary assumptions, Table 16 presents the projected increases in annual operating and maintenance costs under the various improvement scenarios.

Table 16. Projected Increase and Annual Operating and Maintenance Costs Under Improvement Scenarios

Scenario	MAS	Eu	Curve Improv.	Train Equip.	Stops: Albany to Rouses Pt.	Running Time With PAD	Annual Equipment O&M [1]	Annual Track Mainten. [2]	Total O&M ($Mill)
Existing	70	1	Existing	Existing	9	4:35	$ -	$ -	$ -
MU	70	1	Existing	Existing	9	4:21	$ -	$ -	$ -
1	70	3	Existing	Existing	9	3:50	$ 6	$ -	$ 6
2	70	3	Existing	Existing	3	3:37	$ 6	$ -	$ 6
3	70	5	Existing	Existing	3	3:33	$ 13	$ -	$ 13
4	79	5	Improved	Existing	9	3:24	$ 13	$ -	$ 13
5	79	5	Improved	Existing	3	3:11	$ 13	$ 2	$ 15
6	79	7	Improved	Tilt Train	3	3:02	$ 13	$ 2	$ 15
7	90	5	Improved	Existing	9	3:16	$ 13	$ 2	$ 15
8	90	5	Improved	Existing	3	3:03	$ 13	$ 5	$ 18
9	90	7	Improved	Tilt Train	9	3:07	$ 19	$ 5	$ 24
10	90	7	Improved	Tilt Train	3	2:54	$ 19	$ 5	$ 24
11	90	9	Improved	Tilt Train	3	2:47	$ 19	$ 5	$ 24
12	110	7	Improved	Tilt Train	9	2:59	$ 19	$ 5	$ 24
13	110	7	Improved	Tilt Train	3	2:44	$ 19	$ 10	$ 29
14	110	9	Improved	Tilt Train	3	2:38	$ 19	$ 10	$ 29
15	125	7	Improved	Tilt Train	9	2:54	$ 19	$ 12	$ 31
16	125	7	Improved	Tilt Train	3	2:39	$ 19	$ 12	$ 31
17	125	9	Improved	Tilt Train	3	2:34	$ 19	$ 12	$ 31
18	79	5	Improved	DMU	9	3:24	$ 6	$ 2	$ 8
19	79	5	Improved	DMU	3	3:11	$ 6	$ 2	$ 8
HSR	150	9	New Align.	Tilt Train	3-9	2:08	$ 38	$ 25	$ 63

[1] Assumes approximately $6.3 million annual O&M costs for each conventional train in operation in the corridor and approximately $7.5 million for each Jet Train set in operation. Number of train operations assumed to increase with travel time savings, from 1 additional train for minimal improvement scenarios to 3 additional trains for higher-speed scenarios on existing alignment. For full 150 MPH service, 5 trains are assumed to be added.
[2] Approximately $2 million to go to 79, and rough proportionate rise thereafter, with flattening out at 110-125 mph.

6.4. Potential Ridership

Determining Ridership Potential

The corridor presently offers passengers four options – private auto, privately-operated bus and airplane services, and Amtrak. The air service is limited and often very expensive, while the train and bus services take a long time and are subject to frequent delays. National long distance trip data indicates that personal automobiles are the primary mode of transportation for eight out of ten trips greater than 100 miles in length. In the I-87 corridor, it is estimated that this proportion is even higher due to limited alternative travel choices in the corridor.

In recent decades, longer passenger trips have been taken over by the private auto and air service. Although roughly half of Amtrak's passenger miles are on trips greater than 500 miles, the main focus is on the shorter trips. The operation's greatest successes have been in developing improved service in key travel corridors. The Empire Corridor, with over 1 million passengers annually, is one of the bright spots for Amtrak, with further growth expected due to planned improvements. The Capital Corridor in California is another success story, with 135 percent ridership growth in the past five years and service frequency increased from 3 to 9 roundtrip trains daily. The Cascades corridor service in Oregon and Washington, which introduced tilt-train technology to improve service reliability and reduce travel time, has had similar success.

A detailed demand analysis is needed to determine the potential ridership of a high-speed service in the I-87 corridor. Corridor travel behavior and the factors that travelers use in making trip choice decisions need to be further analyzed. Relationships of trip type and potential diversion for each mode must be developed and applied to future year scenarios to predict future corridor travel for the proposed mode.

Once potential ridership in various markets in the corridor are established, decision makers must consider additional benefits that the high-speed rail line will provide in terms of passenger transportation. While high-speed rail analysis typically focuses on trip generation through long trips, additional benefits will accrue to other users of the track.

For example, the proposed service upgrades will provide enhanced opportunities to connect to rail services throughout the Northeast and across the country. Also, high-speed rail can make high volume airports more accessible to communities with limited airport access. In the I-87 corridor, this would require a transfer to a different service but for customers in Montreal, VIA rail service already links the Dorval rail station with the Montreal International Airport. Finally improvements made to the tracks and structure can improve services on existing non-high speed rail services such as commuter rail services. These improvements can lead to enhanced ridership levels on these services as well.

Potential Ridership in NYC-Montreal Market

A determination of potential ridership in the New York City to Montreal market is really a question of sub-markets. As shown in the Boston-to-Montreal HSR studies, although the greatest time savings, in absolute and percentage terms, and the biggest percentage growth in ridership would be in the Boston-Montreal market, the bulk of the ridership would come from the shorter trips, in what could be considered an expanded Greater Boston commuter shed.

In the New York City to Montreal market, the biggest component is presently between New York and Albany, one of the more successful passenger service markets in the country. Other components of the Empire Corridor (NYC-Albany-Buffalo) also have considerably higher ridership than the Adirondack service to Montreal, which is understandable given the substantial differences in population and employment levels along the two corridors. Table 17 indicates the present Amtrak ridership on routes within New York State.

Table 17. Amtrak Ridership in New York State

Route		Annual Ridership (2002)
ALBANY – NY PENN		576,943
EMPIRE WEST	NYC – Buffalo/Niagara Falls	349,778
MAPLE LEAF	NYC - Toronto	257,234
ADIRONDACK	Schenectady – Montreal	91,060
ETHAN ALLEN	Albany-Rutland, VT [1]	69,281
OTHER	[2]	26,143
SUBTOTAL		**1,370,439**
LAKE SHORE LIMITED	Chicago-NY Penn/Boston [1]	287,779
TOTAL		**1,658,218**

[1] NYS portion only.
[2] Includes seasonal service to Saratoga Raceway and the NYS Fair.
Source: NYSDOT, Intercity Passenger Rail Section, 2003

With an approximately 40% reduction in travel time (including the elimination of both the Customs stop and the need to switch to a bus for the final portion of the trip to Montreal), the Boston-to-Montreal study projected a 15-fold increase in Boston-Montreal ridership, from less than 14,000 to over 220,000 annually. Under the 150 MPH scenario (both in New York and Quebec), with the same elimination of the Customs stop, even greater travel time savings are projected – 60% for the overall NYC-Montreal trip and over 72% for the Albany-Montreal portion. An increase similar to what was projected for Boston-to-Montreal would mean ridership of roughly 1.4 million for 4-hour service between New York and Montreal. However, the markets are similar but not directly comparable, and this potentially large ridership rise assumes a $4 billion investment and a significant increase in service levels above the present 1 train/day in the corridor. It is unlikely that the ridership growth would be that significant, and that it could justify the substantial capital and on-going operating costs under that scheme.

As was true in the Boston-Montreal market, the ridership growth under more modest improvement scenarios, while not as dramatic as projected under European-type HSR service, is more likely to justify the considerably more modest capital and operating requirements. If, for example, scenarios that would continue to use existing non-tilt trains, somewhat higher speeds (e.g., 90 MPH MAS), moderate curve improvements, realizable increases in imbalance and the assumed benefit of no Customs stop, travel time savings of roughly 3 hours or over 30% are projected. While the 15-fold (1500%) increases in ridership under 150 MPH service would not be realized, a more modest increase – 150% to 200%, from roughly 90,000 to 230,000 to 270,000 annually -- could be realized. Viewed simply from a capital cost/rider basis, the more modest scenario would cost roughly $370/additional rider vs. $2,700/rider under the 150 MPH HSR option.

There are a broad range of other issues that need to be considered, both dealing with costs and the numerous market segments that exist in the corridor and how each of them would react. These issues, which require further study, would include the following:

- What is the trade-off between the number of stops and frequency of service and ridership potential? Part of this can be addressed by a mixture of local and express service. For example, between Albany and Montreal, an express train, possibly twice a day, might make only 3 stops, while a local train (possibly only within New York State) would provide local and connector service in the corridor.
- What is the potential for commuter-type service in an expanded Capital District commuter shed? With an improved alignment and better travel time and reliability, could service between, say, Glens Fall and Saratoga to Albany be successfully marketed? Further, as the New York to Albany run gets reliably under 2 hours, the Capital District starts to become part of the commuter shed of New York City.
- How will services offered in New York State be balanced with possible improvements in Vermont, and in the Boston-Montreal corridor?
- To what extent will continued growth in discount air service (e.g., Jet Blue) to key points along the corridor affect the long-term potential for improved rail service?

The ability of HSR to compete with the convenience, comfort, and travel time of alternative modes (especially plane and car) is critical to its potential market penetration. For, example, consider a CBD-to-CBD trip between New York City and Montreal. The origin is assumed to be Midtown Manhattan and the destination the Montreal CBD. Travel time to JFK Airport was approximately one hour, with passengers expected to arrive at least one hour prior to departure. A direct flight on American Airlines from JFK to Dorval Airport in Montreal is listed as 1:20 – 1:30. A taxi from Dorval International Airport to Downtown Montreal was estimated at 40 minutes.

Midtown Manhattan – Downtown Montreal by Air	
Midtown Manhattan to JFK	1:00
Check-in at JFK	1:00
Flight Time	1:20 – 1:30
Dorval to Downtown	0:40
Total	**4:00 – 4:10**

By car, the distance from Midtown to Montreal is approximately 360 miles. Assuming an average driving speed of 60 mph, the trip could be made in six hours. An additional 90 minutes were assumed for stops for food and restroom use, and to account for traffic congestion in areas close to or within the cities:

Midtown Manhattan – Montreal CBD by Car	
Driving Time (360 miles @ 60 mph)	6:00
Food/Rest Stops, Congestion	1:30
Total	**7:30**

The 150 MPH HSR option would provide CBD-to-CBD service in just over 4 hours – comparable to the figure shown for air service. However, the quality of the travel experience during those four hours would likely be considerably better for the train passenger. Compared to auto travel, full HSR would be both faster and more relaxing. The main benefit of car travel is having the use of the car to arrive at one's eventual destination, although depending on the nature of the trip and eventual destination, that could be handled in many other ways (taxi, subway, picked up by someone else, etc.). However, even some of the more modest service improvements discussed in this report – ones that could cut the present New York to Montreal time from over 10 hours to 6-7 hours – would result in significant ridership increases.

Preliminary estimates from the MTQ project annual ridership increases in the New York City to Montreal corridor of approximately 650,000 to 700,000. These projections assume full HSR service service between the two cities, with 5-6 trains per day in each direction. These projections are based primarily on studies done in the 1980s for higher-speed (180-200 MPH) service in the Montreal to Boston market.

Based on these factors and on the range of ridership projections associated with previous and on-going HSR studies, Table 18 shows preliminary estimates for ridership increases in the Albany – Montreal corridor associated with each scenario.

Table 18. Ridership Projections

Scenario	Total Run Time (Hr:Min)	Additional Annual Ridership
Existing	10:15	-
MU	10:01	25,000
1	9:30	50,000
2	9:17	75,000
5	8:51	100,000
8	8:43	125,000
9	8:37	125,000
10	8:24	150,000
14	8:08	175,000
19	8:51	100,000
HSR-1	7:38	400,000
HSR-2	7:08	400,000
HSR-3 [1]	4:45	500,000
HSR-4 [1]	4:05	550,000

[1] HSR-3 assumes 150 MPH service in Quebec + no Customs stop, while HSR-4 assumes 35-minute reduction in NYC-Albany portion of alignment.

These figures, in the same order-of-magnitude as the 650,000-700,000 ridership projection by MTQ, are very preliminary estimates. Potential future ridership levels would be substantially impacted by internal factors (e.g., service frequency, fare levels, etc.) and external factors (e.g., growth in discount air service, gasoline prices, etc.).

6.5. Rolling Stock Needs

Scenarios discussed in this report that would involve relatively minor adjustments to the existing alignment and operating parameters, with minor overall changes in running time, would likely not result in major ridership growth and an associated short-term need for additional or new rolling stock. However, improvements to the alignment that would require the use of tilt-train technology (i.e., with a relatively high Eu), and certainly the 150 MPH scenario on a new alignment, would require the purchase of new HSR equipment. Both the NYSDOT and MTQ studies assumed the use of Jet Train technology or its equivalent would be assumed for these types of operations. These train sets have a maximum operating speed to 150 MPH and do not require electrification.

The train consists to be assumed would reflect the level of ridership and the frequency of service. The MTQ studies assumed a maximum frequency of 5-6 trains per day in each direction between New York City and Montreal, compared to one train per day under present operations. Assuming roughly 4-hour service with a 1-hour turn-around time at each end, this service would likely require 6 train sets. The approximate cost for this type of equipment is $3.5 million for each locomotive and $2.0 million for the passenger cars. With a train consist of two locomotives and 5-6 cars, each train set would cost roughly $17 to $19 million, or roughly $102 - $114 million total. As noted earlier in this section, this is approximately the same as the $100 million figure for rolling stock assumed in the MTQ study.

The DMU service discussed earlier in this report assumes the use of the Colorado Rail Car. Assuming that these trains were used only for the Albany to Montreal portion of the trip, at a cost of roughly $11 million per train (3 power cars, 2 carriage cars), and a 6-train set fleet, a total cost for rolling stock under that scenario is approximately $66 million.

Further marketing studies are needed to determine the service levels warranted in each of the corridor's market segments (NYC-Montreal, Albany-Montreal, local vs. express service, etc.). However, it is unlikely that an investment as significant as a dedicated HSR corridor would occur without a commitment to provide relatively frequent service.

6.6. Community and Environmental Benefits

The primary benefit of substantial improvements in intercity rail service is the increase in mobility provided to travelers along the affected corridor, and the impact that improvement in accessibility has on the social and economic viability of those areas. I-87 is already part of one of the most successful HSR corridors in the country – the Empire Corridor between New York, Albany and Buffalo/Niagara Falls. However, this serves only the New York-Albany portion of the corridor – an area with considerably different mobility needs than the less densely populated Albany to Montreal portion. That area presently has very limited, subsidized train service that while lightly used is still vital to communities served by it. Maintaining and improving service in that portion of the corridor can play a significant role in their ability to support sustained economic development. This includes alternative means of access to recreational and tourist attractions in the Adirondack region, many of which have a limited ability to grow if the only way visitors can arrive is by car. The ability to provide appealing travel options to the State's auto-less population is also an important policy goal.

An additional benefit, especially in urbanized areas, is the greater energy efficiency and lower pollutant loads associated with trains vs. autos or air travel. A typical intercity Amtrak train uses about 2,441 BTUs per passenger-mile, well below the 4,000 required for airlines (Source: Oak Ridge National Laboratory, 1998). In terms of carbon monoxide (CO), persons traveling in trains generate roughly a third the amount generated by auto travel, with similar disparities in CO_2 and other greenhouse-type pollutants. However, these types of benefits can only be realized if the train service that is provided is well-utilized. The long-term viability of high-density modes like rail service depends on land use policies and a variety of factors that support more public transportation-oriented development patterns.

The actual benefits of HSR service in this corridor cannot be calculated until the service options, market share, ridership, track maintenance needs, and related factors are defined in more detail. However, the economic and environmental benefits of expanded use of more efficient modes are widely recognized.

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Appendix 1

Initial Design Guidelines for 150 MPH Alignment

Design Criteria

There are multiple high speed ground transportation technologies available, including diesel-electric, turbine, and electric powered steel wheel/steel rail systems. They can be equipped with either conventional or tilt suspensions. The latter, while being more costly and complex, can allow shorter travel times on a route with numerous curves. The performance and infrastructure requirements of the different technologies vary. The key differences are maximum speeds attainable, ranging from 120 mph to 200 mph, and the rates of acceleration. For the purposes of this study, maximum operating speed is limited to 150 mph because electrification is not being considered.

The High Speed Rail civil design assumptions presented herein serve as a starting point to develop a generalized infrastructure concept that will accommodate a rail system capable of speeds of 150 mph for a significant portion of the overall Albany-Canadian Border-Montreal route. From this generalized infrastructure configuration, order of magnitude costs will be developed, enabling further evaluation of 150 mph operational and economic viability.

As envisioned, the high speed rail system would be used by high speed passenger equipment and would not be used for general railway freight transport. The high speed equipment may include special, similarly constructed freight cars, operating in separate trains or as part of passenger train consists. Conventional track maintenance equipment, including work trains with conventional road-switcher-type locomotives, ballast cars, tampers and other maintenance equipment, track geometry cars, and hi-rail vehicles would be permitted to operate on the track.

Codes, Standards and Regulations

Tracks would be designed to meet applicable requirements of Track Safety Standards 49 U.S.C. Part 213 Subpart G for Class 8 track.

Railroad track and structures would be designed in accord with recommended practice of the AREMA Manual for Railway Engineering 2002.

Right of Way

Options will be considered for right of way using highway medians and/or completely new alignments. Where applicable, tangent segments of the high speed rail alignment would be designed to fit within a 50 foot envelope within existing railroad alignments, and a 44 foot envelope in highway medians. Curves and spirals may require a greater envelope width and/or additional right of way.

Design Speeds

The pre-feasibility engineering alignment would be designed for a peak operating speed of 150 mph, where not restricted by right of way limitations.

Track and Guideway

Mainline roadbed, trackwork and alignment would be designed for high speed passenger service at speeds up to 150 mph, unless otherwise restricted by geometric considerations, special trackwork, or yard limits. Where high-speed operation is permissible, the facilities would be designed to support Class 8 gauge, alignment and surface criteria without excessive maintenance.

A double track mainline would be constructed to ensure reliable service. High speed crossovers are required at roughly 25 mile intervals to allow heavy maintenance under single track operations without shutting down the system.

Main tracks used by passenger service would be constructed using new 136RE or heavier continuous welded and controlled cooled rail (CWR). Rail for sidings and yards would be either new 136RE CWR (as above) or relayed continuous welded rail of not less than 115 lbs. per yard.

Main track would use reinforced concrete ties. Yard track may use either concrete or timber ties. The concrete tie track would be suitably designed to provide electric isolation of one rail from the other and both from ground to satisfy train control circuit integrity requirements.

Track gage would be 4 ft 8.5 in measured at right angles to the track alignment 5/8 in below the top of rail.

The mainline track would be entirely grade separated. Grade crossings are permitted in yards and possibly in slow speed territory, where grade separation is not economically feasible. Grade crossings would include gated warning systems.

Special Trackwork

All new turnouts, crossovers, and special crossings would be in accordance with current AREMA Portfolio of Trackwork Plans for standard curved switch and rigid frog lateral turnouts, unless otherwise modified due to location within mainline track curves and spirals.

The point of switch or heel of frog would be located no closer than the following:

TS or ST of adjoining mainline track curve	200 feet
PVC or PVT of a vertical curve	100 feet

Where unconstrained by geometry, all mainline crossovers would be at least #32.75 with movable point frogs. Crossovers and turnouts in close proximity to terminal stations may be #20 with curved switch points and RBM frogs. Yard turnouts would be no smaller than #8. All mainline turnouts would be on concrete ties.

Horizontal Alignment

The following design guidelines are based on AREMA 2002. All horizontal alignment design would conform to current AREMA guidelines.

Tangents

The minimum tangent length between curves would be the greater of 100 feet or three times the design speed. The alignment would be tangent through the platform area to a distance of 100 feet from platform edges.

Curvature

Curvature would not exceed 9 degrees on mainline tracks approaching stations/terminals and other similarly restricted areas, and 12 degrees on yard tracks. The minimum length of circular curve would be determined by the formula: L = 2.22*V, where L is in ft and V is in mph. In no case would the length of circular curve be less than 100 feet

Superelevation/Cant Deficiency

Mainline curves would be superelevated. The maximum design superelevation E(A) would not exceed 7 inches.

Maximum cant deficiency E(U) would not exceed 9 inches. (FRA permits a maximum cant deficiency of 9 inches on qualified equipment, i.e. tilt body equipment. For non-tilt body equipment E(U) would be limited to 3 inches unless the roll angle is within limits specified by AREMA in which case the E(U) may be increased to 4.5 inches.)

Actual and unbalanced superelevation may be simultaneously introduced provided that AREMA spiral length guidelines are followed.

Spirals

Mainline curves and tangents would be connected with a spiral transition. Spiral and curve geometry would be determined using the formula and notation of AREMA 5-3-2 through 5-3-5.

Vertical Alignment

The following design guidelines are based on AREMA 2002. All vertical alignment design would conform to current AREMA guidelines.

Grades

The vertical alignment would follow the existing track or highway gradients, wherever practicable. The desired maximum grade would not exceed 1.0%. Under no circumstances would the grade exceed 5%. Yard tracks and station track grades would not exceed .25%. It is desired to design such tracks at 0% grade.

Vertical Curves

Where changes in grade occur, gradient lines should be connected by vertical curves, observing the following provisions:

The length of a vertical curve is determined by the difference in grades to be connected and the rate of change adopted. For high-speed main tracks, the rate of change should not be more than 0.05' per station of 100' in sag curves and not more than 0.10' per station of 100' in crest curves.

The minimum vertical curve length, $LVC_{(min)}$, would not be less than 100 feet

Clearances and Track Centers

Tangent

Main tracks would be constructed at 14.0 foot minimum track centers on tangent. The desirable main line high speed rail track centers would be 15.0 feet. High speed rail tracks would be separated from adjacent freight rail tracks by a distance of not less than 25 feet measured between freight and high speed rail track centerlines. This does not apply in station areas where existing tracks may be used for short distances.

Yard and storage tracks would be spaced at not less than 14.0 feet measured between track centerlines.

The minimum permissible clearance from track centerlines to adjacent fixed obstructions would be 8 feet measured from the track centerline.

Curves

The minimum horizontal clearance (9.0 feet) and track spacing (14.0 feet) would be increased 1.5 inches per degree of curvature. Where superelevation is applied, the minimum horizontal clearance of 8.0 feet would be increased on the inside of the curve 3 inches per inch of actual superelevation.

Vertical Clearance

The high speed rail alignment would be designed to provide 23 feet of clearance between the top of rail and the low point of the bridge. (Note: This clearance value allows for the potential installation of a catenary system for a 25kV power system.)

Vehicular Dynamic Clearance

The vehicular dynamic clearance would not exceed AREMA Plate C.

Structures

Bridges

Highway bridge piers within 25 feet of a track centerline would be protected with a reinforced concrete deflection wall to a height of 6 feet above the top of rail elevation.

High speed rail bridges would be constructed with a side walkway, where permitted by median width or railroad right of way width.

Retaining Walls

The desirable clearance to retaining walls would be 10.0 minimum from centerline of track to near face of wall.

Barriers

Highway median barriers would be employed on the boundaries of highway median running high speed rail systems to deflect errant highway vehicles and trains from entering each others' paths. On the inside of curves the height of standard barriers would be increased to 7.5 feet.

Fencing

Chain link fencing 6 feet high would be installed on the boundaries of the new rail alignment. The fencing would be installed on the top of the highway median barrier separating high speed rail from automotive traffic.

Stations

Platform length would be not less than for 6 car trains including locomotives. For initial configuration, a platform length of 700 feet would be used. Center platforms would be a minimum of 24 feet in width. Platforms would be high level and meet ADA clearance requirements.

HSR Rolling Stock

The general performance characteristics of Acelarail 150/FRA/Bombardier Next Generation non-electric locomotive would be used. The assumed consist is two locomotives, five passenger vehicles, and one Bistro vehicle. It should be noted that the use of the foregoing stated equipment in this report does not infer a recommendation for the selection of such equipment.

Equipment Technology

Pertinent characteristics of JetTrain Power car (locomotive) are:

Operating speed	150 mph
Engine	5000 hp turbine
Fuel	Standard Diesel fuel
Length	69' 7 3/8"
Width	10' 5" over side sheets
Height	14' 2" rail to roof
Weight	200,000 lbs.
Propulsion	AC traction motors, continuous 4,400 hp
Carbody	Stainless steel carbody structure with ASLA steel end underframe

Jet Train Passenger cars

Carbody	Stainless steel carboy structure with HSLA steel end underframe

Monitoring	A state-of-the-art computerized monitoring system with dedicated computers that control, diagnose, and monitor every system and subsystem for optimum safety and reliability
Tilting	Computer controlled and hydraulically activated advance tilting system assuring full stability and passenger comfort when negotiating curves at higher speeds
Doors	Outside sliding plug type, high platform boarding
Length	87′ 5″
Width	10′ 4 ¼″ over side sheets
Height	13′ 10 5/8″ rail to roof
Passenger services	Fully ADA compliant Public phone booths Audio entertainment (all cars) Video entertainment (service car) Information display signs Rotating seats Meal service (service and business class cars)