Memorandum

TO: Hillsborough MPO

FROM: Jacobs Engineering

DATE: November 12, 2012

RE: Post-Referendum Analysis Phase Three: Hybrid Rail Conceptual Capital Costs

Introduction

Phase Three of the Post Referendum Analysis consists of evaluating the potential of implementing premium transit using a "hybrid rail" vehicle using diesel multiple unit (DMU) propulsion along the existing CSX rail corridor from the University of South Florida (USF) area to Downtown Tampa. The termini of the proposed service are the intersection of Polk Street and Marion Street in Downtown Tampa and 50th Street south of Fowler Avenue in the USF area.

As a part of this evaluation, high level capital cost estimates were developed for hybrid rail service along this corridor. Twelve capital cost scenarios were used with varying combinations based on:

- Guideway/track,
- Stations,
- Service plans, and
- Right-of-way costs.

An additional analysis was conducted of a potential Bus Rapid Transit (BRT) service connecting Downtown Tampa to the Tampa International Airport using managed lanes planned for I-275 by the Florida Department of Transportation (FDOT). This project is discussed in a separate memo.

Capital Cost Estimates

DMU Capital Cost Estimate Scenarios

For this analysis, 12 capital cost models were developed to further examine the cost potential of implementing premium transit using DMU technology considering the following elements:

- Two track configurations (utilizing the existing CSX single track corridor with sidings vs. reconstruction of the corridor to accommodate double tracking);
- Two station scenarios (13 and 8); and
- Three frequency scenarios (15-minute peak/30 minute off-peak, 30 minute peak/ 60 minute off-peak, and 60 minute peak/60 minute off-peak). The DMU service scenarios used in this analysis are summarized in **Table 1**. For purposes of developing and reporting capital costs, each scenario was assigned a number 1-12.

Table 1: Proposed Hybrid Rail Service Scenarios

Scenario	Track	Number of Stations	Frequencies (peak/ off-peak)
1	Double	13	15/30
2	Double	8	15/30
3	Double	13	30/60
4	Double	8	30/60
5	Double	13	60/60
6	Double	8	60/60
7	Single	13	15/30
8	Single	8	15/30
9	Single	13	30/60
10	Single	8	30/60
11	Single	13	60/60
12	Single	8	30/60

"High" and "low" right-of-way costs obtained from FDOT were applied to the scenarios listed above; thus, creating a cost range for each of the twelve scenarios.

Cost Data

Cost data was developed using multiple resources, including information obtained from FDOT and national examples of transit projects. In line with FTA guidelines and FTA's Standard Cost Categories (SCC), the capital cost estimates utilize a unit cost for each line item where a general scope of work is known. Where work items could not be estimated using quantitative data, items or cost categories were calculated as a percentage, ranging from five percent to 40 percent of the base amount.

The following sources were used to develop the capital costs:

- Unit costs associated with civil or structural construction elements, generally common to both transit and highway construction projects, were obtained from the FDOT's Long Range Estimating System (LRE) database.
- Unit costs associated with trackwork, stations, and systems construction elements were derived from recent construction bids for transit projects around the country.
- Unit costs for a maintenance facility were derived from the Hillsborough County Metropolitan Planning Organization (MPO) 2035 Long Range Transportation Plan.
- Unit costs associated with the purchase of the track and associated right-of-way was estimated based on the agreement between FDOT and CSX for the purchase of 61.5 miles of CSX tracks in Central Florida for the SunRail Commuter Rail project.

Methodology

Capital cost estimates for the DMU scenarios were formulated by using the latest revision of FTA's SCC worksheet as the basic format and structure for reporting capital costs. A "high level" evaluation and analysis of the DMU scenarios consisted of the preliminary identification of station locations and development of transit operating plans. This analysis identified the infrastructure elements needed to prepare the capital cost estimates, such as siding requirements and fleet vehicle requirements. Quantitative data used to calculate capital costs for the scenarios was obtained from aerial measurements using Geographic Information Systems (GIS) as well as typical sections. Typical sections for the scenarios were used to determine right-of-way and guideway construction requirements.

Typical sections were created for each scenario to identify preliminary right-of-way needs (if any) outside of the existing right-of-way. Right-of-way impacts were then determined through offsets using the established centerline alignments from the typical sections. Estimated right-of-way unit costs were provided by FDOT. In this case, two sets of right-of-way costs were used to create a range from "low" to "high". Right-of-way cost estimates were calculated by multiplying the estimated square footage of acquisition for each scenario by the corresponding unit cost by land use.

Furthermore, the following are additional assumptions used to develop the capital cost estimates:

- Costs are presented in present day (2012)
- Only existing vehicle technologies were considered
- The construction schedule will proceed under normal State of Florida laws, conditions, and rules.

Capital Cost Categories

Costs were developed in accordance with FTA's SCC, to establish a consistent format for reporting, estimating, and managing capital costs. The capital cost estimates presented are based on these general category guidelines and are grouped into capital cost estimates categories to align with FTA guidelines, as shown in **Table 2**.

Table 2: FTA Capital Cost Categories

FTA Category	Description
10	Guideway and Track Elements
20	Stations, Stops, Terminals, Intermodal
30	Support Facilities: Structures
40	Sitework and Special Conditions
50	Systems
60	Right-of-way, Land, Existing Improvements
70	Vehicles
80	Professional Services
90	Unallocated Contingencies
100	Finance Charges

Guideway and Track Elements (Category 10)

Guideway and track elements are components of the transit system where costs are generally quantifiable to an acceptable level of accuracy. Quantities were applied by the measurement of alignment and siding lengths. Guideway elements are grouped by a number of sub-categories based on construction type: at-grade, aerial, and retained cut or fill/underground. For the rail technology, the cost category includes all of the foundational construction elements and costs associated with the guideway, such as bed preparations, drainage, and grading. Track elements are sub-categorized by construction type: ballasted, direct fixation, or embedded. The special trackwork category includes all track components such as curves, turnouts, crossovers, and switches.

Guideway Elements

Guideway elements use parametric unit costs based on the scope of work included in the typical cross-section. The parametric guideway cost estimates provide for, but are not limited to, the following construction components:

- Traffic control
- Site work, including clearing, demolition, and earthwork
- Erosion control and soil stabilization
- Drainage
- Concrete base slab for embedded guideway construction
- Pedestrian access and protection

Track Elements

Track elements use parametric unit costs based on the scope of work included in the typical cross-section. The parametric trackwork cost estimates provide for, but are not limited to, the following construction components:

- Embedded or paved track (typically used in street) and includes rail, rail welding, reinforced concrete track slab, structural running surface, coated tie bars, and rail embedding materials
- Ballasted track (typically used in at-grade or retained cut or fill construction) and includes rail, concrete ties with ballast, rail welding, rail fasteners, and rail anchors
- Special trackwork is a percentage (15 percent) allowance calculated on the total base amount of the trackwork categories combined. Special trackwork generally includes, but is not limited to, placing track in curves, turnouts, switches, crossovers, wyes, pocket tracks, and rail crossings.

Cost Category Assumptions

The following assumptions were made in regards to the project:

- Use of existing CSX single track and sidings is assumed
- Embedded track in Downtown Tampa only; all remaining track is assumed ballasted open
- Bridge or aerial structure widening for an existing 1,875 square foot bridge structure across the Hillsborough River
- No underground, direct fixation, or retained cut or fill construction
- Guideway and trackwork lengths used for all scenarios are summarized in Table 3 and 4.

Stations, Stops, Terminals, Intermodal (Category 20)

Station costs include the fixed facilities and/or structures for transit stations. The parametric unit costs developed are based on a general assumption of the types of stations anticipated. Costs for parking are also included in this category.

Station parametric unit costs include, but are not limited to, the following construction components:

- Station platforms (side or center); platform lengths determined by length and number of transit vehicles and operating characteristics
- At-grade concrete footings, walls, and platform slabs
- Station platform canopy(ies)
- Standard amenities (e.g., lighting, electrical, mechanical, signage, furnishings, and other amenities)

Automobile parking parametric unit costs include, but are not limited to, the following construction components:

Table 3: USF (50th Street) to Downtown Tampa Single Track Guideway and Trackwork Assumptions

Description	Single Track					
	Maximum Stations (15 min Headways)	Maximum Stations (30 min Headways)	Maximum Stations (60 min Headways)	Minimum Stations (15 min Headways)	Minimum Stations (30 min Headways)	Minimum Stations (60 min Headways)
Existing Single Track	51,920	51,920	51,920	51,920	51,920	51,920
Existing Sidings	9,340	9,340	9,340	9,340	9,340	9,340
Total Existing Guideway/Track	**61,260**	**61,260**	**61,260**	**61,260**	**61,260**	**61,260**
New Single Guideway/Track - Ballasted (Including Sidings)	20,170	11,410	8,450	21,280	8,450	8,450
New Single Guideway/Track - Embedded (Including Sidings)	0	0	0	0	0	0
New Double Guideway/Track - Ballasted	0	0	0	0	0	0
New Double Guideway/Track - Embedded	0	0	0	0	0	0
Total New Guideway/Track	**20,170**	**11,410**	**8,450**	**21,280**	**8,450**	**8,450**

Note: All units of measurement are expressed in feet

Table 4: USF (50th Street) to Downtown Tampa Double Track Guideway and Trackwork Assumptions

Description	Double Track					
	Maximum Stations (15 min Headways)	Maximum Stations (30 min Headways)	Maximum Stations (60 min Headways)	Minimum Stations (15 min Headways)	Minimum Stations (30 min Headways)	Minimum Stations (60 min Headways)
Existing Single Track	51,920	51,920	51,920	51,920	51,920	51,920
Existing Sidings	9,340	9,340	9,340	9,340	9,340	9,340
Total Existing Guideway/Track	**61,260**	**61,260**	**61,260**	**61,260**	**61,260**	**61,260**
New Single Guideway/Track - Ballasted (Including Sidings)	51,920	51,920	51,920	51,920	51,920	51,920
New Single Guideway/Track - Embedded (Including Sidings)	900	900	900	900	900	900
New Double Guideway/Track - Ballasted	8,450	8,450	8,450	8,450	8,450	8,450
New Double Guideway/Track - Embedded	0	0	0	0	0	0
Total New Guideway/Track	**61,270**	**61,270**	**61,270**	**61,270**	**61,270**	**61,270**

Note: All units of measurement are expressed in feet

- Traffic control
- Surface material and striping for surface parking
- Pedestrian access and protection
- Lighting, electrical, and mechanical components
- Driveways or access points to parking areas, including curbs and gutters

Cost Category Assumptions

The following assumptions were made in regards to the project:

- No underground stations
- Two park-n-ride stations; 400 parking spaces each (per station parking space average based upon rail transit systems in Santa Clara, Sacramento, Phoenix, and Maryland)
- Station platform dimensions for DMU vehicles:
  - 200' x 12' side platforms
  - 200' x 15' center platform, at-grade
- Right-of-way and/or land costs for stations are included in Category 60

Support Facilities: Yards, Shops, Administrative Buildings (Category 30)

This cost category includes all costs associated with vehicle storage and maintenance buildings, trackwork for rail vehicles, vehicle maintenance and repair facilities, administrative support buildings, and general equipment associated with such facilities.

Cost Category Assumptions

The following assumptions were made in regards to the project:

- The cost of building a maintenance and storage facility for the rail vehicles was attained from the Hillsborough County MPO 2035 LRTP (additional study is required)

Sitework and Special Conditions (Category 40)

This cost category includes all costs associated with the following:

- Demolition, clearing, and grubbing
- Utility relocations
- Hazardous materials mitigation including contaminated soils and groundwater removal
- Environmental mitigation, including wetlands, cultural assets protection, etc.
- Site structures including bridges
- Landscaping, bike/pedestrian access, and accommodations
- Roadway construction, including modification of road facility in/around major crossings, stations, etc.

The following sub-categories cover many unknown or non-quantifiable elements in transit construction projects.

Demolition, Clearing, and Grubbing

This generally includes demolition of features which fall outside of the guideway construction envelope and is estimated to be eight percent of Categories 10 through 30

Hazardous Material and Environmental Mitigation

This includes contaminated soil removal, groundwater remediation, underground storage tank removal, etc. In addition, the cost category includes impacts to environmentally sensitive lands, park, or historic/archeological resources. Hazardous material and environmental mitigation information is unknown at this time; therefore, the cost category is calculated as two to four percent of the base amount of Categories 10 through 30.

Automobile Accessways

This includes new and reconstructed roadways, streets, surface parking areas, sidewalks, curbs and gutters, and related roadway facilities. Parametric unit costs are developed and calculated on quantities included in the typical sections by alignment. The following assumptions were applied to this sub-category:

- Unit costs for all roadway facility construction were obtained from the FDOT LRE system (2012 dollars)
- Maintenance of traffic (MOT); mobilization; drainage; lighting; paved shoulders and/or curb and gutter. All other roadwork components
- Double Track scenario: Approximately 2,025 feet of milling and resurfacing for all rail crossings with existing roadways

Systems (Category 50)

This includes all electrical, mechanical, and power distribution systems to control and operate the transit system. Many of the costs in this category are directly related to power and operations for rail transit. This includes all costs associated with the following sub-categories:

- Train control and signals (rail only) – signaling and control systems for safe train operation
- Communications line – system providing operational support for transit service including public address system, telephone system, variable message signs, radio receivers, etc.
- Fare collection – provides for self-service or off-board fare collection including ticket vending machines and all associated hardware
- Central control – provision for facilities to provide remote monitoring of train operations; this item may or may not be required depending on operations plans

Cost Category Assumptions

The following assumptions were made in regards to the project:

- Signal system and communication line lengths correspond to length of guideway/trackwork
- No electrification or substations assumed for DMU technology
- One fare collection unit per station platform
- Signal prioritization (includes traffic controller assembly, vehicle detection (video), and associated hardware)
- Existing signal modification (includes traffic controller assembly, vehicle detection (video), and associated hardware)
- Parametric (includes traffic signals, assemblies, and hardware obtained from FDOT)
- Four quadrant gates assumed at all (45) crossings outside of Downtown Tampa for Double Track scenarios

Right-of-way (Category 60)

The right-of-way cost category includes all land acquisition and associated costs required to purchase property needed for construction, operation, and maintenance of the transit system. Costs include fee acquisition, easements, relocation costs, business damages, etc. Right-of-way costs for the purchase of the existing track were estimated based on the agreement between FDOT and CSX for the purchase of the CSX tracks in Central Florida for the SunRail Commuter Rail line. Right-of-way cost estimates for additional right-of-way beyond the existing tracks were calculated by multiplying the estimated square footage of acquisition for each alternative by the corresponding geographic area unit cost. Right-of-way needed for the maintenance facility was not included in this category.

Cost Category Assumptions

The following assumptions were made in regards to the project:

- Tracks right-of-way
  - Unit costs for right-of-way acquisition estimated based on the agreement between FDOT and CSX tracks in Central Florida for the SunRail Commuter Rail line.
- Other right-of-way
  - Unit costs for right-of-way acquisition provided by FDOT District Seven
  - Unit costs include all phases associated with right-of-way acquisition (e.g., attorney fees, appraisals, relocation costs, business damages)
  - Right-of-way cost estimates based on two assumptions, purchasing from CSX and purchasing from other land owners, representing the high and low range of the capital cost estimates
  - "High end" unit costs from assumptions made using planning level estimates in coordination with FDOT District 7: Commercial = $90 per square foot, Industrial = $45 per square foot, and Residential = $15 per square foot
  - "Low end" unit costs from assumptions made using planning level estimates in coordination with FDOT District 7: Commercial = $30 per square foot, Industrial = $15 per square foot, and Residential = $5 per square foot
  - Right-of-way for stations (2 acres or 87,210 square feet per station)
  - Right-of-way for parking (300 square feet per parking space)

Vehicles (Category 70)

This includes all revenue and non-revenue vehicles. Unit cost development is based on historical data from recent transit projects.

Cost Category Assumptions

Vehicle requirements for each scenario are shown in **Table 4**.

- HART to provide supporting bus service (not included)
- Rail vehicle cost from Denton Co. Texas example; 11 cars for $73.7 million ($6.7m per vehicle in 2012)

Table 4: Vehicle Requirements

Scenario	Track	Number of Stations	Frequencies	Number of Vehicles
1	Double	13	15/30	12
2	Double	8	15/30	10
3	Double	13	30/60	8
4	Double	8	30/60	5
5	Double	13	60/60	5
6	Double	8	60/60	3
7	Single	13	15/30	12
8	Single	8	15/30	12
9	Single	13	30/60	8
10	Single	8	30/60	5
11	Single	13	60/60	5
12	Single	8	60/60	3

Professional Services (Category 80)

Professional services costs are calculated as a percentage of the base amount totals of Categories 10 through 50. Per FTA, the sub-categories and associated percent multipliers listed below include costs for all professional, technical, and management services associated with the design and construction of the fixed guideway throughout preliminary engineering, final design, and construction the project.

- Preliminary Engineering 5 percent
- Final Design 10 percent
- Project Management for Design and Construction 5 percent
- Construction Administration and Management 7 percent
- Insurance 3 percent
- Legal/Permits/Review Fees by other agencies, cities, etc. 0.5 percent
- Surveys, Testing, Investigation, Inspection 2 percent
- Agency Force Account Work 1 percent

Unallocated Contingencies (Category 90)

An unallocated contingency is an allowance for unknown or uncertain project costs inherent at this planning stage of project development. While allocated contingencies are assumed to address uncertainty in specific parametric unit cost developments, the unallocated contingency is considered compensation for unknowns or changes in project scope and schedule. A 10 percent contingency multiplied on the base amount totals for Categories 10 through 70 is assumed.

Finance Charges (Category 100)

Specific financing is unknown at this stage of project development. As a result, no financing charges were included in the cost estimates.

Allocated Contingencies

Due to fluctuations in labor and commodity costs, contingencies of five percent to 40 percent are added onto each item's unit cost. Allocated contingency allowances are directly related to the level of known detail regarding project design information and the level of difficulty in establishing unit costs for individual work items. The percentage selected in each category is based on national best practices, professional judgment, and knowledge of historic cost variations for work items. **Table 5** lists the allocated contingency percentages that were utilized by cost category.

Capital Cost Estimating Results

The capital cost estimates were computed using a simple cost model to tabulate the item costs and contingencies. Centerline alignments were determined based on currently available aerial images and/or computer aided design and drafting (CADD) files. Typical sections for each alternative were developed using the centerline alignments and horizontal measurements from the aerial images and/or CADD files. The typical sections for each scenario were used to determine guideway construction requirements. The guideway lengths, stations, parking lots/spaces, and vehicles were entered into the capital cost spreadsheets to tabulate total dollar amounts by scenario. The results of the capital cost estimations for all scenarios are provided in **Tables 6** through **9**.

Table 5: Allocated Contingency Percentages for Planning Estimates

FTA Category	Description	Allocated Contingency Percentage
10	*Guideway and Track Elements*	
	Guideway Elements (Rail)	25%
	Track Elements	15%
20	*Stations, Stops, Terminals, Intermodal*	
	Stations	20%
	Parking (Surface and Structured)	10%
	Pedestrian Overpass	10%
30	Support Facilities: Yards, Shops, Administrative Buildings	30%
40	*Sitework and Special Conditions*	
	Demolition, Clearing and Grubbing	8%
	Hazardous Materials	2%
	Environmental Mitigation	4%
	Structures	5%
	Automobile Access including Roads	5%
50	Systems	15%
60	Right-of-way, Land, Existing Improvements	30-40%
70	Vehicles	10%

Table 6: USF (50th Street) to Downtown Tampa Single Track Capital Cost Estimates (Maximum Stations)

Cat. No.	Description	Single Track					
		Maximum Stations (15 min Headways)		Maximum Stations (30 min Headways)		Maximum Stations (60 min Headways)	
		"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)	"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)	"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)
10	GUIDEWAY & TRACK ELEMENTS	$16,899,939	$16,899,939	$9,560,154	$9,560,154	$7,080,044	$7,080,044
20	STATIONS, STOPS, TERMINALS, INTERMODAL	$21,560,000	$21,560,000	$21,560,000	$21,560,000	$21,560,000	$21,560,000
30	SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000
40	SITEWORK & SPECIAL CONDITIONS	$4,435,900	$4,435,900	$3,638,740	$3,638,740	$3,369,380	$3,369,380
50	SYSTEMS	$10,542,683	$10,542,683	$7,369,373	$7,369,373	$6,297,113	$6,297,113
60	ROW, LAND, EXISTING IMPROVEMENTS	$135,241,396	$138,685,788	$135,227,978	$138,645,534	$104,713,446	$108,085,938
70	VEHICLES	$88,440,000	$88,440,000	$58,960,000	$58,960,000	$36,850,000	$36,850,000
80	PROFESSIONAL SERVICES	$15,433,800	$15,433,800	$12,180,796	$12,180,796	$11,081,607	$11,081,607
90	UNALLOCATED CONTINGENCY	$25,512,919	$25,758,947	$21,857,008	$22,093,307	$17,339,654	$17,573,477
100	FINANCE CHARGES	$0	$0	$0	$0	$0	$0
Total Project Cost (10-100)		**$357,066,637**	**$360,757,057**	**$309,354,049**	**$313,007,904**	**$247,291,244**	**$250,897,559**

Table 7: USF (50th Street) to Downtown Tampa Single Track Capital Cost Estimates (Minimum Stations)

Cat. No.	Description	Single Track					
		Minimum Stations (15 min Headways)		Minimum Stations (30 min Headways)		Minimum Stations (60 min Headways)	
		"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)	"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)	"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)
10	GUIDEWAY & TRACK ELEMENTS	$17,829,980	$17,829,980	$7,080,044	$7,080,044	$7,080,044	$7,080,044
20	STATIONS, STOPS, TERMINALS, INTERMODAL	$14,960,000	$14,960,000	$14,960,000	$14,960,000	$14,960,000	$14,960,000
30	SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000
40	SITEWORK & SPECIAL CONDITIONS	$3,766,910	$3,766,910	$2,599,380	$2,599,380	$2,599,380	$2,599,380
50	SYSTEMS	$10,496,280	$10,496,280	$5,848,613	$5,848,613	$5,848,613	$5,848,613
60	ROW, LAND, EXISTING IMPROVEMENTS	$105,100,877	$109,248,231	$104,713,446	$108,085,938	$104,713,446	$108,085,938
70	VEHICLES	$88,440,000	$88,440,000	$36,850,000	$36,850,000	$22,110,000	$22,110,000
80	PROFESSIONAL SERVICES	$13,614,896	$13,614,896	$8,850,507	$8,850,507	$8,850,507	$8,850,507
90	UNALLOCATED CONTINGENCY	$22,801,211	$23,065,737	$16,673,654	$16,907,477	$15,333,654	$15,567,477
100	FINANCE CHARGES	$0	$0	$0	$0	$0	$0
Total Project Cost (10-100)		**$316,010,154**	**$320,422,034**	**$236,575,644**	**$240,181,959**	**$220,495,644**	**$224,101,959**

Table 8: USF (50th Street) to Downtown Tampa Double Track Capital Cost Estimates (Maximum Stations)

Cat. No.	Description	Double Track					
		Maximum Stations (15 min Headways)		Maximum Stations (30 min Headways)		Maximum Stations (60 min Headways)	
		"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)	"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)	"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)
10	GUIDEWAY & TRACK ELEMENTS	$56,385,689	$56,385,689	$56,385,689	$56,385,689	$56,385,689	$56,385,689
20	STATIONS, STOPS, TERMINALS, INTERMODAL	$24,680,000	$24,680,000	$24,680,000	$24,680,000	$24,680,000	$24,680,000
30	SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000
40	SITEWORK & SPECIAL CONDITIONS	$8,210,449	$8,210,449	$8,210,449	$8,210,449	$8,210,449	$8,210,449
50	SYSTEMS	$44,847,758	$44,847,758	$44,847,758	$44,847,758	$44,847,758	$44,847,758
60	ROW, LAND, EXISTING IMPROVEMENTS	$136,365,645	$142,058,535	$136,365,645	$142,058,535	$136,365,645	$142,058,535
70	VEHICLES	$88,440,000	$88,440,000	$58,960,000	$58,960,000	$36,850,000	$36,850,000
80	PROFESSIONAL SERVICES	$38,685,388	$38,685,388	$38,685,388	$38,685,388	$38,685,388	$38,685,388
90	UNALLOCATED CONTINGENCY	$32,533,995	$32,940,630	$29,853,995	$30,260,630	$27,843,995	$28,250,630
100	FINANCE CHARGES	$0	$0	$0	$0	$0	$0
Total Project Cost (10-100)		**$469,148,924**	**$475,248,449**	**$436,988,924**	**$443,088,449**	**$412,868,924**	**$418,968,449**

Table 9: USF (50th Street) to Downtown Tampa Double Track Capital Cost Estimates (Minimum Stations)

Cat. No.	Description	Double Track					
		Minimum Stations (15 min Headways)		Minimum Stations (30 min Headways)		Minimum Stations (60 min Headways)	
		"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)	"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)	"Low" Total Amount (2012 dollars)	"High" Total Amount (2012 dollars)
10	GUIDEWAY & TRACK ELEMENTS	$56,385,689	$56,385,689	$56,385,689	$56,385,689	$56,385,689	$56,385,689
20	STATIONS, STOPS, TERMINALS, INTERMODAL	$16,880,000	$16,880,000	$16,880,000	$16,880,000	$16,880,000	$16,880,000
30	SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000	$39,000,000
40	SITEWORK & SPECIAL CONDITIONS	$7,300,449	$7,300,449	$7,300,449	$7,300,449	$7,300,449	$7,300,449
50	SYSTEMS	$44,399,258	$44,399,258	$44,399,258	$44,399,258	$44,399,258	$44,399,258
60	ROW, LAND, EXISTING IMPROVEMENTS	$105,873,645	$111,566,535	$105,873,645	$111,566,535	$105,873,645	$111,566,535
70	VEHICLES	$73,700,000	$73,700,000	$36,850,000	$36,850,000	$22,110,000	$22,110,000
80	PROFESSIONAL SERVICES	$36,072,388	$36,072,388	$36,072,388	$36,072,388	$36,072,388	$36,072,388
90	UNALLOCATED CONTINGENCY	$28,235,995	$28,642,630	$24,885,995	$25,292,630	$23,545,995	$23,952,630
100	FINANCE CHARGES	$0	$0	$0	$0	$0	$0
Total Project Cost (10-100)		**$407,847,424**	**$413,946,949**	**$367,647,424**	**$373,746,949**	**$351,567,424**	**$357,666,949**

Date: October 4, 2012

To: Hillsborough County MPO

From: Connetics Transportation Group

Re: Post-Referendum Analysis Phase Three: Hybrid Rail Conceptual Operating Plans and O&M Cost Analysis

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Under Phase 3 of the 2035 Plan Post-Referendum Analysis, Connetics Transportation Group (CTG) was tasked to develop and evaluate potential diesel multiple unit (DMU) operating plans and estimate operating and maintenance (O&M) costs for a proposed transit corridor that connects the University of South Florida and Downtown Tampa. This memo addresses the following elements of the DMU transit service concept:

- Alignment and station assumptions;
- Vehicle assumptions;
- Three service plan scenarios;
- Travel time estimates;
- Single track with passing tracks vs. double track operations;
- Service requirements (peak/fleet vehicle requirements, annual revenue train-hours and car-miles); and
- DMU O&M cost estimates.

An additional analysis was conducted of a potential BRT service connecting Downtown Tampa to the Tampa International Airport using managed lanes planned for I-275. This analysis is discussed in a separate memo.

A. Alignment and Station Assumptions

Figure 1 shows the general alignment proposed, which utilizes existing freight rail tracks just south of Fowler Avenue near USF, through north Tampa and into Downtown. Two station scenarios were analyzed – a 'maximum" station scenario with 13 rail stations, and a "minimum" station scenario with eight stations. The proposed station assumptions are identified in Table 1.

Figure 1
General Alignment

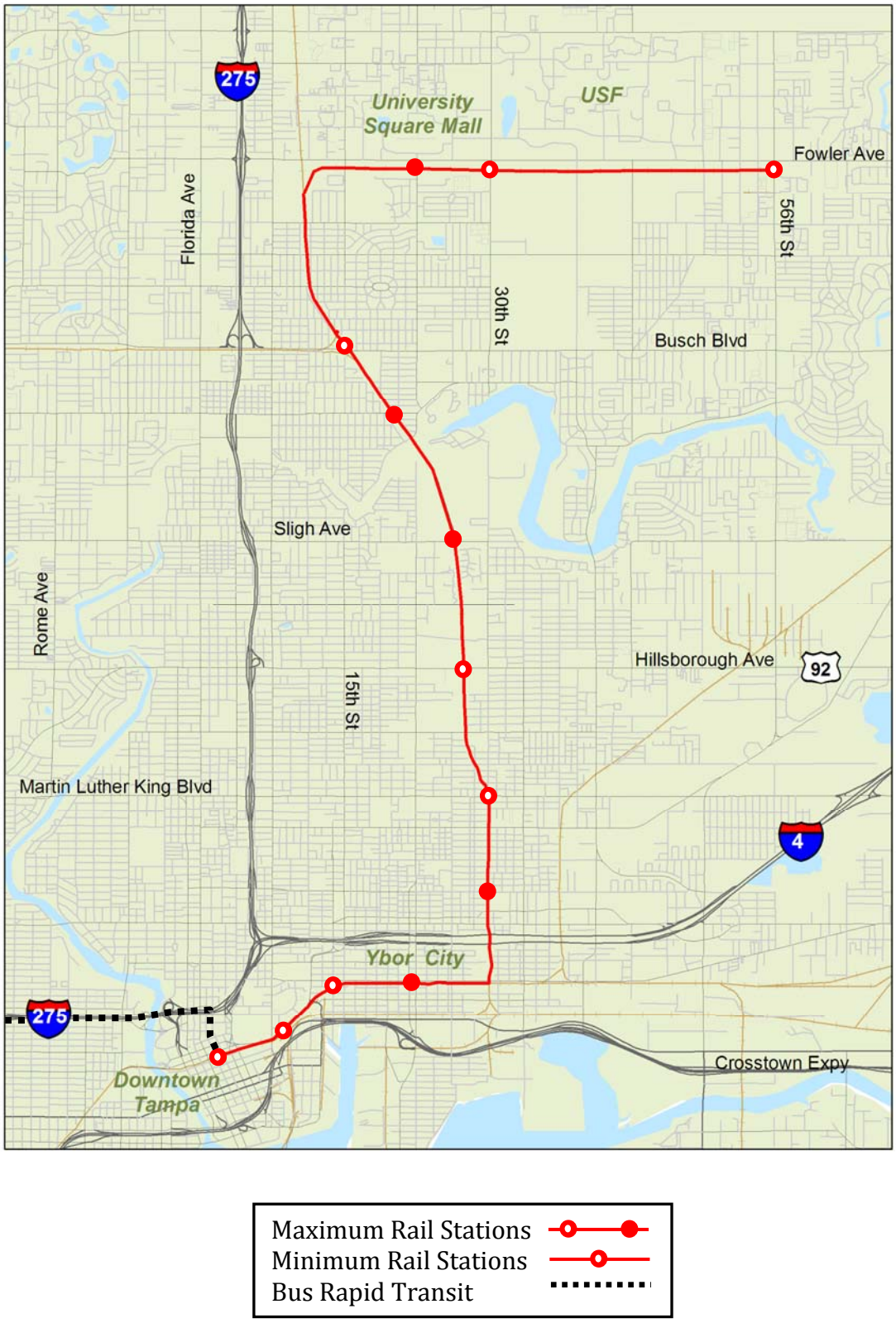


Table 1: Station Location Assumptions
Maximum vs. Minimum Station Scenarios

Station	Max. Station Scenario	Min. Station Scenario
56th Street (Temple Terrace)	X	X
30th Street	X	X
22nd Street	X	
Busch Blvd.	X	X
Waters Ave.	X	
Sligh Avenue	X	
Hillsborough Avenue	X	X
MLK Jr. Boulevard	X	X
21st Avenue	X	
21st/22nd Street	X	
14th Street (Streetcar connection)	X	X
Union Station/Amtrak	X	X
Marion Street	X	X

B. Vehicle Assumptions

A FRA-compliant DMU was assumed in this analysis; specifically the Stadler GTW 2/6 DMU used in Austin and Denton, Texas. Travel time estimates reflect acceleration/deceleration rates for the Stadler DMU of approximately 2.2 miles per hour per second (mphps) and 2.5 mphps respectively (a slightly lower deceleration rate than manufacturer specs was considered to account for typical operator reaction time).

C. Service Plan Scenarios

The following three service plan scenarios were defined for use in this analysis:

Table 2: Service Frequency Assumptions
Frequent vs. Reduced Service Scenarios

Day	Time Period	Hours	Frequent Service Scenario	Reduced Service Scenario	Minimum Service Scenario
Weekday	AM Peak	5:30-8:30 a.m.	15 min.	30 min.	60 min.
	Midday	8:30 a.m.-3:30 p.m.	30 min.	60 min.	60 min.
	PM Peak	3:30-6:30 p.m.	15 min.	30 min.	60 min.
	Evening	6:30-10:30 p.m.	60 min.	60 min.	60 min.
Saturday	Day	5:30 a.m.-6:30 p.m.	30 min.	60 min.	60 min.
	Evening	6:30-10:30 p.m.	60 min.	60 min.	60 min.
Sunday	Day	7:30 a.m.-6:30 p.m.	60 min.	60 min.	No Service
	Evening	6:30-8:30 p.m.	60 min.	No Service	No Service

D. Travel Time Estimates

The following information/assumptions were used to determine preliminary station-to-station travel time estimates:

- Stadler GTW 2/6 DMU acceleration/deceleration rates, as noted above in Section B of this memo;
- 45 mph maximum speeds assumed when trains are operating within dedicated railroad alignment, 25 mph maximum speeds when trains are operating in a street alignment (i.e., between Union Station/Amtrak and Marion Street Stations)
- 30 second average dwell times at all stations; and
- Traffic signal delays that average 20 seconds per signalized intersection between Union Station/Amtrak and Marion Street Stations.

Tables 3 and 4 present estimated travel times for the two station scenarios (maximum vs. minimum station scenarios) assuming a double track configuration. As noted in these tables, the minimum station scenario has an end-to-end travel time that is approximately 4.5 minutes faster than the maximum station scenario. Travel time estimates are based on imprecise measurements from aerials available on the internet. Typically, detailed plan and profile drawings are used to determine station and curve locations, and speed restrictions.

Travel time estimates for the single track configurations are presented on Tables 5 through 8. These estimates consider the maximum and minimum station scenarios, as well as 15- and 30-minute peak frequencies. The single track configuration with passing track will result in slightly slower train travel times, for trains will need to reduce speed through switches at passing track locations. For purposes of this analysis, an extra 15 seconds of travel time has been assumed at each end of a passing track section. Train meet locations were initially determined under the double track scenario to identify approximate locations where passing track may be required. Additional delay was then added at each of those locations. Additional travel time impacts are as follows:

<u>Maximum Station Scenarios</u>

1. Under the 15-minute peak period train scenario, an estimated two minutes of travel time is likely to be incurred (to accommodate 4 train meets).
2. Under the 30-minute peak period train scenario, an estimated one minute of travel time is likely to be incurred (to accommodate 2 train meets).
3. Under the 60-minute peak period train scenario, an estimated 30 seconds of travel time is likely to be incurred (to accommodate one train meet).

<u>Minimum Station Scenarios</u>

1. Under the 15-minute peak period train scenario, an estimated 1:30 minutes of travel time is likely to be incurred (to accommodate 3 train meets).
2. Under the 30-minute peak period train scenario, an estimated 30 seconds of travel time is likely to be incurred (to accommodate one train meet).
3. Under the 60-minute peak period train scenario, no additional travel time is needed to accommodate train meets, for only one train is required to be in operation under this scenario.

Table 3:
DMU Travel Time Estimate: Maximum Station Scenario
Double Track Configuration

Station	Max Spd. (mph)	Dist. Feet	Distance (miles) Incr.	Distance (miles) Total	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
56th Street/Temple Terrace				**0.00**			**0:00:00**	**0:00:00**
	45	10,100	1.91		0:02:54	0:00:00		
30th Street/USF				**1.91**			**0:00:30**	**0:03:24**
	45	3,310	0.63		0:01:02	0:00:00		
22nd Street				**2.54**			**0:00:30**	**0:04:56**
	45	3,050	0.58		0:00:59	0:00:00		
Start 30 mph Curve				3.12			0:00:00	0:05:55
	30	1,500	0.28		0:00:34	0:00:00		
End 30 mph Curve				3.40			0:00:00	0:06:29
	45	6,740	1.28		0:01:54	0:00:00		
Busch Boulevard				**4.68**			**0:00:30**	**0:08:53**
	45	3,430	0.65		0:01:13	0:00:00		
Waters Avenue				**5.33**			**0:00:30**	**0:10:36**
	45	5,640	1.07		0:01:47	0:00:00		
Sligh Avenue				**6.40**			**0:00:30**	**0:12:53**
	45	5,900	1.12		0:01:42	0:00:00		
Sligh Avenue				**7.51**			**0:00:30**	**0:15:05**
	45	4,780	0.91		0:01:34	0:00:00		
Martin Luther King Boulevard				**8.42**			**0:00:30**	**0:17:09**
	45	4,390	0.83		0:01:28	0:00:00		
21st Avenue				**9.25**			**0:00:30**	**0:19:07**
	45	3,450	0.65		0:01:07	0:00:00		
Start 20 mph Curve				9.90			0:00:00	0:20:14
	20	650	0.12		0:00:22	0:00:00		
End 20 mph Curve				10.03			0:00:00	0:20:36
	45	2,350	0.45		0:00:50	0:00:00		
21st & 22nd Streets				**10.47**			**0:00:30**	**0:21:56**
	30	2,800	0.53		0:01:17	0:00:00		
14th Street				**11.00**			**0:00:30**	**0:23:43**
	25	2,950	0.56		0:01:31	0:00:00		
Amtrak/Nebraska Avenue				**11.56**			**0:00:30**	**0:25:44**
	25	2,510	0.48		0:01:19	0:01:20		
Polk & Marion				**12.04**			**0:00:30**	**0:28:53**
TOTAL				**12.04**	**0:21:33**	**0:01:20**	**0:06:00** Avg Speed =	**0:28:53** **25.00**

Notes:

1. *Maximum 45 mph operating speed assumed in north Tampa.*
2. *Maximum 25 mph assumed in Downtown.*
3. *Delays assume 20 seconds per signalized intersection between Nebraska Ave. and Marion St. via Polk St.*

Table 4:
DMU Travel Time Estimate: Minimum Station Scenario
Double Track Configuration

Station	Max Spd. (mph)	Dist. Feet	Distance (miles) Incr.	Distance (miles) Total	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
56th Street/Temple Terrace				**0.00**			**0:00:00**	**0:00:00**
	45	10,100	1.91		0:02:54	0:00:00		
30th Street/USF				**1.91**			**0:00:30**	**0:03:24**
	45	6,360	1.20		0:01:49	0:00:00		
Start 30 mph Curve				3.12			0:00:00	0:05:13
	30	1,500	0.28		0:00:34	0:00:00		
End 30 mph Curve				3.40			0:00:00	0:05:47
	45	6,740	1.28		0:01:54	0:00:00		
Busch Boulevard				**4.68**			**0:00:30**	**0:08:11**
	45	14,970	2.84		0:04:08	0:00:00		
Hillsborough Avenue				**7.51**			**0:00:30**	**0:12:49**
	45	4,780	0.91		0:01:34	0:00:00		
Martin Luther King Boulevard				**8.42**			**0:00:30**	**0:14:53**
	45	7,840	1.48		0:02:14	0:00:00		
Start Curve				9.90			0:00:00	0:17:07
	20	650	0.12		0:00:22	0:00:00		
End Curve				10.03			0:00:00	0:17:29
	45	5,150	0.98		0:01:32	0:00:00		
14th Street				**11.00**			**0:00:30**	**0:19:31**
	25	2,950	0.56		0:01:31	0:00:00		
Amtrak/Nebraska Avenue				**11.56**			**0:00:30**	**0:21:32**
	25	2,510	0.48		0:01:19	0:01:20		
Polk & Marion				**12.04**			**0:00:30**	**0:24:41**
TOTAL				**12.04**	**0:19:51**	**0:01:20**	**0:03:30**	**0:24:41**
							Avg Speed =	**29.26**

Notes:

1. *Maximum 45 mph operating speed assumed in north Tampa.*
2. *Maximum 25 mph assumed in Downtown.*
3. *Delays assume 20 seconds per signalized intersection between Nebraska Ave. and Marion St. via Polk St.*

Table 5:
DMU Travel Time Estimate: Maximum Station Scenario
Single Track Configuration with 15-Minute Peak Frequencies
(Four Train Meets)

Station	Max Spd. (mph)	Dist. Feet	Distance (miles) Incr.	Distance (miles) Total	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
56th Street/Temple Terrace				**0.00**			**0:00:00**	**0:00:00**
	45	10,100	1.91		0:02:54	0:00:30		
30th Street/USF				**1.91**			**0:00:30**	**0:03:54**
	30	380	0.07		0:00:16	0:00:00		
Start Existing Siding				1.98			0:00:00	0:04:10
	45	1,630	0.31		0:00:27	0:00:00		
End Existing Siding				2.29			0:00:00	0:04:37
	45	1,300	0.25		0:00:29	0:00:00		
22nd Street				**2.54**			**0:00:30**	**0:05:36**
	45	3,050	0.58		0:00:59	0:00:00		
Start 30 mph Curve				3.12			0:00:00	0:06:35
	30	1,500	0.28		0:00:34	0:00:00		
End 30 mph Curve				3.40			0:00:00	0:07:09
	45	6,740	1.28		0:01:54	0:00:00		
Busch Boulevard				**4.68**			**0:00:30**	**0:09:33**
	30	500	0.09		0:00:18	0:00:15		
Start Existing Siding				4.77			0:00:00	0:10:06
	45	2,930	0.55		0:00:56	0:00:15		
Waters Avenue				**5.33**			**0:00:30**	**0:11:47**
	35	850	0.16		0:00:25	0:00:00		
End Existing Siding				5.49			0:00:00	0:12:12
	45	4,790	0.91		0:01:23	0:00:00		
Sligh Avenue				**6.40**			**0:00:30**	**0:14:05**
	45	3,620	0.69		0:01:07	0:00:00		
Start Existing Siding				7.08			0:00:00	0:15:12
	45	2,280	0.43		0:00:44	0:00:00		
Hillsborough Avenue				**7.51**			**0:00:30**	**0:16:26**
	45	1,630	0.31		0:00:37	0:00:00		
End Existing Siding				7.82			0:00:00	0:17:03
	45	3,150	0.60		0:00:57	0:00:15		
Martin Luther King Boulevard				**8.42**			**0:00:30**	**0:18:45**
	45	4,390	0.83		0:01:28	0:00:15		
21st Avenue				**9.25**			**0:00:30**	**0:20:58**
	45	3,450	0.65		0:01:07	0:00:00		
Start 20 mph Curve				9.90			0:00:00	0:22:05
	20	650	0.12		0:00:22	0:00:00		
End 20 mph Curve				10.03			0:00:00	0:22:27
	45	2,350	0.45		0:00:50	0:00:00		
21st & 22nd Streets				**10.47**			**0:00:30**	**0:23:47**
	30	2,800	0.53		0:01:17	0:00:00		
14th Street				**11.00**			**0:00:30**	**0:25:34**
	25	2,950	0.56		0:01:31	0:00:30		
Amtrak/Nebraska Avenue				**11.56**			**0:00:30**	**0:28:05**
	25	2,510	0.48		0:01:19	0:01:20		
Polk & Marion				**12.04**			**0:00:30**	**0:31:14**
TOTAL				**12.04**	**0:21:54**	**0:03:20**	**0:06:00**	**0:31:14**
							Avg Speed =	**23.12**

Notes:

1. *Maximum 45 mph operating speed assumed in north Tampa.*
2. *Maximum 25 mph assumed in Downtown.*
3. *Delays assume 20 seconds per signalized intersection between Nebraska Ave. and Marion St. via Polk St.*
4. *30-second delays assumed at siding location to reflect slwowing for track switches.*

Table 6:
DMU Travel Time Estimate: Maximum Station Scenario
Single Track Configuration with 30-Minute Peak Frequencies
(Two Train Meets)

Station	Max Spd. (mph)	Dist. Feet	Distance (miles) Incr.	Distance (miles) Total	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
56th Street/Temple Terrace				**0.00**			**0:00:00**	**0:00:00**
	45	10,100	1.91		0:02:54	0:00:00		
30th Street/USF				**1.91**			**0:00:30**	**0:03:24**
	30	380	0.07		0:00:16	0:00:00		
Start Existing Siding				1.98			0:00:00	0:03:40
	45	1,630	0.31		0:00:27	0:00:00		
End Existing Siding				2.29			0:00:00	0:04:07
	45	1,300	0.25		0:00:29	0:00:00		
22nd Street				**2.54**			**0:00:30**	**0:05:06**
	45	3,050	0.58		0:00:59	0:00:00		
Start 30 mph Curve				3.12			0:00:00	0:06:05
	30	1,500	0.28		0:00:34	0:00:00		
End 30 mph Curve				3.40			0:00:00	0:06:39
	45	6,740	1.28		0:01:54	0:00:00		
Busch Boulevard				**4.68**			**0:00:30**	**0:09:03**
	30	500	0.09		0:00:18	0:00:15		
Start Existing Siding				4.77			0:00:00	0:09:36
	45	2,930	0.55		0:00:56	0:00:00		
Waters Avenue				**5.33**			**0:00:30**	**0:11:02**
	35	850	0.16		0:00:25	0:00:00		
End Existing Siding				5.49			0:00:00	0:11:27
	45	4,790	0.91		0:01:23	0:00:15		
Sligh Avenue				**6.40**			**0:00:30**	**0:13:35**
	45	3,620	0.69		0:01:07	0:00:00		
Start Existing Siding				7.08			0:00:00	0:14:42
	45	2,280	0.43		0:00:44	0:00:00		
Hillsborough Avenue				**7.51**			**0:00:30**	**0:15:56**
	45	1,630	0.31		0:00:37	0:00:00		
End Existing Siding				7.82			0:00:00	0:16:33
	45	3,150	0.60		0:00:57	0:00:00		
Martin Luther King Boulevard				**8.42**			**0:00:30**	**0:18:00**
	45	4,390	0.83		0:01:28	0:00:00		
21st Avenue				**9.25**			**0:00:30**	**0:19:58**
	45	3,450	0.65		0:01:07	0:00:00		
Start 20 mph Curve				9.90			0:00:00	0:21:05
	20	650	0.12		0:00:22	0:00:00		
End 20 mph Curve				10.03			0:00:00	0:21:27
	45	2,350	0.45		0:00:50	0:00:00		
21st & 22nd Streets				**10.47**			**0:00:30**	**0:22:47**
	30	2,800	0.53		0:01:17	0:00:00		
14th Street				**11.00**			**0:00:30**	**0:24:34**
	25	2,950	0.56		0:01:31	0:00:30		
Amtrak/Nebraska Avenue				**11.56**			**0:00:30**	**0:27:05**
	25	2,510	0.48		0:01:19	0:01:20		
Polk & Marion				**12.04**			**0:00:30**	**0:30:14**
TOTAL				**12.04**	**0:21:54**	**0:02:20**	**0:06:00** Avg Speed =	**0:30:14** **23.89**

Notes:

1. *Maximum 45 mph operating speed assumed in north Tampa.*
2. *Maximum 25 mph assumed in Downtown.*
3. *Delays assume 20 seconds per signalized intersection between Nebraska Ave. and Marion St. via Polk St.*
4. *30-second delays assumed at siding location to reflect slwowing for track switches.*

Table 7:
DMU Travel Time Estimate: Minimum Station Scenario
Single Track Configuration with 15-Minute Peak Frequencies
(Three Train Meets)

Station	Max Spd. (mph)	Dist. Feet	Distance (miles) Incr.	Distance (miles) Total	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
56th Street/Temple Terrace				**0.00**			**0:00:00**	**0:00:00**
	45	10,100	1.91		0:02:54	0:00:00		
30th Street/USF				**1.91**			**0:00:30**	**0:03:24**
	30	380	0.07		0:00:16	0:00:30		
Start Existing Siding				1.98			0:00:00	0:04:10
	45	1,630	0.31		0:00:27	0:00:00		
End Existing Siding				2.29			0:00:00	0:04:37
	45	4,350	0.82		0:01:07	0:00:00		
Start 30 mph Curve				3.12			0:00:00	0:05:44
	30	1,500	0.28		0:00:34	0:00:00		
End 30 mph Curve				3.40			0:00:00	0:06:18
	45	6,740	1.28		0:01:54	0:00:00		
Busch Boulevard				**4.68**			**0:00:30**	**0:08:42**
	30	500	0.09		0:00:18	0:00:15		
Start Existing Siding				4.77			0:00:00	0:09:15
	45	3,780	0.72		0:01:00	0:00:00		
End Existing Siding				5.49			0:00:00	0:10:15
	45	8,410	1.59		0:02:07	0:00:15		
Start Existing Siding				7.08			0:00:00	0:12:37
	45	2,280	0.43		0:00:44	0:00:00		
Hillsborough Avenue				**7.51**			**0:00:30**	**0:13:51**
	45	1,630	0.31		0:00:37	0:00:00		
End Existing Siding				7.82			0:00:00	0:14:28
	45	3,150	0.60		0:00:57	0:00:00		
Martin Luther King Boulevard				**8.42**			**0:00:30**	**0:15:55**
	45	7,840	1.48		0:02:14	0:00:00		
Start 20 mph Curve				9.90			0:00:00	0:18:09
	20	650	0.12		0:00:22	0:00:00		
End 20 mph Curve				10.03			0:00:00	0:18:31
	45	5,150	0.98		0:01:32	0:00:00		
14th Street				**11.00**			**0:00:30**	**0:20:33**
	25	2,950	0.56		0:01:31	0:00:30		
Amtrak/Nebraska Avenue				**11.56**			**0:00:30**	**0:23:04**
	25	2,510	0.48		0:01:19	0:01:20		
Polk & Marion				**12.04**			**0:00:30**	**0:26:13**
TOTAL				**12.04**	**0:19:53**	**0:02:50**	**0:03:30**	**0:26:13**
							Avg Speed =	**27.55**

Notes:

1. *Maximum 45 mph operating speed assumed in north Tampa.*
2. *Maximum 25 mph assumed in Downtown.*
3. *Delays assume 20 seconds per signalized intersection between Nebraska Ave. and Marion St. via Polk St.*
4. *30-second delays assumed at siding location to reflect slwowing for track switches.*
5. *Double-track configuration at 56th Street Station.*

Table 8:
DMU Travel Time Estimate: Minimum Station Scenario
Single Track Configuration with 30-Minute Peak Frequencies
(One Train Meet)

Station	Max Spd. (mph)	Dist. Feet	Distance (miles) Incr.	Distance (miles) Total	Run Time (hr:min:sec)	Delay Time (hr:min:sec)	Dwell Time (hr:min:sec)	Total Time (hr:min:sec)
56th Street/Temple Terrace				**0.00**			**0:00:00**	**0:00:00**
	45	10,100	1.91		0:02:54	0:00:00		
30th Street/USF				**1.91**			**0:00:30**	**0:03:24**
	30	380	0.07		0:00:16	0:00:00		
Start Existing Siding				1.98			0:00:00	0:03:40
	45	1,630	0.31		0:00:27	0:00:00		
End Existing Siding				2.29			0:00:00	0:04:07
	45	4,350	0.82		0:01:07	0:00:00		
Start 30 mph Curve				3.12			0:00:00	0:05:14
	30	1,500	0.28		0:00:34	0:00:00		
End 30 mph Curve				3.40			0:00:00	0:05:48
	45	6,740	1.28		0:01:54	0:00:00		
Busch Boulevard				**4.68**			**0:00:30**	**0:08:12**
	30	500	0.09		0:00:18	0:00:00		
Start Existing Siding				4.77			0:00:00	0:08:30
	45	3,780	0.72		0:01:00	0:00:00		
End Existing Siding				5.49			0:00:00	0:09:30
	45	8,410	1.59		0:02:07	0:00:15		
Start Existing Siding				7.08			0:00:00	0:11:52
	45	2,280	0.43		0:00:44	0:00:00		
Hillsborough Avenue				**7.51**			**0:00:30**	**0:13:06**
	45	1,630	0.31		0:00:37	0:00:00		
End Existing Siding				7.82			0:00:00	0:13:43
	45	3,150	0.60		0:00:57	0:00:15		
Martin Luther King Boulevard				**8.42**			**0:00:30**	**0:15:25**
	45	7,840	1.48		0:02:14	0:00:00		
Start 20 mph Curve				9.90			0:00:00	0:17:39
	20	650	0.12		0:00:22	0:00:00		
End 20 mph Curve				10.03			0:00:00	0:18:01
	45	5,150	0.98		0:01:32	0:00:00		
14th Street				**11.00**			**0:00:30**	**0:20:03**
	25	2,950	0.56		0:01:31	0:00:00		
Amtrak/Nebraska Avenue				**11.56**			**0:00:30**	**0:22:04**
	25	2,510	0.48		0:01:19	0:01:20		
Polk & Marion				**12.04**			**0:00:30**	**0:25:13**
TOTAL				**12.04**	**0:19:53**	**0:01:50**	**0:03:30** Avg Speed =	**0:25:13** **28.64**

Notes:

1. *Maximum 45 mph operating speed assumed in north Tampa.*
2. *Maximum 25 mph assumed in Downtown.*
3. *Delays assume 20 seconds per signalized intersection between Nebraska Ave. and Marion St. via Polk St.*
4. *30-second delays assumed at siding location to reflect slwowing for track switches.*
5. *Double-track configuration at 56th Street Station.*

E. Single vs. Double Track Operations

As noted in the above tables, should the full alignment be double tracked, the estimated one-way travel time is approximately 28:53 minutes for the maximum station scenario and approximately 24:41 for the minimum station scenario. Proposed train cycle times (round trip times) and train requirements for each station scenario under a double track configuration are as follows:

Double Track: Maximum Station Scenarios

1. Under the 15-minute peak period service scenario, 75-minute peak period and 90-minute midday cycle times are proposed, resulting in 5 peak period/3 midday period trains in operation.
2. Under the 30-minute peak period service scenario, 90-minute peak period and 120-minute midday cycle times are proposed, resulting in 3 peak period/2 midday period trains in operation.
3. Under the 60-minute all-day service scenario, two trains are required to be in operation during all time periods, resulting in a 120-minute cycle time..

Double Track: Minimum Station Scenarios

1. Under the 15-minute peak period service scenario, 60-minute peak period and midday cycle times are proposed, resulting in 4 peak period/2 midday period trains in operation.
2. Under the 30-minute peak period service scenario, 60-minute peak period and midday cycle times are proposed, resulting in 2 peak period and midday period trains in operation.
3. Under the 60-minute all-day service scenario, one train is required to be in operation during all time periods, resulting in a 60-minute cycle time.

As noted in Section D of this memo, slightly longer train travel times are anticipated under a single track configuration because trains must reduce speed through switches at the beginning and end of each passing track section. Single track travel time estimates for the 15 and 30-minute peak period service frequency scenarios appear in the appendix (Tables A1 through A4).

Train schedules were developed for the 15-minute and 30-minute scenarios to determine approximate train meet locations where passing track is required to accommodate those train meet locations (schedules were not developed for the 60-minute service scenario, for there is only one train meet under the maximum station scenario and no train meets under the minimum station scenario). Layover times at each end-of-line were adjusted as necessary to avoid a train meet in downtown Tampa (i.e., west of the Union Station/Amtrak station), with an attempt to achieve train meets where existing railroad track sidings exists. The proposed DMU alignment has three existing track sidings. String line diagrams were created to illustrate locations of train meets, and are presented in Figures 2 through 5. Following are findings of this analysis.

Single Track: Maximum Station Scenarios

1. Under the 15-minute peak period service scenario, 75-minute peak period and 90-minute midday period cycle times are recommended, resulting in 5 peak period/3 midday period trains in operation. In the peak period, this provides for 7-minutes of dwell/layover at Marion and 7-minutes of dwell/layover at 56th Street (i.e., 19% of total cycle time). Train meets occur at the following locations:

- Between the Amtrak and 14th Street stations
- Between the 21st Avenue and MLK Blvd. Stations
- Just south of the Waters Avenue station
- Between the 22nd Street and 30th Street stations

Passing track recommendations for this scenario are as follows:

- Between the Amtrak and 14th Street stations
- Between the 21st Avenue and MLK Blvd. stations
- Extend the existing siding at Waters Avenue station south (approximately ½ mile south of the existing siding)
- Extend the existing siding between 22nd Street and 30th

In addition, a double track station configuration is required at 56th Street for end-of-line train operations.

2. Under the 30-minute peak period service scenario, 90-minute peak period and 120-minute midday period cycle times are recommended, resulting in 3 peak period/2 midday period trains in operation. In the peak period, 20 minutes of layover time is proposed at Marion Station, with about 11 minutes of layover at 56th Street. Resulting train meet locations are as follows:
   - Between the Amtrak and 14th Street stations
   - Between the Waters Avenue and Busch Blvd. Stations

   Passing track recommendations for this scenario are as follows:
   - Between the Amtrak and 14th Street stations
   - Utilize the existing siding that begins south of Waters Avenue and ends at Busch Blvd. station

   In addition, a double track station configuration is required at 56th Street for end-of-line train operations.

<u>Single Track: Minimum Station Scenarios</u>

1. Under the 15-minute peak period service scenario, 75-minute peak period and 90-minute midday period cycle times are recommended, resulting in 5 peak period/3 midday period trains in operation. In the peak period, this provides for 7 minutes of dwell/layover at Marion and 17.5 minutes of dwell/layover at 56th Street. Train meets occur at the following locations:
   - Between the Amtrak and 14th Street stations
   - Between the MLK Blvd. and Hillsborough stations
   - North of the Busch Blvd. station

   Passing track recommendations for this scenario are as follows:
   - Between the Amtrak and 14th Street stations
   - Extend the existing siding south of Hillsborough Station to the MLK Blvd. Station
   - Extend the existing siding from Busch Blvd. north to cover the anticipated train meet at this location; 1.25-mile extension is proposed

   In addition, a double track station configuration is required at 56th Street for end-of-line train operations.

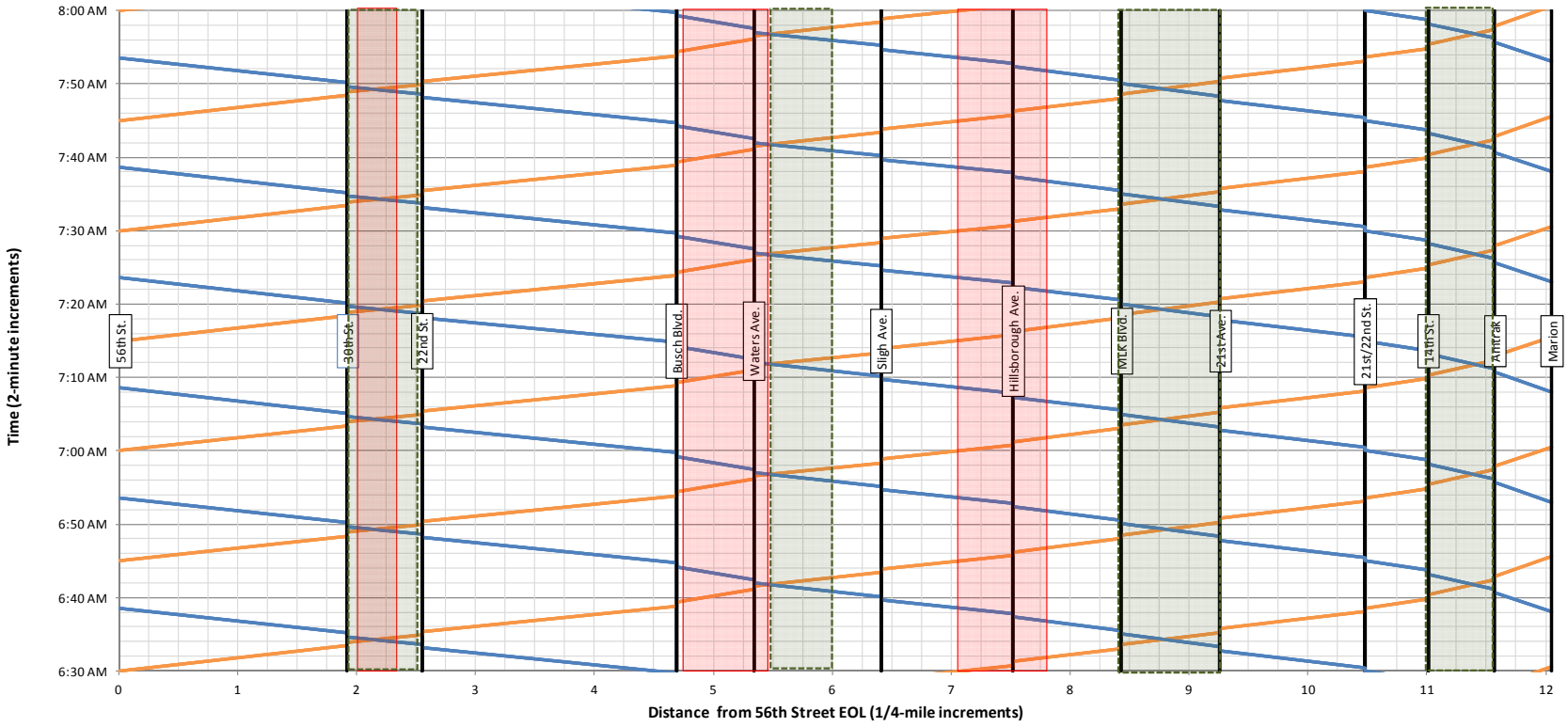
2. Under the 30-minute peak period service scenario, 60-minute peak period and 60-minute midday period cycle times are recommended, resulting in 2 peak period/1 midday period trains in operation. In the peak period, 6 minutes of layover is proposed at Marion Station, with 5.5 minutes of layover at 56th Street. There is one train meet in this scenario – at the Hillsborough station. A siding already exists at this location. Therefore, no additional passing track is needed. However, a double track station configuration is required at 56th Street for end-of-line train operations.

As previously noted, the string line diagrams appearing in Figures 2 through 5 illustrate peak period train meets under the various station and service frequency scenarios. Orange lines are read left to right and represent southbound trains to Downtown Tampa. Blue lines are read right to left and represent northbound trains to 56th Street. Locations where the Orange and Blue lines cross represent train meet locations. Areas shaded as light red identify locations of existing sidings. Areas shaded in green identify locations where additional passing track is proposed. Table 9 summarizes cycle times, train requirements, train meets and passing track requirements for each scenario. Note that passing track requirements do not take into consideration the condition of existing sidings that are used to accommodate train meet locations. It is possible some existing sidings may require track replacement to accommodate passenger rail operations.

F. Service Requirements

Peak/fleet rail car requirements were estimated by assuming 2-car trains and a 20 percent spare ratio. Annual revenue train-hours and car-miles were calculated based on the service plans presented in Section C of this memo and train requirements as presented in Section E. Tables 10 and 11 present rail operating plans and statistics for each DMU operating scenario.

Figure 3:
String Line Diagram for Single Track Operations
Maximum Station Scenario – 15-minute Peak Frequencies



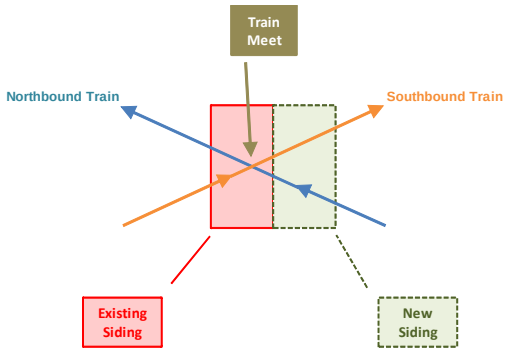
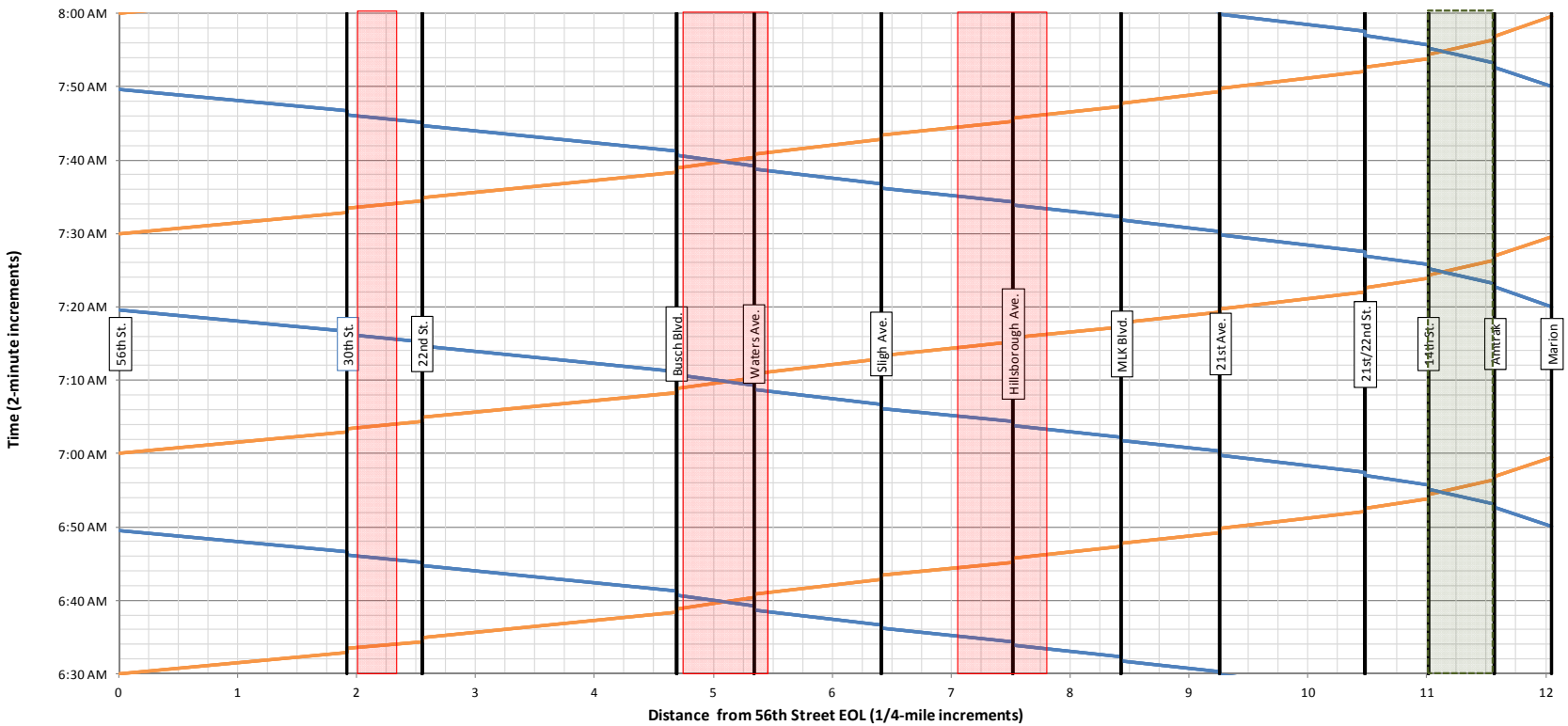


Figure 4:
String Line Diagram for Single Track Operations
Maximum Station Scenario – 30-minute Peak Frequencies



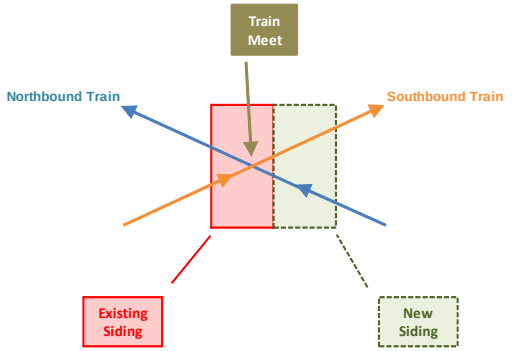
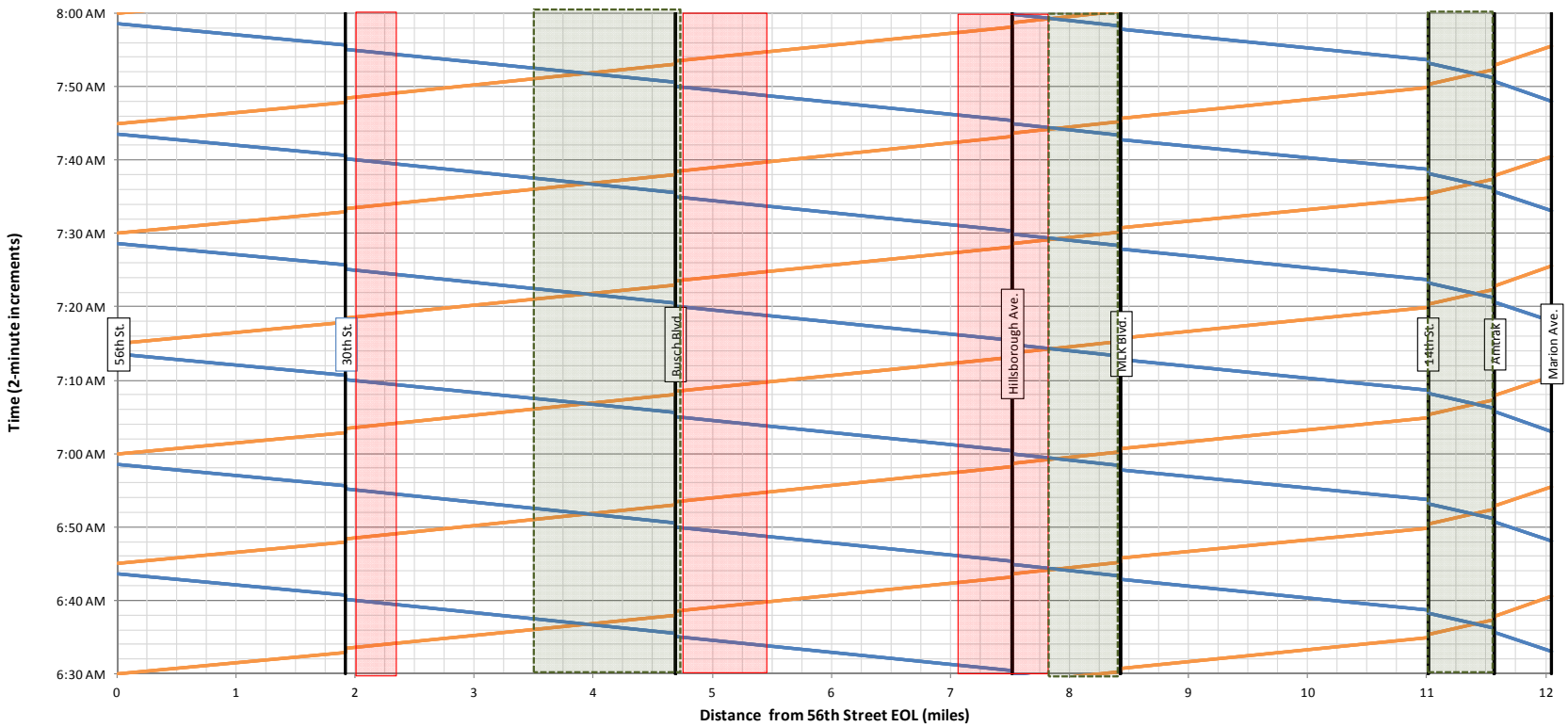


Figure 5:
String Line Diagram for Single Track Operations
Minimum Station Scenario – 15-minute Peak Frequencies



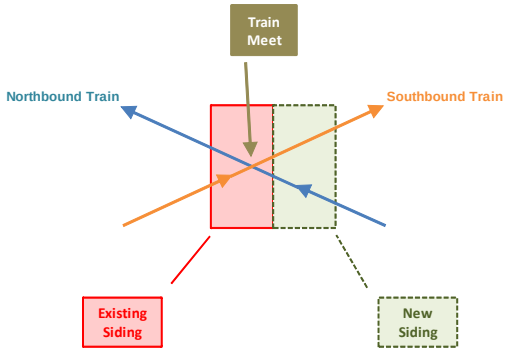
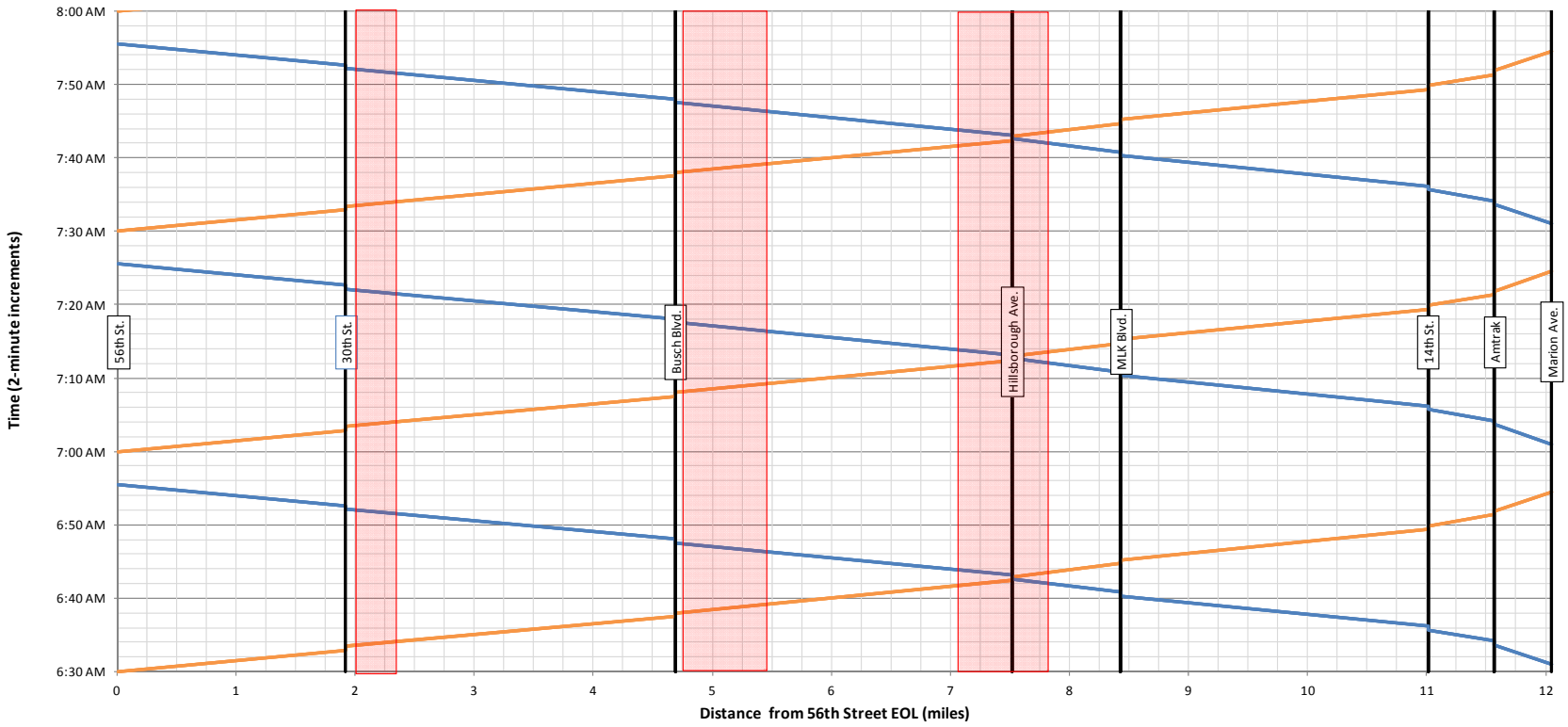


Figure 6:
String Line Diagram for Single Track Operations
Minimum Station Scenario – 30-minute Peak Frequencies



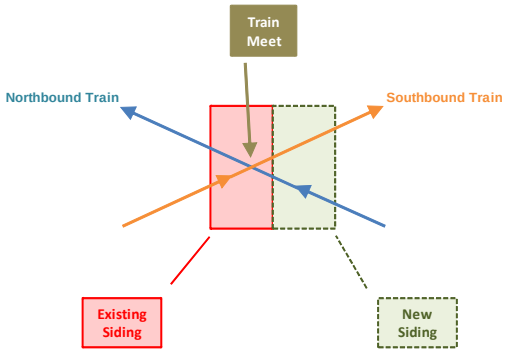


Table 9:
Summary of Travel Time Estimates, Train and Passing Track Requirements

Station Scenario	Characteristic	15/30 Frequency		30/60 Frequency		60/60 Frequency	
		Double Track	Single Track	Double Track	Single Track	Double Track	Single Track
Maximum Station Scenarios	One-Way Travel Time	29:02	31:02	29:02	30:02	29:02	29:32
	Peak Cycle Time	75 min.	75 min.	90 min.	90 min.	120 min.	120 min.
	Peak Train Req.	5 trains	5 trains	3 trains	3 trains	2 trains	2 trains
	Midday Cycle Time	90 min.	90 min.	120 min.	120 min.	120 min.	120 min.
	Midday Train Req.	3 trains	3 trains	2 trains	2 trains	2 trains	2 trains
	Peak Period Train Meets	n/a	4	n/a	2	n/a	1
	Add'l Pass. Track Req'd.	n/a	2.25 miles	n/a	0.75 miles	n/a	0 miles
Minimum Station Scenarios	One-Way Travel Time	24:31	26:01	24:31	25:01	24:31	24:31
	Peak Cycle Time	60	75 min.	60 min.	60 min.	60 min.	60 min.
	Peak Train Req.	4 trains	5 trains	2 trains	2 trains	1 train	1 train
	Midday Cycle Time	60 min.	90 min.	60 min.	60 min.	60 min.	60 min.
	Midday Train Req.	2 trains	3 trains	1 train	1 train	1 train	1 train
	Peak Period Train Meets	n/a	3	n/a	1	n/a	0
	Add'l Pass. Track Req'd.	n/a	2.5 miles	n/a	0 miles	n/a	0 miles

Note: Additional passing track required is approximate and does not take into consideration potential need to replace existing sidings.

Table 10:
Train Operating Plan and Requirements for Maximum Station Scenarios

Scenario	Run Time (minutes)	Distance (miles)	Headway				Consist			Vehicles		Daily		Annual		Daily Trains		
			Day	Peak	Base	Eve	Peak	Base	Eve	Peak	Total	Car-Miles	Train-Hrs	Car-Miles	Train-Hrs	Peak	Base	Eve
Full Double Track	29.0	12.04	M-F	15	30	60	2.0	2.0	2.0	10	12	2,022.8	59.0	513,800	14,990	5	3	2
15 peak/30 midday			Sat	30	30	60	2.0	2.0	2.0			1,445.1	39.0	73,700	1,990	3	3	0
			Sun	60	60	60	2.0	2.0	2.0			626.7	22.0	37,600	1,320	2	2	0
ESTIMATED TOTALS:										**10**	**12**			**625,100**	**18,300**	**5**	**3**	**2**
Full Double Track	29.0	12.04	M-F	30	60	60	2.0	2.0	2.0	6	8	1,107.9	40.0	281,400	10,160	3	2	2
30 peak/60 midday			Sat	60	60	60	2.0	2.0	2.0			819.6	26.1	41,800	1,330	2	2	0
			Sun	60	60	0	2.0	2.0	0.0			530.0	22.0	31,800	1,320	2	2	0
ESTIMATED TOTALS:										**6**	**8**			**355,000**	**12,810**	**3**	**2**	**2**
Full Double Track	29.0	12.04	M-F	60	60	0	2.0	2.0	2.0	4	5	626.0	26.0	159,000	6,600	2	2	0
60 peak/60 midday			Sat	60	60	0	2.0	2.0	2.0			625.5	26.1	31,900	1,330	2	2	0
			Sun	60	60	0	2.0	2.0	0.0			530.0	22.0	31,800	1,320	2	2	0
ESTIMATED TOTALS:										**4**	**5**			**222,700**	**9,250**	**2**	**2**	**0**
Single Track With Sidings	31.0	12.04	M-F	15	30	60	2.0	2.0	2.0	10	12	2,022.8	59.0	513,800	14,990	5	3	2
15 peak/30 midday			Sat	30	30	60	2.0	2.0	2.0			1,445.1	39.0	73,700	1,990	3	3	0
			Sun	60	60	60	2.0	2.0	2.0			626.7	22.0	37,600	1,320	2	2	0
ESTIMATED TOTALS:										**10**	**12**			**625,100**	**18,300**	**5**	**3**	**2**
Single Track With Sidings	30.0	12.04	M-F	30	60	60	2.0	2.0	2.0	6	8	1,107.9	40.0	281,400	10,160	3	2	2
30 peak/60 midday			Sat	60	60	60	2.0	2.0	2.0			819.6	26.1	41,800	1,330	2	2	0
			Sun	60	60	0	2.0	2.0	0.0			530.0	22.0	31,800	1,320	2	2	0
ESTIMATED TOTALS:										**6**	**8**			**355,000**	**12,810**	**3**	**2**	**2**
Single Track With Sidings	29.5	12.04	M-F	60	60	0	2.0	2.0	2.0	4	5	626.0	26.0	159,000	6,600	2	2	0
60 peak/60 midday			Sat	60	60	0	2.0	2.0	2.0			625.5	26.1	31,900	1,330	2	2	0
			Sun	60	60	0	2.0	2.0	0.0			530.0	22.0	31,800	1,320	2	2	0
ESTIMATED TOTALS:										**4**	**5**			**222,700**	**9,250**	**2**	**2**	**0**

Table 11:
Train Operating Plan and Requirements for Minimum Station Scenarios

Scenario	Run Time (minutes)	Distance (miles)	Headway				Consist			Vehicles		Daily		Annual		Daily Trains		
			Day	Peak	Base	Eve	Peak	Base	Eve	Peak	Total	Car-Miles	Train-Hrs	Car-Miles	Train-Hrs	Peak	Base	Eve
Full Double Track	24.5	12.04	M-F	15	30	60	2.0	2.0	2.0	8	10	2,022.8	42.0	513,800	10,670	4	2	1
15 peak/30 midday			Sat	30	30	60	2.0	2.0	2.0			1,445.1	26.1	73,700	1,330	2	2	0
			Sun	60	60	60	2.0	2.0	2.0			626.7	11.0	37,600	660	1	1	0
ESTIMATED TOTALS:										**8**	**10**			**625,100**	**12,660**	**4**	**2**	**1**
Full Double Track	24.5	12.04	M-F	30	60	60	2.0	2.0	2.0	4	5	1,107.9	23.0	281,400	5,840	2	1	1
30 peak/60 midday			Sat	60	60	60	2.0	2.0	2.0			819.6	12.9	41,800	660	1	1	0
			Sun	60	60	0	2.0	2.0	0.0			530.0	11.0	31,800	660	1	1	0
ESTIMATED TOTALS:										**4**	**5**			**355,000**	**7,160**	**2**	**1**	**1**
Full Double Track	24.5	12.04	M-F	60	60	0	2.0	2.0	2.0	2	3	626.0	13.0	159,000	3,300	1	1	0
60 peak/60 midday			Sat	60	60	0	2.0	2.0	2.0			625.5	12.9	31,900	660	1	1	0
			Sun	60	60	0	2.0	2.0	0.0			530.0	11.0	31,800	660	1	1	0
ESTIMATED TOTALS:										**2**	**3**			**222,700**	**4,620**	**1**	**1**	**0**
Single Track With Sidings	26.0	12.04	M-F	15	30	60	2.0	2.0	2.0	10	12	2,022.8	59.0	513,800	14,990	5	3	2
15 peak/30 midday			Sat	30	30	60	2.0	2.0	2.0			1,445.1	39.0	73,700	1,990	3	3	0
			Sun	60	60	60	2.0	2.0	2.0			626.7	22.0	37,600	1,320	2	2	0
ESTIMATED TOTALS:										**10**	**12**			**625,100**	**18,300**	**5**	**3**	**2**
Single Track With Sidings	25.0	12.04	M-F	30	60	60	2.0	2.0	2.0	4	5	1,107.9	23.0	281,400	5,840	2	1	1
30 peak/60 midday			Sat	60	60	60	2.0	2.0	2.0			819.6	12.9	41,800	660	1	1	0
			Sun	60	60	0	2.0	2.0	0.0			530.0	11.0	31,800	660	1	1	0
ESTIMATED TOTALS:										**4**	**5**			**355,000**	**7,160**	**2**	**1**	**1**
Single Track With Sidings	24.5	12.04	M-F	60	60	0	2.0	2.0	2.0	2	3	626.0	13.0	159,000	3,300	1	1	0
60 peak/60 midday			Sat	60	60	0	2.0	2.0	2.0			625.5	12.9	31,900	660	1	1	0
			Sun	60	60	0	2.0	2.0	0.0			530.0	11.0	31,800	660	1	1	0
ESTIMATED TOTALS:										**2**	**3**			**222,700**	**4,620**	**1**	**1**	**0**

G. Annual O&M Cost Estimates

There are presently few DMU operations with FRA-compliant vehicles in the U.S. Thus, cost data available for estimating potential O&M costs for a Hillsborough DMU operation is limited. For purposes of this conceptual analysis, we reviewed cost data that is available for the A-Train, operated by the Denton County Transportation Authority (DCTA). The A-Train provides FRA-compliant DMU service between Denton and Carrollton, north of Dallas. The south end of the alignment (in Carrollton) connects with DART's LRT Green Line. The A-Train has a 21-mile alignment with five stations, and operates with eight vehicles (four 2-car trains). Peak period frequencies are approximately 25 minutes. Midday service is provided through a midday shuttle bus. Train service is also provided on Saturdays. Estimated FY 2013 annual revenue train-hours are 11,258. The A-Train presently operates with RDC Budd rail diesel cars (former TRE rail cars). Beginning this fall, Stadler GTW 2/6 DMU's will be used for A-Train service. Herzog Transit Services operates the A-Train service, along with TRE commuter rail service between Dallas and Fort Worth. Herzog's operation of both services provides for some cost savings for certain expenses (e.g., dispatching, insurance premiums).

DCTA's proposed FY 2013 operating budget (when the Stadler vehicles will be in operation) is approximately $10.4 million (in 2012 dollars). This equates to approximately $920 per revenue train-hour. However, this budget amount is strictly for train service-related expenses. Other general administrative expenses will also be incurred with the introduction of DMU service in Tampa, such as marketing, customer service functions, etc. HART's 2010 expenses, as reported in National Transit Database (NTD) was reviewed to determine the percentage of HART's expenses that are related to G&A expenditures for its fixed route bus services. This percentage was calculated to be approximately 33 percent of non G&A expenditures (not including insurance costs, which are already accounted for in the DCTA cost figures). It is not likely that introduction of DMU service would require this full level of G&A expenditures. For purposes of this paper, a 20 percent G&A expenditure factor was added to the DCTA-derived rate of $920 per revenue train-hour, resulting in a rate of approximately $1,100 per revenue train-hour. Using NTD information for select systems as a comparison, LRT operating expenditures typically range from $350 to $550 per revenue train-hour. Commuter rail operating expenditures can range from $1,300 to $3,900 per revenue train-hour.

Using the rate of $1,100 per revenue train-hour, potential O&M cost expenses for the various DMU scenarios presented in this memo are presented in Table 12.

H. Alternative Operating Plan Scenarios

This memo presents three different service frequency scenarios (15, 30 and 60-minute peak period service), for two different station scenarios (maximum vs. minimum station), and two different track configurations (double track vs. single track with sidings). Another possible scenario is skip stop service. For example, the 15-minute maximum station scenario could operate with two different operating patterns (i.e., A and B patterns), with each pattern stopping at different stations. This would provide a quicker travel time for the rider, but at the expense of less frequent service at rail stations. A skip stop scenario is only achievable with a double track configuration. Skip stop operations under a single rack configuration would create additional and inconsistent train meet locations, resulting in the need for significantly more sidings, thus negating the capital cost benefits of single track operations.

Table 12:
Potential O&M Cost Estimates for DMU Scenarios (2012 dollars)

Scenario	Track	Frequency	Stations	Annual Rev. Train-Hrs.	Potential Annual O&M$
1	Double	15 peak/ 30 midday	13	18,300	$20.1 million
2			8	12,660	$13.9 million
3		30 peak/ 60 midday	13	12,810	$14.1 million
4			8	7,160	$7.9 million
5		60 peak/ 60 midday	13	9,250	$10.2 million
6			8	4,620	$5.1 million
7	Single w/ Sidings	15 peak/ 30 midday	13	18,300	$20.1 million
8			8	18,300	$20.1 million
9		30 peak/ 60 midday	13	12,810	$14.1 million
10			8	7,160	$7.9 million
11		60 peak/ 60 midday	13	9,250	$10.2 million
12			8	4,620	$5.1 million