LTK Engineering Services

Future of FrontRunner
Final Report

Prepared for
UTA

by
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In association with
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0 Revision History

Revision No.	Date	Description of Revision
0	12/21/2017	Initial Release with Baseline Simulation
1	2/8/2018	Future Baseline with PTC Simulation Results
2	4/23/2018	Future Low Investment Scenarios Simulation Results
3	9/14/2018	Added Future Medium, High, and High with Infill Scenarios Simulation Results, incorporated Fehr & Peers tech memos, added Executive Summary
4	9/28/2018	Addressed LTK internal review comments, Fehr & Peers review comments, UTA Planning and UTA FrontRunner management.

1 Executive Summary

The Future of FrontRunner Study is a long-range look at the UTA's FrontRunner commuter rail service. The operation of today's FrontRunner service on the largely single-track system results in poor reliability, limited frequencies, and slow speeds that do not allow service to compete effectively with automobile travel. Modifications to FrontRunner's train control system in order to comply with federal Positive Train Control (PTC) requirements will further challenge reliability. A constrained funding environment means that additional track must be built in phases with capital investments carefully planned to support the ability of FrontRunner to be fully double tracked and electrified in the future.

The purpose of this study, therefore, is to evaluate a broad range of FrontRunner improvement and expansion scenarios and use the results to identify the most effective scenario in terms of affordability, improved reliability, faster travel times, and additional service or a combination of incremental investments. Additional service includes improved frequencies on the core systems between Provo, Salt Lake City, and Ogden as well as extension of service to Payson/Santaquin on the south and Brigham City on the north.

This report presents the overall results of the study, including ridership modeling, operations analysis/simulation modeling, double track feasibility, and capital cost estimates, including both fleet and rail infrastructure. The study's ridership analysis includes projections of future ridership in 2050 under four separate investment scenarios as well as investigation of the ridership potential of Sunday service and ridership sensitivity to reliability issues.

LTK applied its TrainOps® simulation software to the FrontRunner operations analysis. TrainOps is a modern generation operations simulation tool developed and enhanced by LTK over the last 15 years; it has been applied to more than 20 commuter rail operations across North America. This report documents the calibration of the TrainOps simulation model to existing FrontRunner operations and presents the results of six simulation scenarios:

- Baseline (calibration) simulation reflecting operations prior to implementation of PTC
- Future Baseline with PTC Scenario
- Low Investment Scenario
- Medium Investment Scenario
- High Investment Scenario
- High Investment Scenario with Infill Stations

The calibration process ensures accurate modeling of train performance, UTA dispatching, and system reliability. The calibrated baseline simulation, after being accepted by the UTA, has been modified to include committed projects (including PTC) to create a future baseline model. Due to the extended simulated trip times caused by PTC, it was necessary to add an additional train set to the future FrontRunner schedule for the Future Baseline with PTC Scenario. FrontRunner's "real world" experience with PTC resulted in the same operating challenges and the actual operating plan was modified to include an additional peak trainset as well.

The Future Baseline model is used as a comparison tool for evaluating future investment scenarios coupled with potential increases in FrontRunner service frequencies. Some of the future investment scenarios also include electrification, which will require a new FrontRunner fleet and offer the prospect of higher operating speeds/reduced trip times. All of the future scenarios include one or more service extensions, one or more infill stations on the existing core network, and expansion of some existing single-track segments to double-track.

The calibrated baseline model is designed to replicate FrontRunner's recent on-time performance (OTP) experience. This requires the introduction of multiple operating challenges ("perturbations") each day in the simulation model. The simulation model responds to these perturbations by shifting meets to alternative locations, shortening terminal turn times, and other strategies to return the operation to full schedule adherence. These perturbations have been carried forth in all future models so that the benefits of potential investment scenarios in terms of making FrontRunner more resilient to perturbations are quantified in the form of improved OTP.

Table 1 summarizes the attributes of the five Future of FrontRunner scenarios that reflect future operations.

Table 1 – Summary of Future of FrontRunner Scenarios

	Standard Train Consist	Peak Trains Required (Excluding Spares)	Additional Miles of Double Track Ogden-Provo	Additional Miles of Track (Extensions)	Peak / Off-Peak Headways
Future Baseline with PTC	Loco + Single Level Coach + 3 Bi-Levels	10	0	0	30/60
2050 Low Investment	Loco + 5 Bi-Levels	11	10	17 (Provo–Payson)	30/60
2050 Medium Investment	Loco + 6 Bi-Levels	22	46	17 (Provo–Payson)	15/30
2050 High Investment	8-Car EMU Diesel Shuttle	20 2	34	17 (Provo–Payson)	15/30
2050 High Investment w/ Infill Stations	8-Car EMU Diesel Shuttle	20 4	34	42 (Provo–Santaquin, Ogden–Brigham City)	15/30

The scenarios were defined early in the study to quantify ridership and operational performance benefits of specific FrontRunner improvements, such as doubling the frequency of service as well as upgrading the system to operate with high-performance Electric Multiple Unit (EMU) trains. The number of scenarios was necessarily limited, so not all improvements are individually tested. In terms of infill stations, for example, the ridership attracted to new stations at Vineyard, Bluffdale, Centerville, and Sunset is included in certain study scenarios. However, the introduction of each new station is coupled with other FrontRunner investments and not tested individually in terms of ridership projections or FrontRunner operational performance.

Table 2 – Future of FrontRunner Scenario Characteristics

Scenario and Concept	Positive Train Control	Vineyard Station	Bluffdale Station	Centerville Station	Sunset Station	Ogden BDO Station	Payson Extension	Santaquin Extension	Brigham City Extension	15 Minute Headways	Electrification
Future PTC Baseline • Existing conditions plus Positive Train Control	X										
2030 Low Investment Scenario • Adds double track to help with reliability issues	X	X					X				
2050 Medium Investment Scenario • Adds double track to allow 15 minute headways • Continues diesel operations	X	X					X			X	
2050 High Investment Scenario • Adds double track to allow 15 minute headways • Electrified system, more travel time savings	X	X					X			X	X
2050 High Investment Scenario with Infill Stations • Adds double track to allow 15 minute headways • Electrified system • More stations, may limit travel time savings	X	X	X	X	X	X	X	X	X	X	X

The five study scenarios all maintain the present 79 MPH maximum operating speed and at least some single-track operation. Three of the scenarios have peak service levels of 4 trains per hour per direction in the single track. While there is no doubt that elimination of all single-track segments would improve reliability, electrified commuter rail operations in Denver (Airport Line and soon-to-open Golden Line) and Philadelphia (SEPTA West Trenton Line) operate 4 trains per hour per direction with multiple single-track segments.

However, the study did perform a sensitivity test of the travel time, fleet requirements, and capacity benefits of full double track on FrontRunner coupled with higher speed (90 MPH) operation. Figure 1-1 summarizes the Provo–Ogden simulated peak travel times for the five Future of FrontRunner future scenarios as well as the Full Double Track sensitivity test (which was run without additional infill stations so is most comparable to the High Investment Scenario). As shown in the figure, end-to-end corridor travel time using Full Double Track is approximately 27 minutes shorter than in the High Investment Scenario. Of this time savings, 3 minutes are attributable to operating speeds higher than 79 MPH and 24 minutes are attributable to elimination of all train "meets" (use of passing sidings) on FrontRunner. This aspirational capital improvement, which has been considered in other studies like the Wasatch Front Central Corridor Study (WFCCS), was not evaluated in terms of ridership or capital cost but does quantify service delivery benefits of a full FrontRunner build-out between Provo and Ogden.

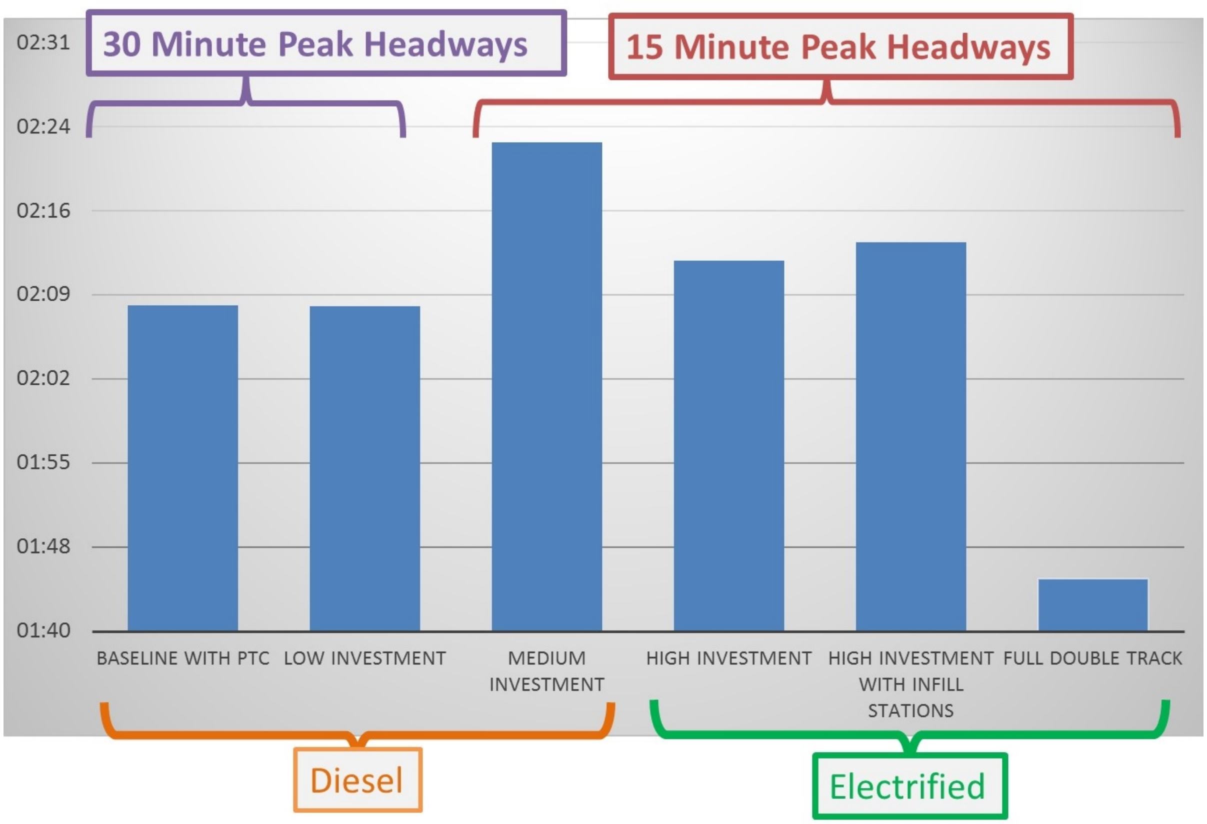

Figure 1-1: Provo–Ogden Travel Times of Future Scenarios and Full Double Track Travel Time Sensitivity Test

As shown in Table 3, capital cost estimates exclusive of any "state of good repair" and recurring fleet replacement costs were developed for the future scenarios. UTA Engineering developed the underlying infrastructure unit costs, such as cost per foot of new track and cost per new two-track grade crossing. Fleet costs are based on per-unit costs developed by UTA for the diesel fleet and by LTK for the electric fleet. The two electrified scenarios (High Investment and High Investment with Infill Stations) assume all new fleet (except for Payson/Santaquin and Brigham City diesel shuttles), whereas the diesel scenarios assume only incremental fleet requirements above the current FrontRunner fleet. All future fleet requirements are based on peak service needs plus a 20% spare margin that provides an allowance for fleet undergoing servicing, inspection or repair, as well as standing by as ready spares. Fleet requirements were not developed for the Full Double Track Sensitivity Test.

Depending on the timing of the alternative, it may be appropriate also to include replacement of the current diesel fleet, at an approximate cost of $686 million (including the unallocated contingency described below). The two electrification scenarios also include two Service & Inspection Facilities (at $72 million each) near the FrontRunner endpoints and a $50 million electrification-related retrofit of the existing Warm Springs Vehicle Maintenance Facility, all of which will significantly improve FrontRunner operational efficiency. Right-of-way acquisition costs are not included in the capital cost estimates. A 30% unallocated contingency, including allowance for soft costs, has been added to all infrastructure and fleet capital cost estimates.

Table 3 – Future of FrontRunner Estimated Capital Costs (in Millions of 2018 Dollars)

	Infrastructure Costs (not including Right-of-Way or Professional Services)	Fleet Costs	Contingency and Soft Costs (30%)	TOTAL (not including Right-of–Way)
Future Baseline with PTC	$0	$0	$0	**$0**
2050 Low Investment	$260	$114	$112	**$486**
2050 Medium Investment	$594	$528	$337	**$1,459**
2050 High Investment	$1,073	$1,102	$653	**$2,828**
2050 High Investment w/ Infill Stations	$1,268	$1,102	$711	**$3,081**

Figure 1-2 through Figure 1-7 display the results of the Future of FrontRunner's Double Track Feasibility Workshop as well as the recommended double tracking by study scenario. Five bands are shown, reflecting existing conditions on top and the four investment scenarios stacked below. For existing, purple reflects segments of the FrontRunner Corridor that are presently double tracked. Each investment scenario includes additional purple segments, reflecting recommended double track.

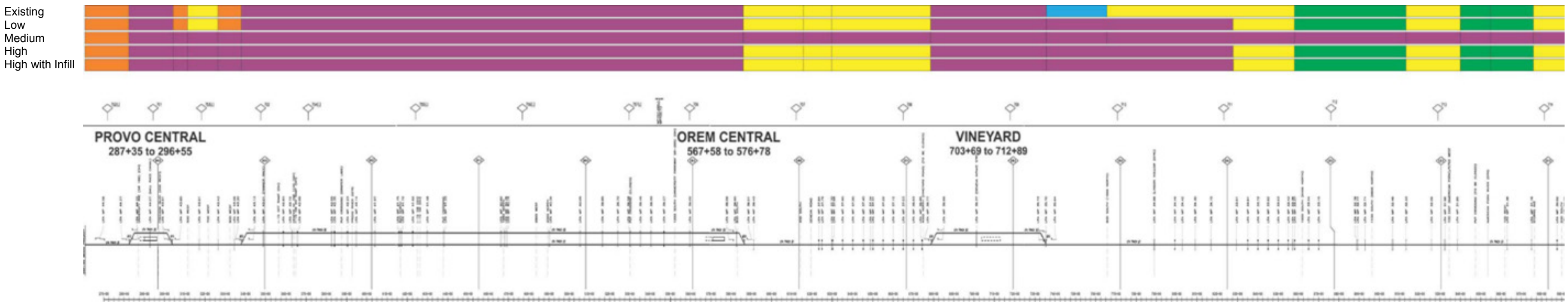

Figure 1-2: Summary of Recommended Double Track by Scenario – Provo to American Fork

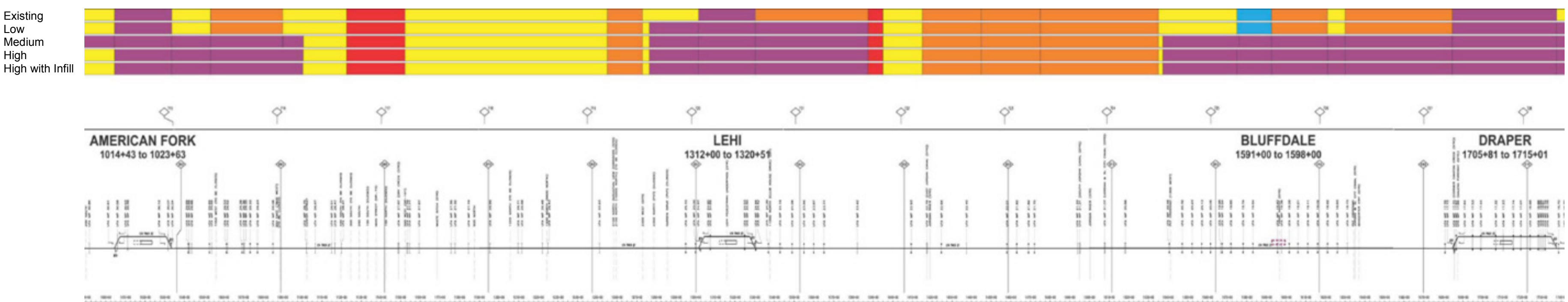

Figure 1-3: Summary of Recommended Double Track by Scenario – American Fork to Draper

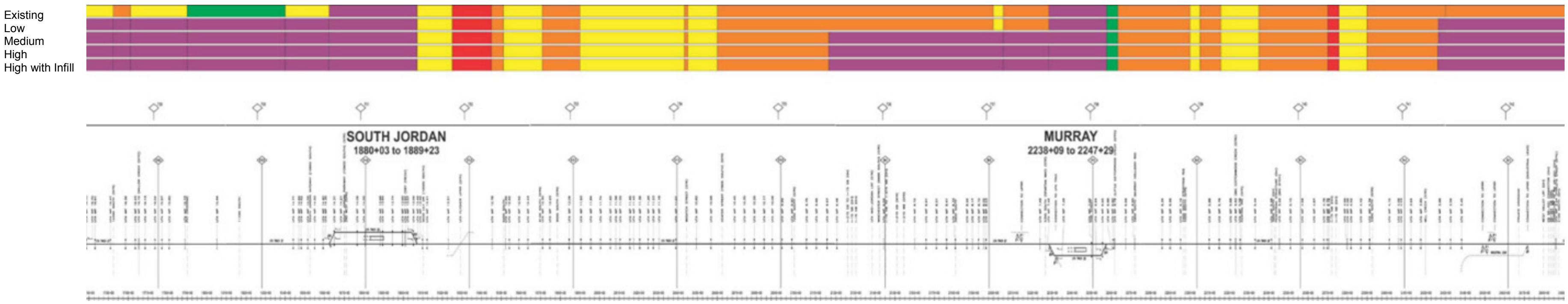

Figure 1-4: Summary of Recommended Double Track by Scenario – Draper to Salt Lake Siding

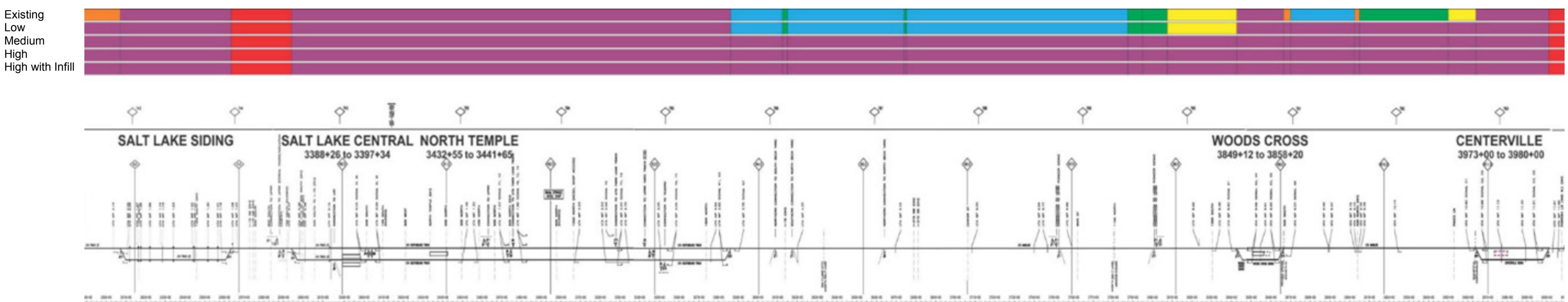

Figure 1-5: Summary of Recommended Double Track by Scenario – Salt Lake Siding to Centerville

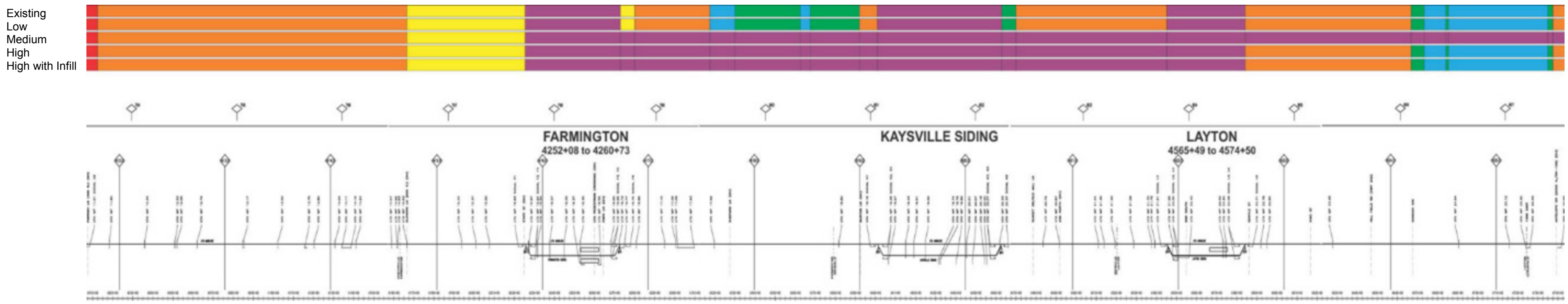

Figure 1-6: Summary of Recommended Double Track by Scenario – Centerville to Layton

Figure 1-7: Summary of Recommended Double Track by Scenario – Layton to Ogden

The other colors shown in Figure 1-2 through Figure 1-7 represent single track segments that have varying levels of difficulty in being double tracked. Blue represents easily double-tracked sections, with green, yellow and orange reflecting progressively more challenging double track construction. The red sections represent the most challenging segments to double track, with significant challenges due to limited right-of-way, major overhead bridges with constraining column placement, adjacent waterbodies that are very close to existing active railroad and adjacent high density property development in the way of a second main track.

The Table 3 capital cost estimates are based on the infrastructure and fleet quantities shown in Table 4. The quantities include the core Ogden-Provo FrontRunner network as well as the extensions to Payson, Santaquin and Brigham City as applicable to each scenario.

Table 4 – Scenario Summary of Capital Cost Estimate Quantities

Capital Unit	Construction Adjacent to Live Rail?	Units	Unit Cost (2018 $)*	Low Investment Scenario Quantities	Medium Investment Scenario Quantities	High Investment Scenario Quantities	High Investment Scenario with Extensions & Infill Stations Quantities
Station Side Platform	Y	Per Platform	$ 1,500,000	1	0	0	3
Station Center Island Platform	Y	Per Platform	$ 2,500,000	3	4	4	9
Station Parking Lot	N.A.	Per Parking Lot	$ 4,000,000	4	4	4	12
Relocated Switch (Freight/Yard)	Y	Per Switch	$ 100,000	4	4	8	8
Relocated Main Track	Y	Per LF of Track (not LF of Rail)	$ 865	18,500	55,300	44,200	44,200
Additional Main Track (Without Signals)	Y	Per LF of Track (not LF of Rail)	$ 1,150	141,300	273,300	251,000	338,000
Interlocking (Single Switch)	Y	Per Interlocking	$ 3,500,000	3	9	9	12
Signal Location (Non-Interlocking)	Y	Per Location	$ 250,000	8	147	114	145
Grade Crossing – Single Track (Signalized)	Y	Per Crossing	$ 1,500,000	0	10	10	27
Grade Crossing – Double Track (Signalized)	N	Per Crossing	$ 2,000,000	0	0	0	1
Grade Crossing – Double Track (Signalized)	Y	Per Crossing	$ 1,750,000	2	20	11	11
Undergrade Bridge - Single Track (LF)	Y	Per LF	$ 186,500	215	465	465	465
Electrification (Single Track)	Y	Per Mile of Track	$ 2,500,000	0	0	24.6	24.6
Electrification (Double Track)	Y	Per Mile of Track	$ 2,450,000	0	0	115.4	115.4
New Light Maintenance Shop and Yard	Y	Per Facility	$ 72,000,000	0	0	2	2
Existing Maintenance Shop and Yard Improvements	Y	Per Facility	$ 50,000,000	0	0	1	1
Diesel Loco	N.A.	Per Unit	$ 6,750,000	1	15	0	0
Bi-Level Coach	N.A.	Per Unit	$ 3,400,000	27	101	0	0
Bi-Level Cab Car	N.A.	Per Unit	$ 3,800,000	4	22	0	0
Electric Multiple Unit Car	N.A.	Per Unit	$ 5,740,000	0	0	192	192

*Anticipate an average cost increase of 5% per year for future costs adjustments

One of the key goals of the Future of FrontRunner Study was to understand the potential to increase system ridership. To measure the ridership effects of the different commuter rail service scenarios, LTK team member Fehr & Peers worked with Wasatch Front Regional Council (WFRC) staff to use the WFRC/Mountainland Association of Governments (MAG) regional travel demand model. WFRC staff ran the models with support, input, and review from Fehr & Peers. The model is a four-step travel demand model used for forecasting transportation demand for both transit and highway systems in the region and includes Utah, Salt Lake, Davis, and Weber Counties, representing the primary UTA service area. The intention of the study was to isolate the effects of FrontRunner on the transit system, so for a forecast year of 2050, all other variables were held constant including land use and socio-economics, and the background highway and transit networks.

The ridership model shows that the highest ridership Future of FrontRunner scenario is the High Investment Scenario with Infill Stations. Nearly 28,200 more weekday transit trips would occur under this scenario than under the Future Baseline (with PTC) Scenario. This is not surprising, given that the scenario includes extensions to the north and south as well as infill stations.

The High Investment Scenario had the second-highest ridership, trailing the High Investment Scenario with Infill Stations total daily boardings by only 1,000. Under this scenario, nearly 27,000 more weekday transit trips occur than under the Future Baseline Scenario.

The Medium Investment Scenario has the third-highest ridership but trailed the High Investment Scenario by about 4,600 daily boardings. As these two scenarios are identical except for the average travel time between stations, this suggests that the electrification of the system and subsequent travel time savings increases boardings on FrontRunner by approximately 8%.

Changes to peak and off-peak headways clearly have the largest effect on FrontRunner ridership. Both the Future Baseline Scenario and the Low Investment Scenario have much lower ridership compared to the scenarios that include 15-minute peak and 30-minute off-peak headways. Boardings for the Medium Investment Scenario are 47% higher than the Low Investment Scenario. The Medium Investment Scenario travel times are actually longer than the Low Investment Scenario, so all of the ridership gains are due to the improvement in headways.

Because the only changes made to the travel model were on the FrontRunner system, it is possible to assess the benefit of the Future of FrontRunner improvements to the transit system as a whole. This can be determined by reporting the regional transit trips and is shown in Table 5. Again, improving the frequency produces the largest increase in transit system ridership and FrontRunner alone is able to account for measurable increases in regional transit trips.

Table 5 provides a summary comparison of the scenarios. Figure 1-8 provides a chart of station level boardings for each scenario.

Table 5 - Travel Model Scenario Comparison

	Weekday 2050 FrontRunner Ridership	Change from Future Baseline with PTC Scenario	Weekday Regional Transit Trips	Change from Future Baseline with PTC Scenario
Future Baseline with PTC	35,600	--	294,600	--
2050 Low Investment	39,600	+11%	298,100	+1%
2050 Medium Investment	58,000	+63%	312,500	+6%
2050 High Investment	62,600	+76%	316,300	+7%
2050 High Investment w/ Infill Stations	63,800	+79%	318,000	+8%

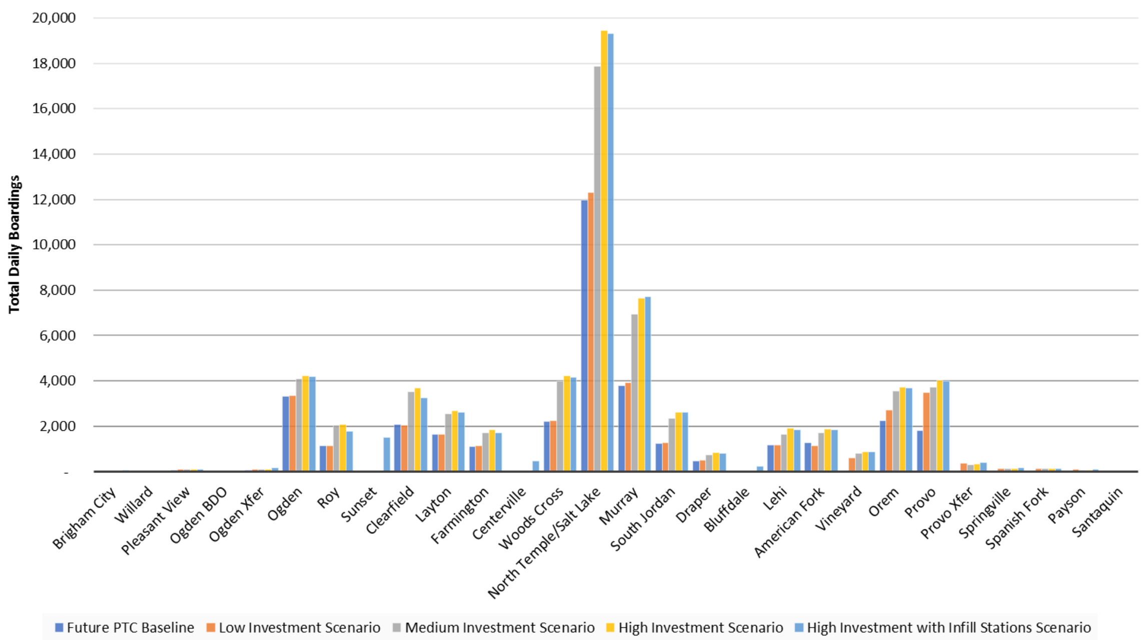

Figure 1-8: Station Boardings Scenario Comparison

Overall, the High Investment Scenario with Infill Stations provides the highest ridership of all the scenarios. However, when looking at total station boardings without the extensions to Santaquin and Brigham City, there is a net increase of only approximately 900 boardings between the High Investment Scenario and the High Investment Scenario with Infill Stations. Figure 1-9 provides a chart comparing these two scenarios at a station boarding level.

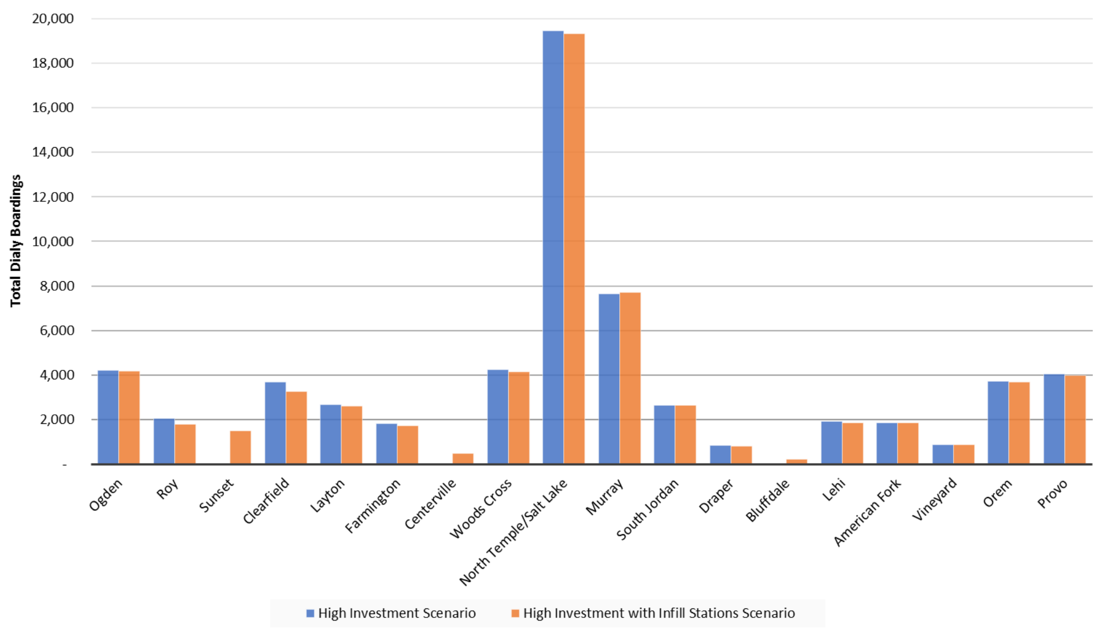

Figure 1-9: High Investment Scenario and High Investment with Infill Stations Ogden to Provo Boardings Comparison

Figure 1-9 shows that boardings slightly decrease at many of the existing stations with the introduction of infill stations. This is due to the added travel time between existing origins and destinations to accommodate stops at the infill stations. In addition, the forecast ridership at infill stations is largely comprised of existing FrontRunner riders attracted from adjacent stations.

Table 6 displays the same information as Table 5 except that projected 2050 peak loads as a percent of available seats on the peak-of-the-peak trip are also shown. This is essentially seat utilization. The service delivery supplied in the Future Baseline with PTC and Low Investment Scenarios is exceeded by projected demand with V/C ratios well above 100%. The study attempted to address this by increasing Low Investment Scenario train lengths to five bi-level coaches from existing three bi-level/one single coach trains, but additional measures are needed to resolve this. Measures may include modifications in fare policy to spread the peak load (by offering discounts for off-peak travel) or increasing train length beyond five coaches (which, however, would degrade FrontRunner acceleration and likely cause additional declines in predicted OTP).

Table 6 – Projected Scenario Ridership and Peak Volume/Capacity Ratios

	Weekday 2050 FrontRunner Ridership	Change from Future Baseline with PTC	Weekday Regional Transit Trips	Change from Future Baseline with PTC	Peak Load (Percent of Seated Capacity)
Future Baseline with PTC	35,600	--	294,600	--	165%
2050 Low Investment	39,600	+11%	298,075	+1%	137%
2050 Medium Investment	58,000	+63%	312,500	+6%	84%
2050 High Investment	62,600	+76%	316,300	+7%	83%
2050 High Investment w/ Infill Stations	63,800	+79%	318,000	+8%	84%

Table 7 provides an overall summary of Future of FrontRunner scenario results. The key findings of the study, encapsulated in this table, are:

- Background regional economic growth through 2050 is forecast to approximately double FrontRunner ridership versus today's levels without additional frequency, service extensions, or infill stations, as shown in the Future Baseline with PTC daily ridership of 35,600.
- Ridership growth above the Future Baseline forecast level is most pronounced when service frequency is doubled to 15-minute peak/30-minute off-peak headways and less sensitive to travel time improvements achieved through electrification.
- The incremental capital cost for electrification is high, though burdened with a complete FrontRunner fleet replacement. Phasing in electrification to coincide with the planned retirement of the current FrontRunner fleet would reduce this incremental capital cost by about $686 million.
- Only the two electrification scenarios come close to satisfying the study's 95% OTP goal. The performance of FrontRunner diesel trains—especially with added coaches to accommodate growing ridership—is incompatible with a largely single-track line and results in cascading delays when minor perturbations such as extended station dwells are experienced.
- The incremental ridership of the three proposed infill stations is limited. Collectively the three stations increase the number of stations between Ogden and Provo by 20% but result in only a 1.4% increase in commuter rail ridership.
- The incremental ridership of the proposed Payson/Santaquin and Brigham City Extensions is limited, though reflective of the assumed limited peak direction hourly headway service.
- As shown in Table 1, the Medium Investment Scenario requires more double track than the two electrification scenarios, which take advantage of higher performing vehicles to traverse single-track sections faster. UTA will need to determine whether to invest incrementally in additional double track to achieve reliable 15-minute peak headway diesel operation or instead to focus limited capital funds on electrification.

This decision point would not be reached until at least 30 additional miles of double track are constructed between Provo and Ogden.

Table 7 – Future of FrontRunner Summary Results

	Reliability	Change from Future Baseline	Ridership	Change from Future Baseline	Capital Cost (Millions of 2018 Dollars)
Future Baseline with PTC	88.1%	—	35,600	—	—
2050 Low Investment	85.7%	- 2.4%	39,600	+11%	**$486**
2050 Medium Investment	84.8%	- 3.3%	58,000	+63%	**$1,459**
2050 High Investment	93.5%	+ 5.4%	62,600	+76%	**$2,828**
2050 High Investment w/ Infill Stations	93.1%	+ 5.0%	63,800	+79%	**$3,081**