LTK
LTK Engineering Services

Future of FrontRunner
Final Report

Prepared for
UTA

by
LTK Engineering Services

In association with
Fehr & Peers
Jacobs Engineering

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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. FrontRunner has seen steady gains in ridership since it opened in 2008 and carried an average weekday ridership of 21,800 in September 2018. Trains during the peak morning and evening commutes frequently operate at or near capacity. Today's FrontRunner service operates on a largely single-track system. This limits the frequency of train service and forces the system to operate at lower than optimum speeds. Reliability is reduced when trains are delayed due to large passenger loads, equipment malfunctions or other incidents. Modifications to FrontRunner's train control system in order to comply with federal Positive Train Control (PTC) requirements will further challenge reliability. Improvements to the FrontRunner system capacity, reliability and speeds could be made through additional double tracking, adding additional passenger cars to the trains and, ultimately, electrifying the system.

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.

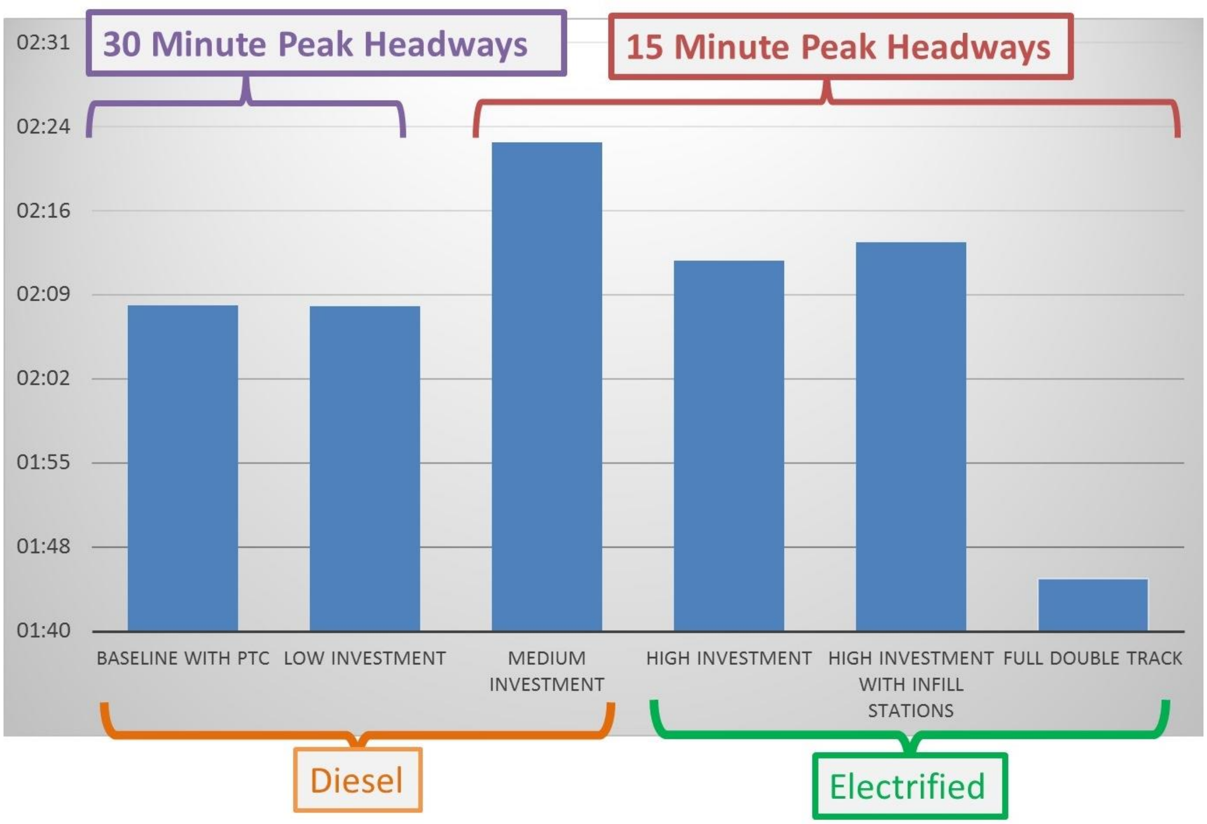


Figure 1-1: Provo–Ogden Travel Times of Future Scenarios and Full Double Track Travel Time Sensitivity Test

As shown in Table 3, capital cost estimates exclusive of any "state of good repair"and right-of-way 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). The diesel scenarios assume the incremental fleet requirements above the current FrontRunner fleet for additional vehicles required for the scenario as well as the cost to replace the entire existing fleet which will reach the end of its useful by 2038 or 2042. 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.

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	$311	$93	**$404**
2050 Low Investment	$268	$425	$208	**$901**
2050 Medium Investment	$609	$839	$434	**$1,882**
2050 High Investment	$1,095	$1,102	$659	**$2,856**
2050 High Investment w/ Infill Stations	$1,290	$1,102	$717	**$3,109**

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.

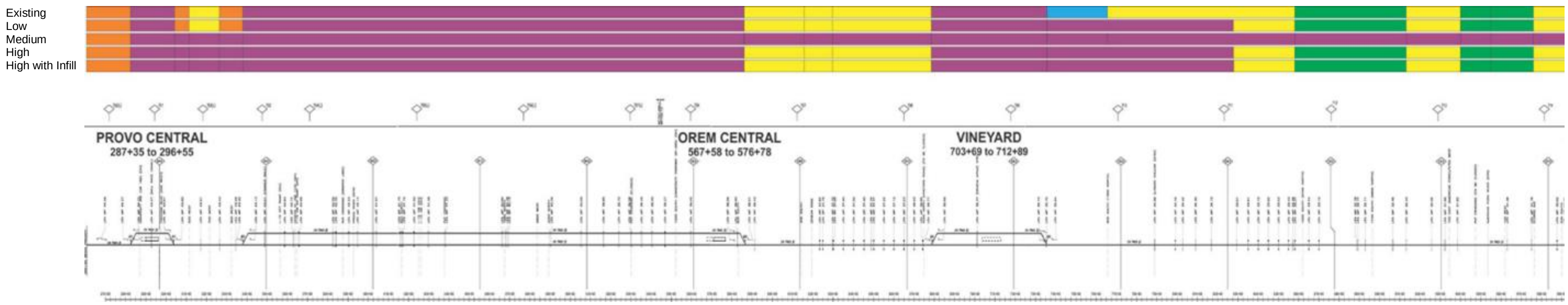


Figure 1-2: Summary of Recommended Double Track by Scenario – Provo to American Fork

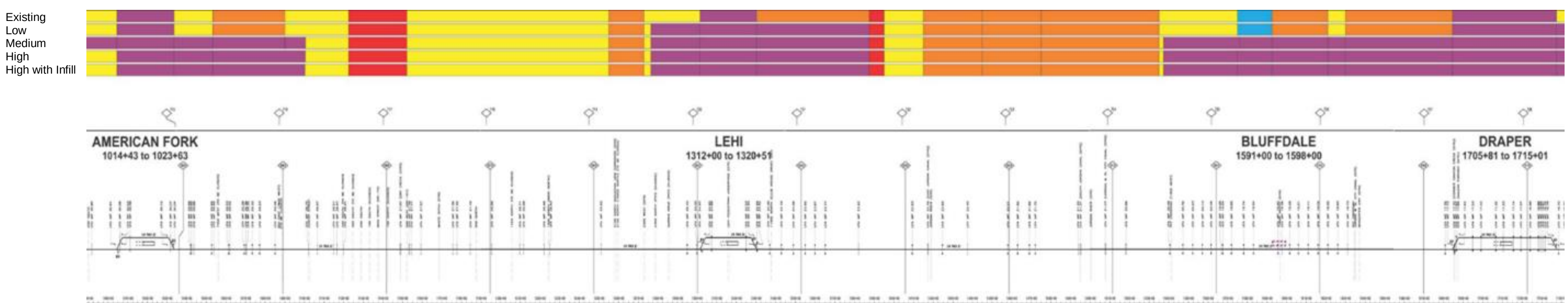


Figure 1-3: Summary of Recommended Double Track by Scenario – American Fork to Draper

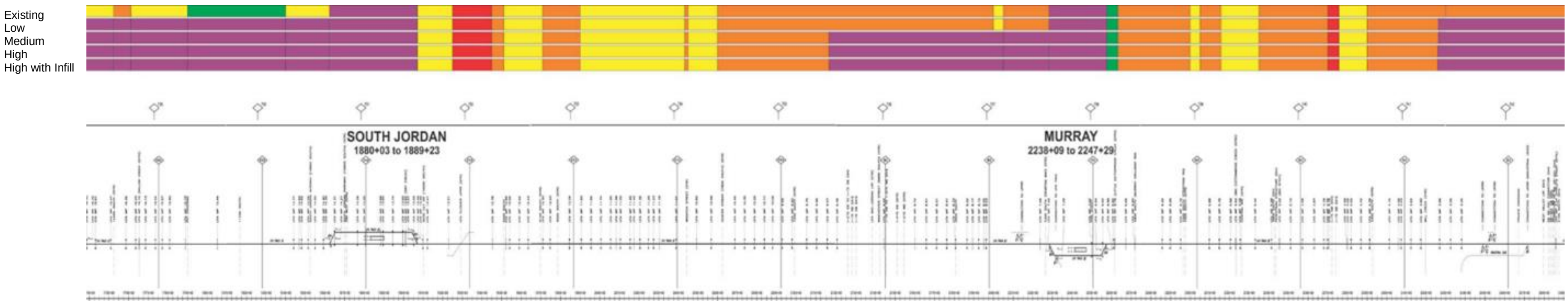


Figure 1-4: Summary of Recommended Double Track by Scenario – Draper to Salt Lake Siding

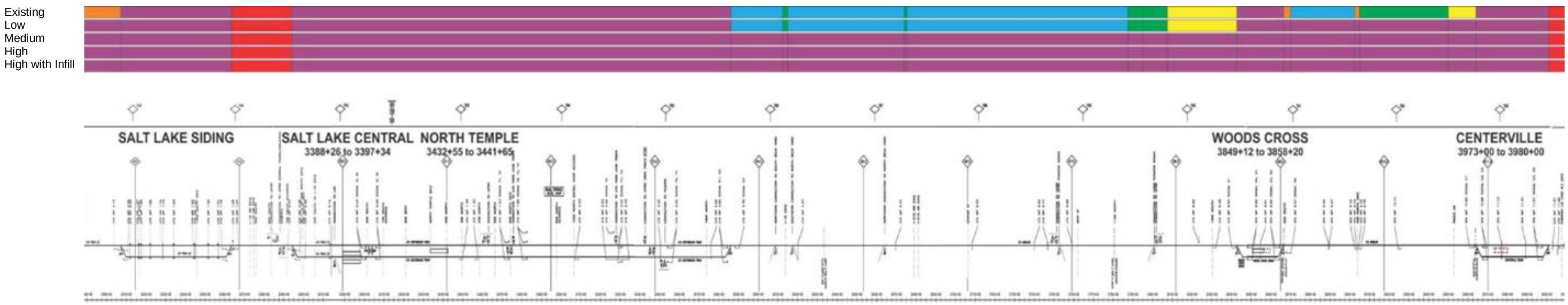


Figure 1-5: Summary of Recommended Double Track by Scenario – Salt Lake Siding to Centerville

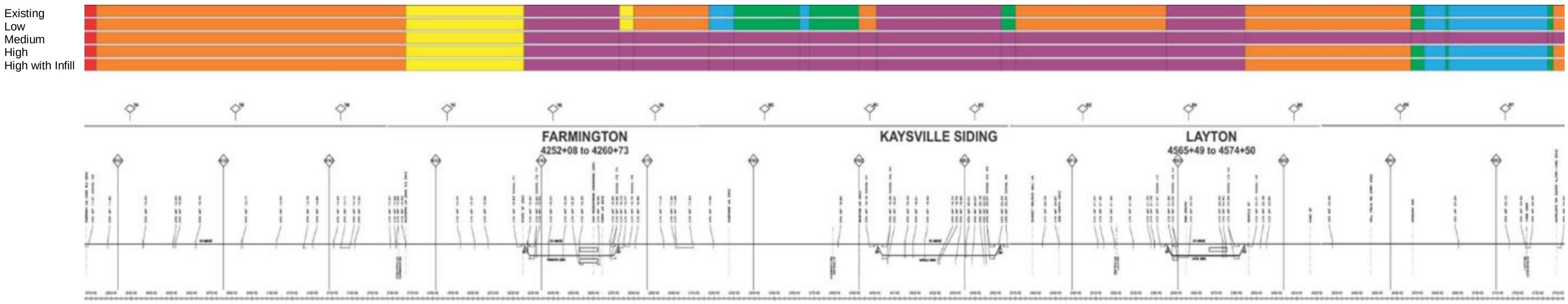


Figure 1-6: Summary of Recommended Double Track by Scenario – Centerville to Layton

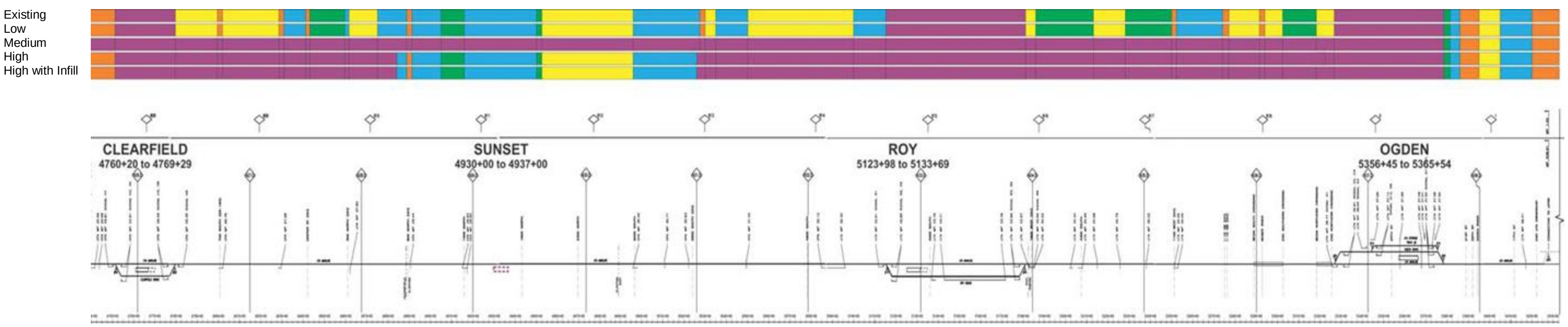


Figure 1-7: Summary of Recommended Double Track by Scenario – Layton to Ogden

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
Raise existing low platform to high platform height - Center	Y	Per car length req'd per platform	$ 250,000	30	34	38	38
Raise existing low platform to high platform height - Side	Y	Per car length req'd per platform	$ 150,000	6	8	10	10
Extend Existing Platform - on existing foundation (south)	Y	Per car length req'd per platform	$ 350,000		8	16	16
Extend Existing Platform - new foundation (north)	Y	Per car length req'd per platform	$ 500,000		4	8	8
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

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
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
Replace existing fleet	N.A.	Lump sum	$ 311,000,000	1	1		

*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%

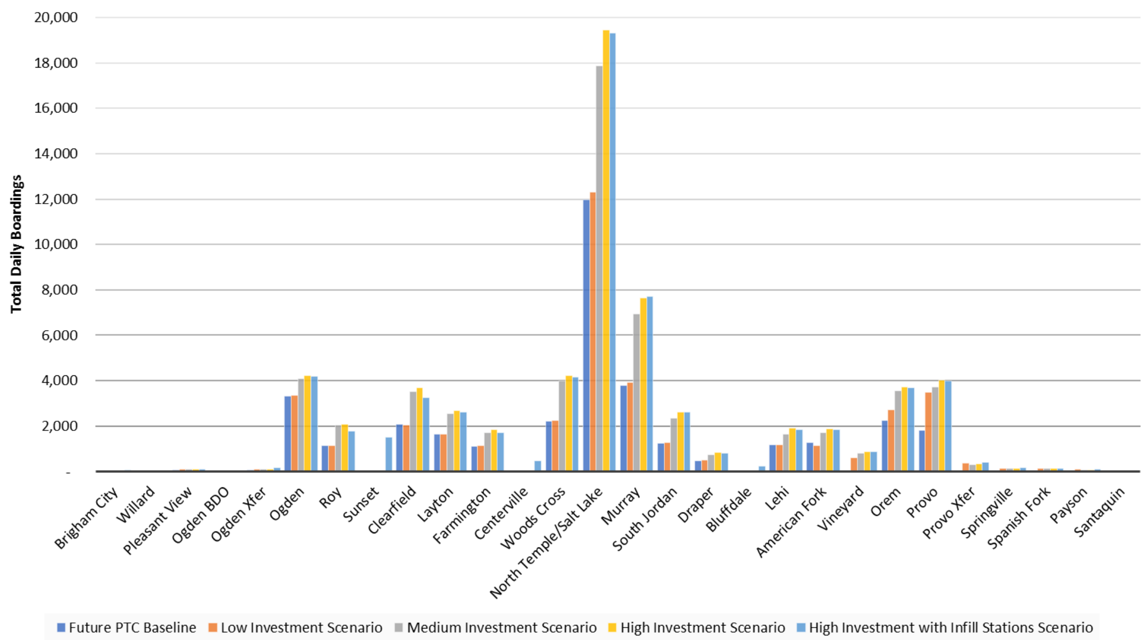


Figure 1-8: Station Boardings Scenario Comparison

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.

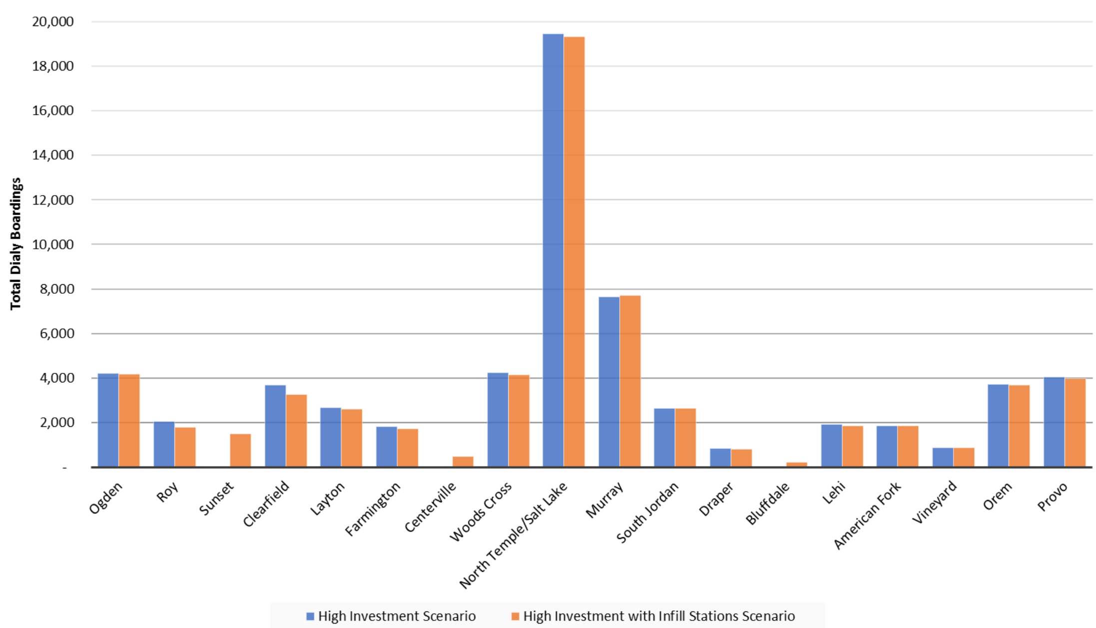


Figure 1-9: High Investment Scenario and High Investment with Infill Stations Ogden to Provo Boardings Comparison

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 leverage money that would have to be spent to replace vehicles that reach the end of their useful lives.
- 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	—	**$404**
2050 Low Investment	85.7%	- 2.4%	39,600	+11%	**$901**
2050 Medium Investment	84.8%	- 3.3%	58,000	+63%	**$1,882**
2050 High Investment	93.5%	+ 5.4%	62,600	+76%	**$2,856**
2050 High Investment w/ Infill Stations	93.1%	+ 5.0%	63,800	+79%	**$3,109**

2 Existing FrontRunner Operations and Infrastructure

UTA's FrontRunner service operates on UTA-owned tracks between Provo, Salt Lake City and Ogden. Existing operations are meant to describe pre-PTC (2017) FrontRunner schedules, infrastructure and dispatching, as represented by the baseline simulation model. The baseline simulation model begins at the Provo tail track and extends through UTA territory to Ogden Station, as shown in Figure 2-1. A single UP track is modeled between Ogden and Pleasant View station (Ogden Subdivision track 1 from UP MP 0.7 to UP MP 6.2.). UTA ended FrontRunner service between Ogden and Pleasant View on August 10, 2018.

2.1 Passenger Train Operations

In order to have the model mimic the current routing used on FrontRunner, LTK consulted with the dispatch office that is located within the FrontRunner Warm Springs Operations and Maintenance Facility. The dispatch office is staffed 24/7/365, including all overnight, Sunday and holiday non-revenue hours (due to freight activity, maintenance of way (MOW) activity, and need to monitor the UTA public grade crossing emergency call number).

The visit to the dispatch office revealed that dispatchers rarely use automatic mode, as it results in inefficient dispatching. According to UTA, automatic mode is applicable only to emergency operations when communication is lost between the dispatch office and the field. Dispatchers almost always use the office (manual) mode, establishing routes with mouse clicks and taking advantage of the dispatch software's "stacked routes" feature to queue route requests to be executed as soon as a conflicting route has been released. Most dispatchers are former train engineers on FrontRunner and have an understanding of the operational implications of the train control system and associated route establishment times. In other words, they know intuitively how far ahead routes must be set to avoid delaying trains.

The route establishment goal in the simulation is set to 395 seconds for the FrontRunner trains. This means that the simulated goal of the dispatcher is to begin establishing the route about 6.5 minutes before a train reaches an interlocking. This models the dispatcher's decision-making and was determined to be an appropriate value based on UTA control center data and GPS data collected for calibration. In areas where the calibration data indicated that the route was requested (and established if no conflicting movements) farther ahead of the train, a route request location was included in the simulation. Route request locations were included for southbound trains at Salt Lake Central signal I8 for Salt Lake Siding South interlocking. There are also northbound route request points in the simulation model at:

- South Jordan signal J6 for Salt Lake Siding South interlocking,
- Murray signal M6 for Salt Lake Central North interlocking, and
- Between Salt Lake Central station and Salt Lake Central North interlocking for Warm Springs South interlocking.

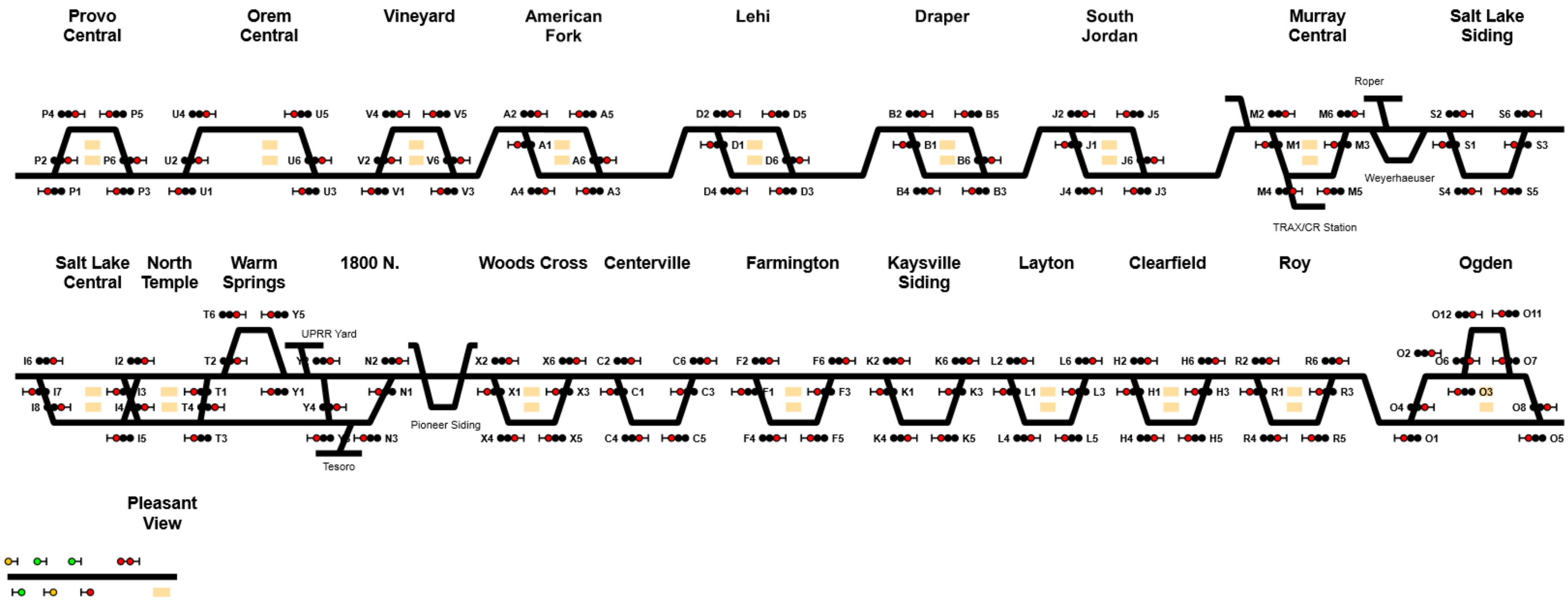


Figure 2-1: TrainOps Track Schematic of FrontRunner Corridor

Not all locations defined as interlockings in the simulation model are fully interlocked in the actual FrontRunner train control system. Some are electric lock switches that must be manipulated by freight crews accessing industry sidings that connect with the FrontRunner Corridor.

Figure 2-2 illustrates the routing used in the baseline calibration simulation in schematic form. Red arrows show preferred routes for northbound trains and blue arrows show preferred routes for southbound trains. If no train prefers the siding during a “meet”, the arrows are straight in both directions. In these situations, TrainOps will attempt to optimize the “meet” between the two trains to produce the lowest overall delay, with one of the trains routed to the siding.

At Provo, the route is always lined southbound to Provo Tail Track in the baseline (pre-PTC) simulation, even when a train will not enter the tail track. When the tail track is empty this allows trains to enter the station with a better cab signal aspect than if no Provo Tail Track is established. When the tail track is occupied with a train laying over, southbound trains will get a 15 MPH cab signal aspect entering the station.

At Vineyard Siding, any train not meeting another train follows the straight route. When a meet does occur, the southbound train always takes the siding. Layton Siding always has northbound trains on the main track and southbound trains on the siding.

The siding configurations at American Fork, Lehi, Draper and South Jordan are configured as “lap” sidings -- not the usual passing sidings as are found in the FrontRunner North alignment. Instead of a single straight route and single diverging route through the station, trains in both directions take the left-hand track in their direction of running, which is the straight track for both directions. Trains departing the station merge back on to the main track through turnouts restricting their speed. This imposes a travel time penalty on trains that do not have a siding “meet” because the “lap” siding routes always include one 45 MPH forced diverging movement.

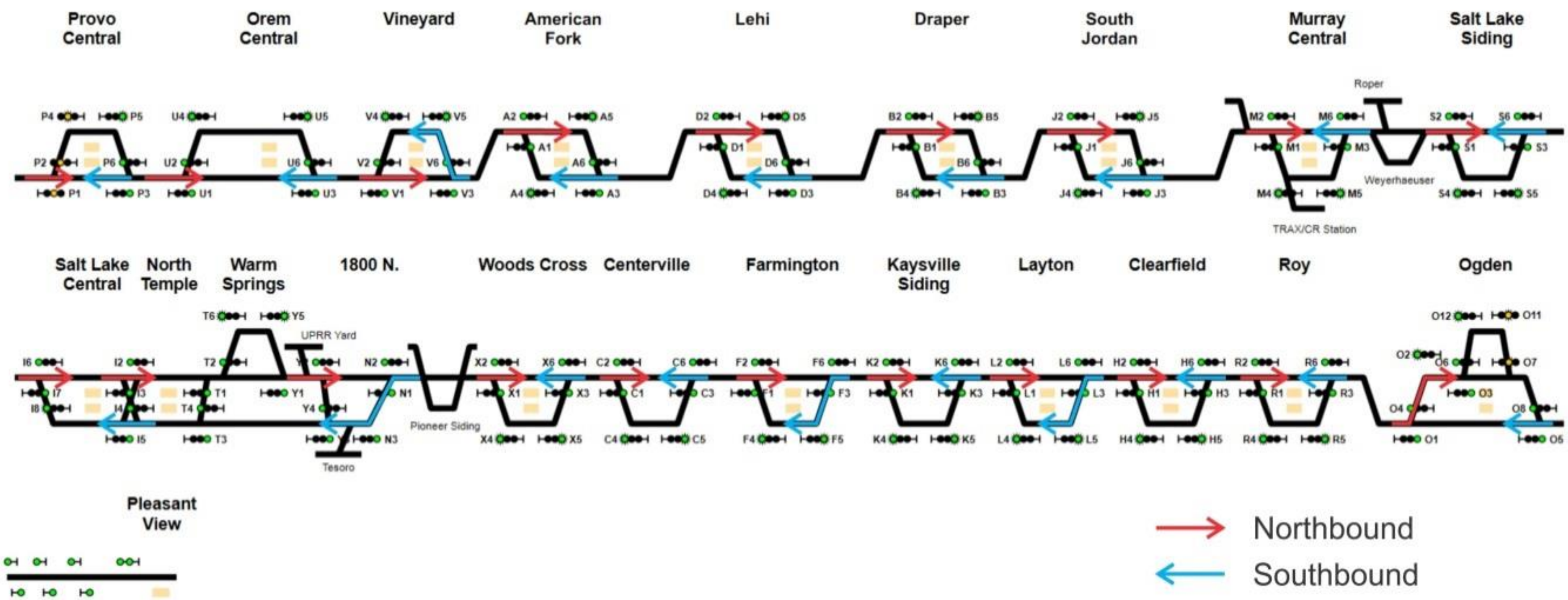


Figure 2-2: Track Schematic showing default simulation routing

There are three locations where routing in the existing (calibration) simulation model is based on passenger boarding considerations:

1. At Farmington, southbound trains always take the siding (even if no meet) due to passenger access considerations to the platform. Enhancing this access to avoid unnecessary Farmington Siding use could be a Future of FrontRunner component,

2. At Salt Lake Central (Intermodal) – North Temple – Warm Springs – 1800 North, trains always run left-handed. Occasionally, returning non-revenue trains from the north can operate to the Warm Springs Maintenance Facility right-handed but the move is slow because of the 15 MPH cab signal approaching non-signaled territory into the yard tracks,

3. At Ogden, northbound trains (even those to Pleasant View) always take the siding because of an issue with FRA cab signal speed enforcement requirements for a civil speed restriction and because the straight route is deemed too fast for a pedestrian at-grade crossing. The only trains on the main at Ogden are southbound trains from Pleasant View because the pedestrian crossing on the south side of the platform is being crossed at a much lower speed due to the station stop. At Ogden, there is no lining of routes beyond the station to provide for a better cab signal entering speed because of the at-grade pedestrian crossing at the south end of the station.

The third Ogden track, Ogden Yard, is used for layover of trains during the afternoon and at night. There is no platform access on this third track. Trains using Ogden Siding drill to/from this track using the Ogden North switch.

Trips to Pleasant View station operated over a segment of UP track until the Pleasant View service ended on August 10, 2018. Requesting a route for the UP segment required a request/confirmation by both railroads' dispatchers. During LTK's observations, the UP Dispatcher requested the route long before FrontRunner needed it, ensuring delay-free operation.

2.2 Freight Train Operations

The UPRR operates numerous freight trains within the FrontRunner Corridor though using tracks parallel to and operationally separate from UTA's own tracks. The Amtrak California Zephyr service also uses these UPRR tracks. These tracks were not included in the simulation model because, except for the cases noted below, UPRR freight trains do not interact with FrontRunner trains.

Freight trains routinely cross the FrontRunner tracks in four locations of the model. Just south of Murray Central, a freight lead track was included in the model for Murray (Sampler) as well as below Track 2 at Murray Central Station for the TRAX light rail platform (freight trains use the TRAX tracks late at night under a temporal separation arrangement). Freight trains also operate from Roper Yard and cross over to the Weyerhaeuser siding on the east side of the FrontRunner Corridor in the simulation model. The UPRR yard lead is located just north of Warm Springs off of the main track and the Tesoro Refinery is located off the siding. South of Woods Cross Station, there are two freight spurs on the east side of the FrontRunner Corridor that connect to Pioneer siding on the west side of the corridor. Only those freight operations which regularly cross the FrontRunner main tracks are included in the simulation model with typical overnight freight movements included in the simulation model to form a complete 24-hour picture of FrontRunner operations.

2.3 Existing FrontRunner Fleet

All FrontRunner trains in regular service presently include one MP36PH-3C locomotive, one Comet I coach and three Bombardier Bi-level VII Commuter Car coaches (2 trailers and 1 cab car). The locomotives and Bombardier coaches were purchased new for the opening of FrontRunner North (2008) with the fleet expanded for the subsequent opening of FrontRunner South (2012). The Comet I coaches date to the 1971-73 era and were purchased used from NJ Transit. The specifications for the simulated locomotive are shown in Table 8 while the underlying tractive effort curve for this model is shown in Figure 2-3. The physical specifications for the coaches modeled in the simulation are found in Table 9.

The locomotives are rated at 3600 HP and include separate generators to power the lights, heat and air conditioning in the coaches. As such, the power available for train movement is not derated by the auxiliary load of the train. The existing FrontRunner train consists have excellent power/weight ratios, supporting relatively high acceleration rates. Some other commuter rail operations pull up to 10 bi-level coaches with the same locomotive, yielding acceleration rates much lower than FrontRunner presently achieves.

Table 8 - Specifications for Simulation - Locomotive

	MP36PH-3C
Length (feet)	68.00
Weight (pounds)	295,000
Number of Axles	4
Maximum Adhesion (percent)	25.00
Continuous Power (HP)	3,600.00
Derate Tractive Power for Auxiliary Load	No
Maximum Speed (mph)	79.00
Initial Acceleration Limit (mph/s)	2.20
Service Brake Rate (mph/s)	1.80
Braking Reaction time (Cab) (seconds)	3.00
Rotational Mass (pounds)	24,000
Rotational Mass (percent)	8.136
Frontal Area (square feet)	164.69

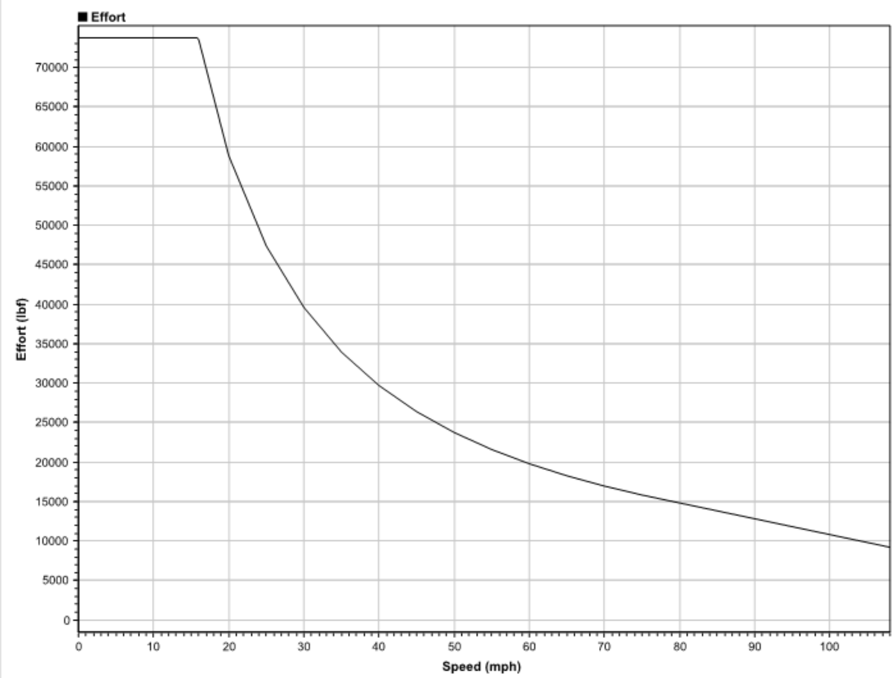


Figure 2-3: MP36PH-3C Tractive Effort

Table 9 - Existing FrontRunner Fleet - Coaches

	UTA FrontRunner, Pullman-Standard Single-level Coaches, Comet I 2008 (1971-73)	Bombardier Bi-level VII Commuter Car, Cab Car 2008	Bombardier Bi-level VII Commuter Car, Trailer 2008
Weight (pounds)	74,000	135,000	118,000
Length (feet)	85.00	85.00	85.00
Number of Axles	4	4	4
Passenger Capacity (Seated)	106	123	148
Passenger Capacity (Total)	223	148	178
Maximum Design Speed (mph)	80.00	100.00	100.00
Maximum Operating Speed (mph)	79.00	79.00	79.00
Auxiliary kW Load (kW)	40.00	50.00	50.00
Rotational Mass (percent)	8.50	8.50	8.50
Service Brake Rate (mph/s)	2.50	1.60	1.60
Frontal Area (square feet)	126.70	159.17	159.17

2.4 Civil Speed Restrictions

All passenger train civil speed restrictions contained in the UTA FrontRunner Ogden-Provo Timetable (Figure 2-4) are contained in the baseline simulation database. Note that many of these speeds changed in the Future Baseline (PTC) scenario and those speed changes were carried forth into the four investment scenario simulations. In addition, the simulation was modified to include a 15 MPH speed restriction at stations where meets are occurring, per UTA's Special Instructions modification of GCOR Rule 6.30.

For FrontRunner GCOR Rule 6.30 is modified to read as follows:

Rule 6.30: Receiving or Discharging Passengers

Trains entering simultaneously or entering an occupied station:

When two passenger trains are nearing a station at the same time and both are scheduled to stop, or if a train is entering a station that is already occupied by another train; Trains must reduce speed to 15 MPH and enter the station with caution ringing the bell and sounding the horn when necessary.

2.5 Cab Signal System

Table 10 displays the applicable wayside signals for automatic ("Block") and controlled ("Interlocking") locations. The table also displays the Indication (meaning) of each wayside signal aspect.

Table 10 - FrontRunner Block and Interlocking Signals

Rule	Name	Aspect	Indication
9.1.1	Clear	Green	Proceed at authorized speed.
9.1.2	Diverging Clear	Flashing Green	Proceed on diverging route at authorized speed.
9.1.3	Approach	Yellow	Proceed at authorized speed, prepare to stop at next signal.
9.1.4	Diverging Approach	Flashing Yellow	Proceed on diverging route at authorized speed, prepare to stop at next signal
9.1.5	Stop	Red	STOP before any part of the train or engine passes the signal.
9.1.6	Restricting	Flashing Red	Proceed at restricted speed, not exceeding prescribed speed. If entering the Warm Springs yard contact yard EIC for instructions.

Table 11 shows the Cab Signal code rates (pulses per minute) and their passenger train speed equivalent.

Table 11 - Cab Signal Code Rates

Code (pulses per minute)	Passenger Train Speed
50	15 MPH
75	30 MPH
120	45 MPH
180	60 MPH
270	79 MPH
420	YARD

Yard Speed is simulated as a maximum speed of 15 MPH with trains being prepared to stop within one half range of vision. LTK did not directly derate the passenger train speeds associated with each cab signal code rate. However, as reported in Section 3.2, an overall 0.3% schedule margin was applied to all FrontRunner performance to ensure practical simulation results. This results in a very slight reduction in FrontRunner train performance (acceleration, maintaining speed, braking, station dwells) versus no schedule margin being included in the model.

UTA FRONTRUNNER

OGDEN - PROVO TIMETABLE

Effective 9/18/16

Mile Post	CP	CP MP	Station Names ▲ North South ▼	Siding Feet
N43.60	P South	N43.30	Pleasant View	
			UP Controlled Track	
N38.6	UP JCT.	N38.6	UP - UTA Junction	
N37.56	O North O Mid O South	N37.70 N37.15 N36.27	Ogden	YARD
N32.96	R North R South	N33.25 N32.69	Roy	5600
N26.06	H North H South	N26.31 N25.80	Clearfield	1800
N22.38	L North L South	N22.66 N21.86	Layton	3000
	K North K South	N20.34 N19.17	Kaysville (Siding)	5200
N16.44	F North F South	N16.55 N15.88	Farmington	3800
	C North C South	N11.58 N10.89	Centerville (Siding)	2700
N8.81	X North X South	N8.94 N8.67	Woods Cross	1400
			Beck Street (Siding)	YARD
	N North	N3.6	1800 North	
N2.10	Y North	N2.75	Warm Springs Yard	YARD
	Y South	N1.6	Tower	
N0.95			North Temple	
N0.07	I North I South	N0.25 S0.46	SLC Intermodal	
	S North S South	S1.07 S2.13	Salt Lake (Siding)	7400
S7.16	M North M South	S6.87 S7.41	Murray	2800
S13.94	J North J South	S13.50 S14.34	South Jordan	
S17.23	B North B South	S16.71 S17.72	Draper	
S24.69	D North D South	S24.43 S24.97	Lehi	
S30.34	A North A South	S30.05 S30.60	American Fork	
	V North V South	S35.65 S36.76	Vineyard (Siding)	5800
S38.76	U North U South	S38.51 S43.20	Orem	
S44.13	P North P South	S43.86 S44.26	Provo	2100

Main Track Authority:

CTC: Between N43.3 thru S 44.26 (ACS and ATC in Effect)

Double Main Track: Between N3.6 thru S0.10
Between S 13.50 thru S 14.34
Between S 16.71 thru S 17.72
Between S 24.43 thru S 24.97
Between S 30.05 thru S 30.60
Between S 38.51 thru S 43.20

Yard Track: Warm Springs tracks 1 thru 18

<u>Maximum Speed Table:</u>	Passenger East Track	Passenger West Track	FRT
Except as listed below	79	79	50
Yard Track	10	10	10
N43.3 - N43.6	25	25	
N37.8 - N38.7	40	40	
N37.3 - N37.8	20	20	
N36.6 - N37.3	40	40	
N35.8 - N36.6	55	55	
N32.5 - N33.1	60	60	
N21.8 - N22.7	55	55	
N15.7 - N16.7	70	70	
N8.4 - N8.6	60	60	40
N2.8 - N3.6	45	60	30
N2.35 - N2.8	45	45	30
N1.85. - N2.35	40	40	25
N0.85 - N1.85	60	60	40
N0.65 - N0.85	30	30	20
N0.25 - N0.65	30	40	20
N.0 - N0.25	20	20	15
S0.0-S0.07	30	30	20
S0.7-S0.39	45	45	30
S0.39-S0.49	30	45	20
S0.49-S0.55	45	45	30
S1.07 - S1.17	45	79	30
S2.04 - S2.14	45	79	30
S6.79-S7.02	30	30	20
S7.25-S7.42	45	79	30
S12.91-13.23	55	55	
S13.50-S13.84	60	45	
S14.27-S14.34	45	79	
S16.71-S17.12	79	45	
S17.64-S17.72	45	79	
S22.10-S22.53	65	65	
S22.60-S23.01	50	50	
S23.16-S23.47	60	60	
S24.43-S24.59	79	45	
S24.96-S24.97	45	79	
S27.80-S28.04	50	50	
S28.24-S28.65	55	55	
S30.05-S30.22	79	45	
S30.44-S30.60	45	79	
S35.65-S35.74	79	45	
S36.67-S36.76	79	45	
S38.51-S38.67	79	45	
S43.11-S43.15	45	40	
S43.15-S43.64	45	45	
S43.86-S44.26	30	30	

Other Speed Restrictions:

Thru sidings and turnouts (Except as below)...... 45
Warm Springs yard tracks 5 thru 17 5
Woods Cross.. 30
Roy South.. 30
Intermodal South.................................. 30
Murray North....................................... 30
Provo North.. 40
Provo South.. 15
Intermodal Cross Over............................ 15

Figure 2-4: Ogden-Provo Timetable effective 9/18/16

3 Existing Operations Calibration

The TrainOps simulation process starts with calibration, ensuring that the model's dispatching, dwell times, train control response times and train performance (including both locomotive and human performance) match "real world" conditions.

During the course of LTK's dispatch center observations, a number of meets were timed to determine the elapsed time between clearance of one train into a double track location and the establishment of a route out of the double track section for the waiting train operating in the opposite direction. In all cases, the Controller used the stacked routes function to ensure fastest possible response. The observed time reflects loss of shunt time, route release time, switch throw time and route establishment time. Concurrent with this is traffic reversal time between sidings. It was noted that FrontRunner South (Salt Lake Central to Provo) has faster response times than FrontRunner North because it is on a fiber network (versus electrocode track circuits on FrontRunner North). Individual observations are shown in Table 12.

Table 12 - Observed Route Establishment Times at Train Meets

FRS	Vineyard South	12 seconds
FRS	Vineyard South	15 seconds
FRS	Vineyard South	17 seconds
FRS	Vineyard South	11 seconds
FRS	Vineyard North	10 seconds
FRS	Vineyard North	13 seconds
FRS	Vineyard North	14 seconds
FRS	Jordan South	32 seconds
FRS	Jordan South	16 seconds
FRS	Jordan North	20 seconds
FRS	Murray North	16 seconds
FRS	Salt Lake Siding South	13 seconds

FRS	Dinosaur CP South	30 seconds
FRS	Dinosaur CP South	33 seconds
FRS	Dinosaur CP North	32 seconds
FRS	Dinosaur CP North	31 seconds
FRS	Dinosaur CP North	33 seconds
FRS	Dinosaur CP North	37 seconds

FRN	Salt Lake Siding North	28 seconds
FRN	1800 North (End of Double Track)	22 seconds
FRN	Centerville South	17 seconds
FRN	Centerville South	19 seconds
FRN	Centerville North	22 seconds
FRN	Centerville North	23 seconds
FRN	Layton South	22 seconds
FRN	Layton South	29 seconds
FRN	Layton North	20 seconds
FRN	Roy South	17 seconds
FRN	Roy North	20 seconds

The observed route establishment times at locations on FrontRunner South and FrontRunner North were averaged separately. Since the times at Dinosaur (Lehi) were significantly different than the rest of the times on FrontRunner South, they were categorized separately. The results of this analysis are shown in Table 13.

Table 13 - Summary of Observed Route Establishment Times

FrontRunner South	Min	0:00:10
	Max	0:00:32
	Ave.	**0:00:16**
FrontRunner North	Min	0:00:17
	Max	0:00:29
	Ave.	**0:00:22**
Dinosaur (Lehi)	Min	0:00:30
	Max	0:00:37
	Ave.	**0:00:33**

The averages for the three categories – FrontRunner South, FrontRunner North and Dinosaur (Lehi) – were used to input into the simulation to model the Route Establishment Time and Route Release Time at individual interlockings. These are shown in Table 14.

Table 14 - TrainOps Route Release/ Route Establishment Inputs

FrontRunner South	Route Establishment Time	0:00:11
	Route Release Time	0:00:05
FrontRunner North	Route Establishment Time	0:00:17
	Route Release Time	0:00:05
Dinosaur (Lehi)	Route Establishment Time	0:00:28
	Route Release Time	0:00:05

For all future investment scenarios, all route establishment and route release times were reconfigured to match the faster FrontRunner South times, including Dinosaur (Lehi). This will require faster communication equipment at the interlockings, at the FrontRunner Dispatch Office and in the links between these locations.

3.1 Dwells and Terminal Turn Times

Dwell time data was compiled from the INIT VBS data dated November 14, 2016 through November 18, 2016. Only data for late trains were used so as to not bias the results with FrontRunner Engineers waiting for their scheduled departure time. Dwell times were determined for late trains by subtracting the recorded door open time from the door close time and adding ten seconds to represent door cycle time. These dwell times (shown in Table 16 through Table 18) were then randomly sampled to produce realistic train dwell times at each station. Three major stations did not have dwell times randomized because their dwell times exceed values at the other stations. These exceptions are shown in Table 15.

Table 15 - Minimum Dwell Times for Through Trains - Non-Randomized

Station	Dwell (mm:ss)
Salt Lake Central	02:00
North Temple	01:30
Ogden	02:00

Analysis of the scheduled "turn" (change of direction) times in the baseline (pre-PTC) timetable found that the minimum scheduled turn times are as follows:

- Provo 8 mins
- Ogden 15 mins
- Pleasant View 15 mins

For the purposes of simulation, LTK assumed a minimum simulation turning dwell of 6 minutes at all terminals. This provides up to 2 minutes of lateness recovery time at the terminal for the shortest baseline scheduled turns. At Ogden and Pleasant View, the minimum simulation turn time of 6 minutes provides a train with the shortest scheduled dwell with the ability to arrive up to 9 minutes late and still leave on time.

Table 16 - Peak Period Dwell Times for Through Trains - Randomized (South End)

Orem		American Fork		Lehi		Draper		South Jordan		Murray Central	
Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences
10	2	15	2	15	2	5	1	15	2	20	1
15	1	20	13	20	7	15	2	20	2	25	3
20	7	25	23	25	17	20	12	25	26	30	6
25	10	30	22	30	19	25	28	30	31	35	22
30	18	35	22	35	10	30	28	35	28	40	20
35	19	40	15	40	7	35	21	40	17	45	19
40	26	45	11	45	6	40	16	45	11	50	15
45	14	50	4	50	7	45	5	50	3	55	9
50	7	55	4	55	5	65	1	55	2	60	7
55	2	65	1	60	4			95	1	65	2
60	3	70	1	65	4			260	1	70	4
70	3	190	1	70	2			365	1	75	4
75	2	195	1	75	3					80	1
85	1			80	3					85	2
				85	4					90	2
				95	3					95	1
				100	4					100	1
				105	1					105	1
				115	1					145	1
				125	2					150	1
				135	1					185	1
				140	1					220	1
				145	2						
				150	2						
				155	1						
				160	1						
				170	1						
				205	1						
				240	1						

Table 17 - Off Peak Period Dwell Times for Through Trains - Randomized (South End)

Orem		American Fork		Lehi		Draper		South Jordan		Murray Central	
Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences
15	1	15	2	15	3	10	1	10	2	20	3
20	8	20	21	20	8	15	6	20	20	25	12
25	13	25	41	25	25	20	23	25	31	30	17
30	12	30	19	30	16	25	34	30	26	35	29
35	22	35	17	35	11	30	21	35	20	40	17
40	14	40	10	40	10	35	10	40	11	45	5
45	10	45	5	45	4	40	12	45	7	50	4
50	12	50	1	50	6	45	2	50	4	55	4
55	1	55	1	55	3	50	2	55	1	65	1
60	1	110	1	60	1	55	1	60	2	70	2
65	3	145	1	65	2	75	1	65	2	75	3
70	2	165	1	70	4	100	1	70	2	80	2
80	1	240	1	75	2	400	1	75	1	85	4
85	2	245	1	90	1	440	1	85	1	90	1
225	1			95	1			100	1	95	1
230	1			100	2			105	1	110	1
240	1			110	1			110	1	115	2
				135	1			115	1	135	1
				140	2			170	1	140	1
				145	2					145	2
				170	2					160	3
				175	2					165	1
				220	1					175	1
				265	1					195	1
				340	1					220	1
				430	1					315	1
										320	1

Table 18 - Peak Period Dwell Times for Through Train - Randomized (North End)

Woods Cross		Farmington		Layton		Clearfield		Roy	
Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences	Dwell Time (in seconds)	# of Occurrences
5	1	15	2	20	4	15	1	10	1
15	1	20	10	25	13	20	11	15	4
20	14	25	11	30	6	25	8	20	21
25	22	30	10	35	18	30	7	25	18
30	13	35	10	40	19	35	4	30	15
35	14	40	7	45	9	40	4	35	16
40	11	45	4	50	8	45	6	40	6
45	10	50	3	55	9	50	3	45	6
50	5	55	4	60	5	55	4	50	2
55	4	60	1	65	3	60	1	60	1
60	3	90	1	70	2	65	3	65	1
65	4	125	1	75	1	70	1	70	1
70	1	165	2	80	1	75	1	75	2
75	1	170	2	95	1	80	2	80	1
80	2	185	1	140	2	85	2	95	3
85	1	195	1	145	1	90	1	130	1
90	1	210	1	150	1	95	1	190	1
95	3	215	1	155	1	120	1	240	1
145	1	230	1			135	**1**	275	1
155	1					140	1		
175	1					145	1		
190	1					150	1		
						235	1		

Table 19 - Off Peak Period Dwell Times for Through Trains - Randomized (North End)

Woods Cross		Farmington		Layton		Clearfield		Roy	
Dwell Time (in seconds)	**# of Occurrences**	**Dwell Time** (in seconds)	**# of Occurrences**	**Dwell Time** (in seconds)	**# of Occurrences**	**Dwell Time** (in seconds)	**# of Occurrences**	**Dwell Time** (in seconds)	**# of Occurrences**
20	18	10	1	15	1	15	1	5	1
25	13	15	1	20	5	20	2	10	0
30	12	20	7	25	9	25	10	15	2
35	4	25	10	30	10	30	7	20	13
40	4	30	4	35	15	40	2	25	10
45	1	35	2	40	13	45	4	30	6
50	1	40	3	45	9	50	2	35	4
60	1	50	2	50	6	55	1	40	4
65	1	55	1	55	5	60	1	45	4
90	1	65	2	60	1	65	2	50	2
95	1	75	1	65	1	70	1	55	1
105	1	100	2	70	1	75	1	65	1
110	2	105	2	90	2	80	1	70	1
115	2	110	1	95	1	90	2	85	1
140	1	130	1	100	3	100	1	90	1
145	1	135	1	105	1	125	1	120	1
185	1	140	1	110	1	250	1	125	1
190	1	145	1	115	1	255	1	165	1
245	1	200	1	165	1			185	1
270	1			240	1			380	1
355	1							385	1
								390	1

3.1 Existing Operations Data

FrontRunner operations were analyzed through the use of UTA event recorder data from the UTA Dispatch Office for the period July 18, 2016 to July 22, 2016. Time-distance string charts were produced from the event recorder data showing the lateness of trains based on their departure times from stations. The red and blue lines in the string charts plot the actual trains' departures from each station while the gray lines indicate the schedule times.

Figure 3-1 shows representative existing (pre-PTC) operations on FrontRunner from start of service to 8:00 a.m. while Figure 3-2 shows the same day from 8:00 a.m. to Noon. None of the red or blue strings deviates more than a minute or two from the gray (scheduled) strings, indicating 100% On-Time Performance for this time period.

The morning peak string charts shown in Figure 3-1 and Figure 3-2, as well as the evening peak string charts shown in Figure 3-3 and Figure 3-4, identify the source of most delays as happening in the FrontRunner South territory and in particular during the evening peak period. Delays are seen cascading between late trains and the Dispatch Office data shows that it is not generally possible to recover until the peak period ends. Figure 3-3 shows FrontRunner operation on a different day from 4:00 to 8:00 p.m. The string chart shows some delays incurred on FrontRunner south (red actual strings to the right of gray scheduled strings) but demonstrates that late northbound trains can recover on FrontRunner North. Figure 3-4 shows a different day of evening peak period operation and shows that late southbound trains have difficulty recovering from lateness on FrontRunner South.

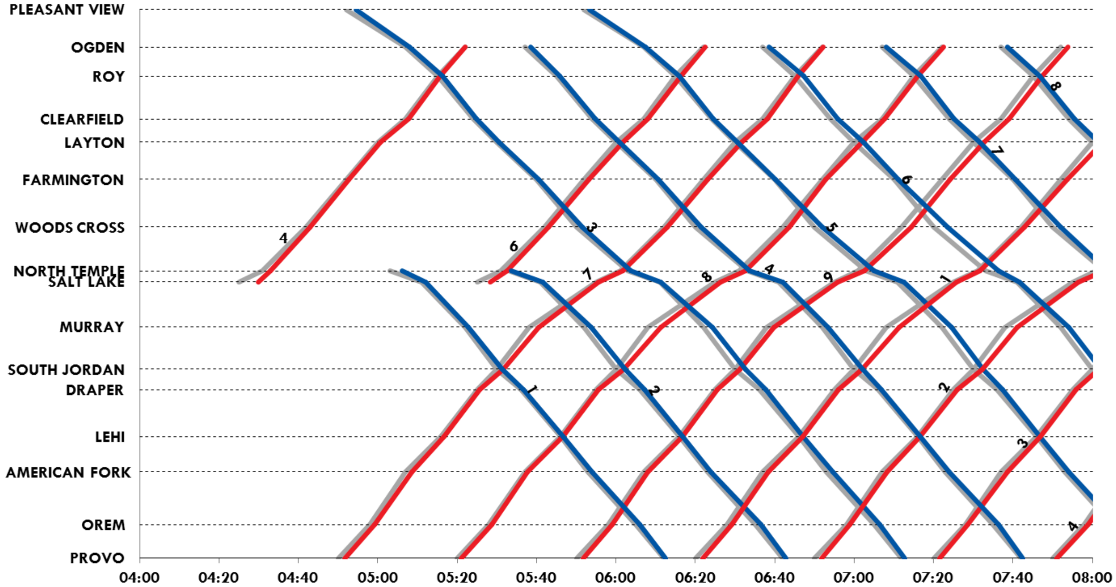


Figure 3-1: Actual Operations Time-Distance String Chart – Morning Peak – Monday July 18, 2016, 04:00 - 08:00

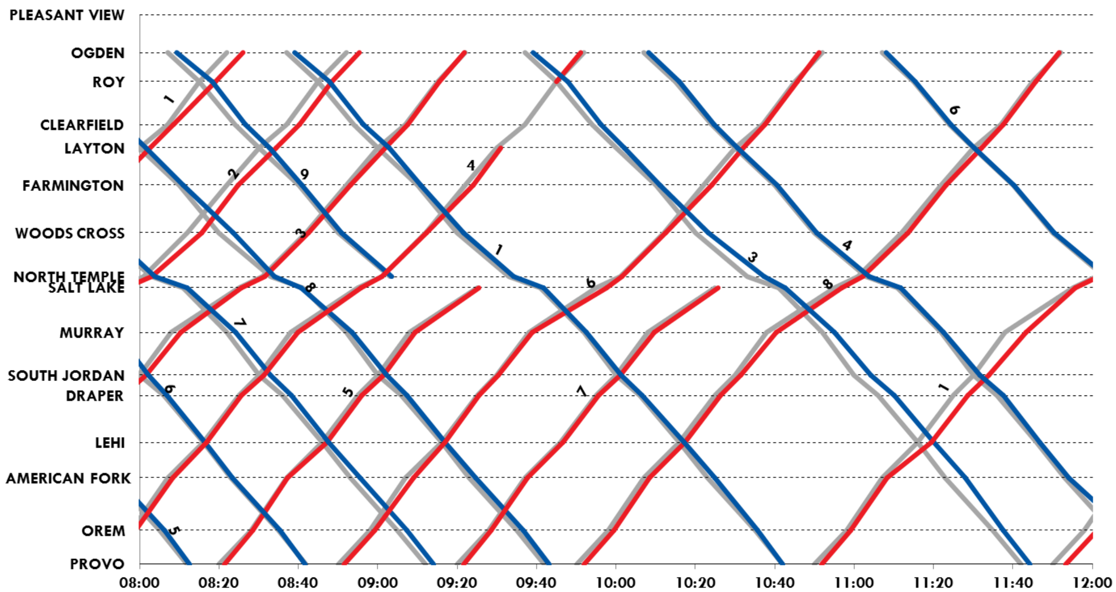


Figure 3-2: Actual Operations Time-Distance String Chart – Morning Peak – Monday July 18, 2016, 08:00 - 12:00

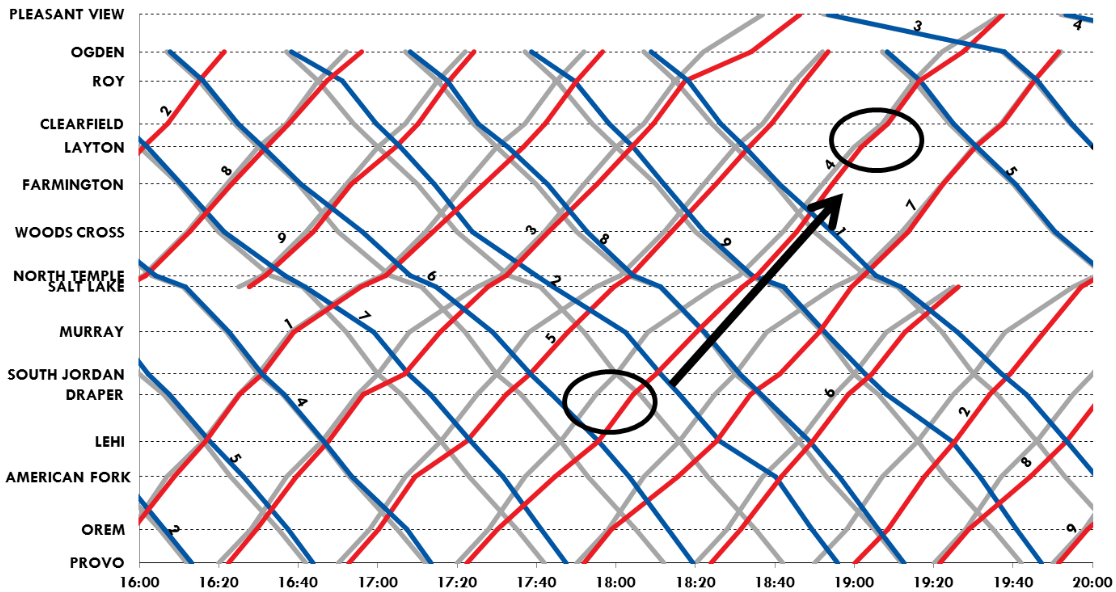


Figure 3-3: Actual Operations Time-Distance String Chart – Evening Peak – Tuesday July 19, 2016, 16:00 - 20:00

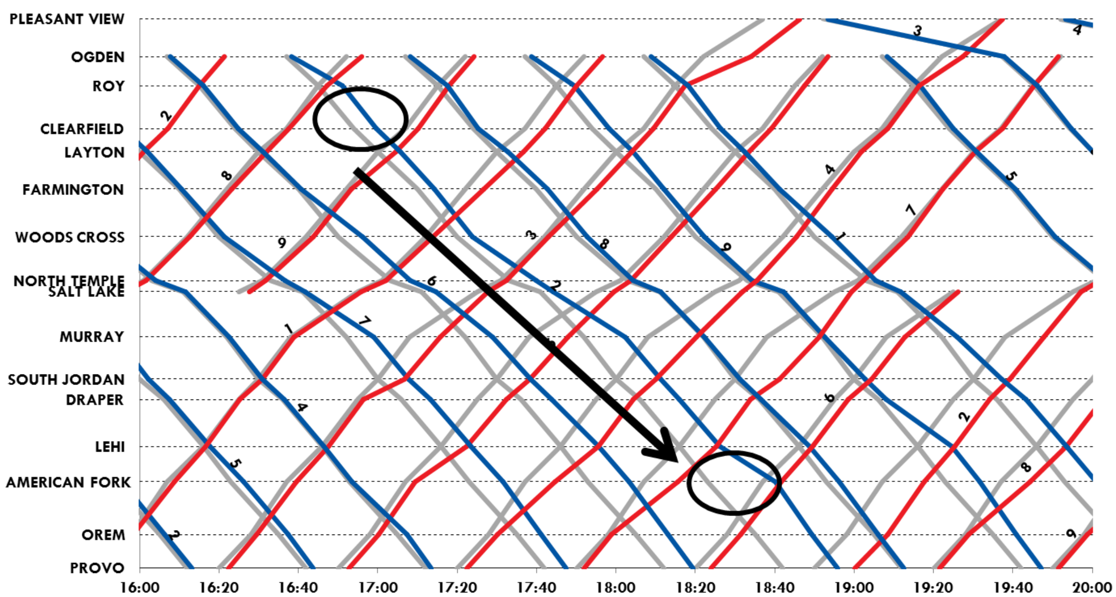


Figure 3-4: Actual Operations Time-Distance String Chart – Evening Peak – Tuesday July 19, 2016, 16:00 - 20:00

The OTP for the five days shown in the string charts is provided in Table 20. FrontRunner OTP is calculated based on scheduled lateness departing individual stations or arriving at the final station. A train may be up to 4 minutes and 59 seconds late and considered on time. Trains that depart a station one second or more earlier than scheduled are not considered on time. This typically occurs approximately a dozen times a day and has a small impact on on-time performance.

Table 20 - FrontRunner On-Time Performance
July 18, 2016 - July 22, 2016

Date	Early Trains	Late Trains	Total Trains	OTP
7/18/2016 Monday	12	69	837	90%
7/19/2016 Tuesday	8	100	837	87%
7/20/2016 Wednesday	12	102	836	86%
7/21/2016 Thursday	10	104	833	86%
7/22/2016 Friday	11	80	831	89%

The historical OTP for 2015 and 2016 in Figure 3-5 shows the day-to-day variation in FrontRunner OTP. The range of variability indicates that the system suffers from significant service reliability issues. OTP does frequently exceed 95%, but there are many time periods where OTP is much lower. It does not appear that seasonality influences OTP.

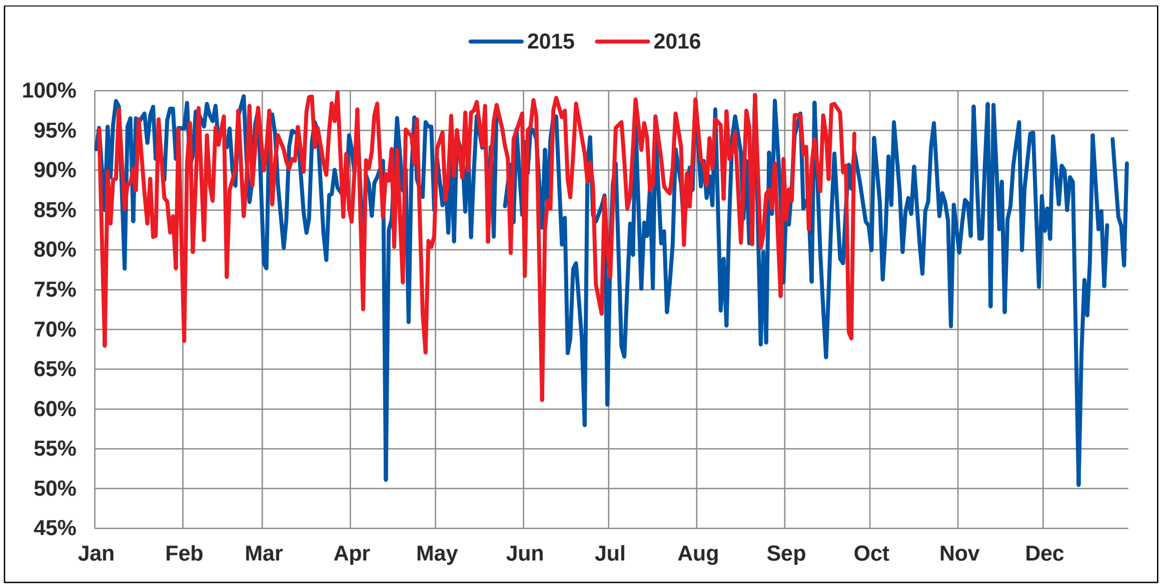


Figure 3-5: Historical FrontRunner System OTP

Figure 3-6 provides the distribution of daily OTP for the first 9 months of 2015 and 2016. It is clear that there has been an improvement in daily reliability from the previous year. In 2016, there are many more days with OTP in the three best categories (85 to 90%, 90 to 95% and 95 to 100%) than there were in 2015. FrontRunner managers indicated that they view 90% OTP as representative of baseline FrontRunner OTP, as measured on a rolling average (three or more months) basis and prior to the implementation of PTC.

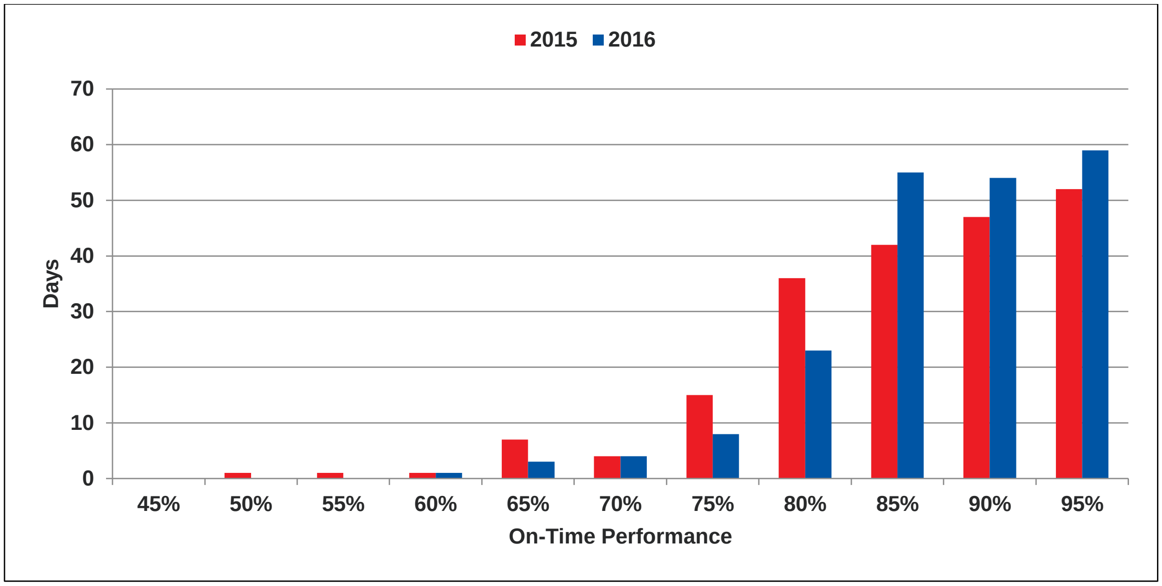


Figure 3-6: 2015-2016 UTA On-Time Performance Distribution January – September

The TrainOps simulation modeling includes five consecutive days with randomized perturbations to capture the real world variability present in the UTA data. The goal of the calibration modeling effort was to produce a five day set of simulations with an average OTP of 90%.

3.2 Schedule Margin

For calibration of FrontRunner operations, one northbound and one southbound trip were observed on each of the FrontRunner South and FrontRunner North segments. The observations took place on August 11, 2016 and August 12, 2016. GPS and dwell time (train stop) data was recorded for each trip for the purposes of calibrating TrainOps train performance to "real world" train performance. Trip graphs were produced from the TrainOps simulation data showing speed versus distance; these were then overlaid with the GPS field data and are shown in Figure 3-7 (FrontRunner South southbound), Figure 3-8 (FrontRunner South northbound), Figure 3-9 (FrontRunner North southbound) and Figure 3-10 (FrontRunner North northbound).

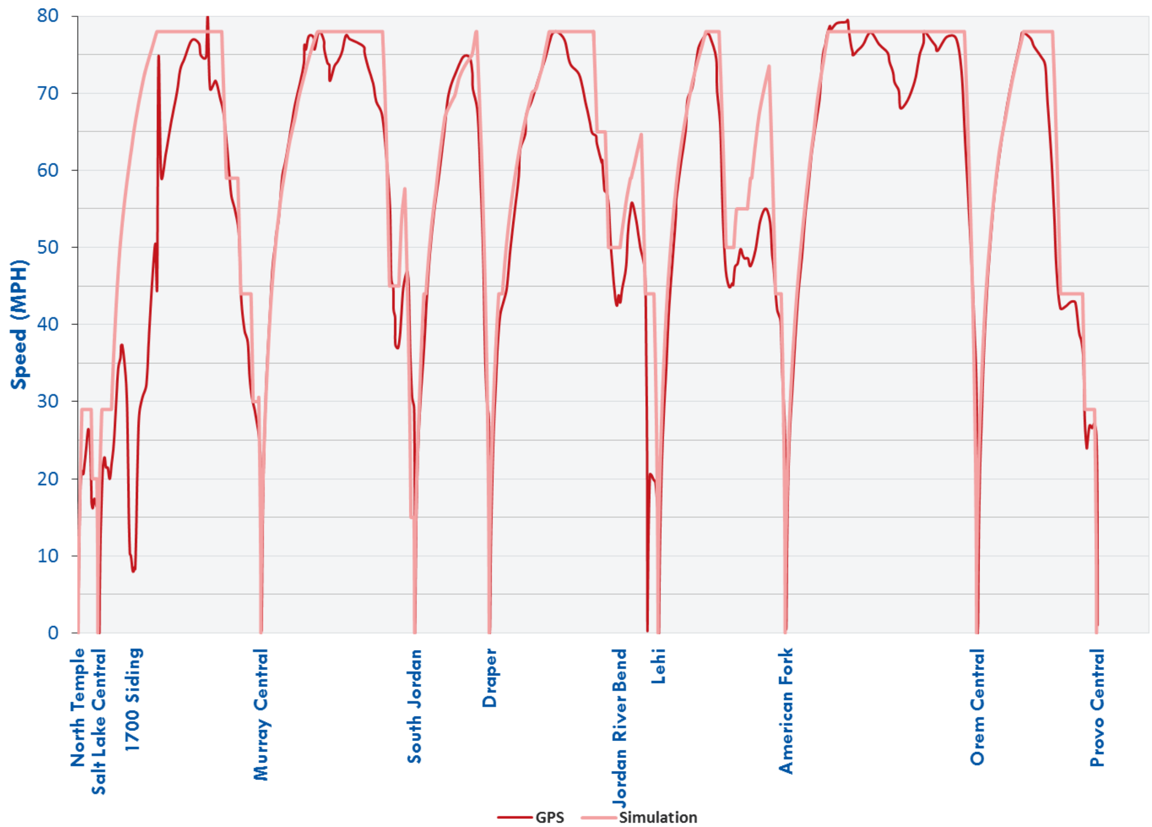


Figure 3-7: Existing Baseline Trip Graph – North Temple to Provo (Southbound)

The TrainOps modeling of perturbations is described in the next chapter and reflects a further calibration of the baseline simulation model.

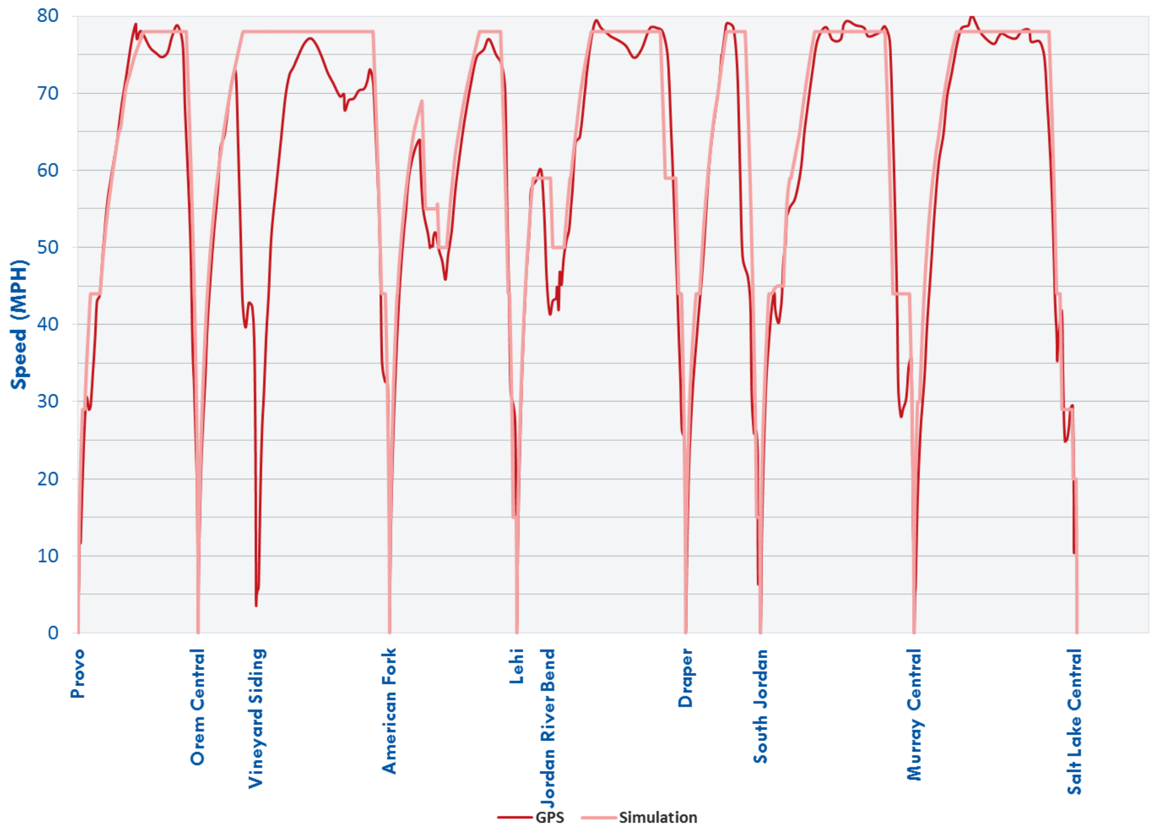


Figure 3-8: Existing Baseline Trip Graph – Provo to Salt Lake Central (Northbound)

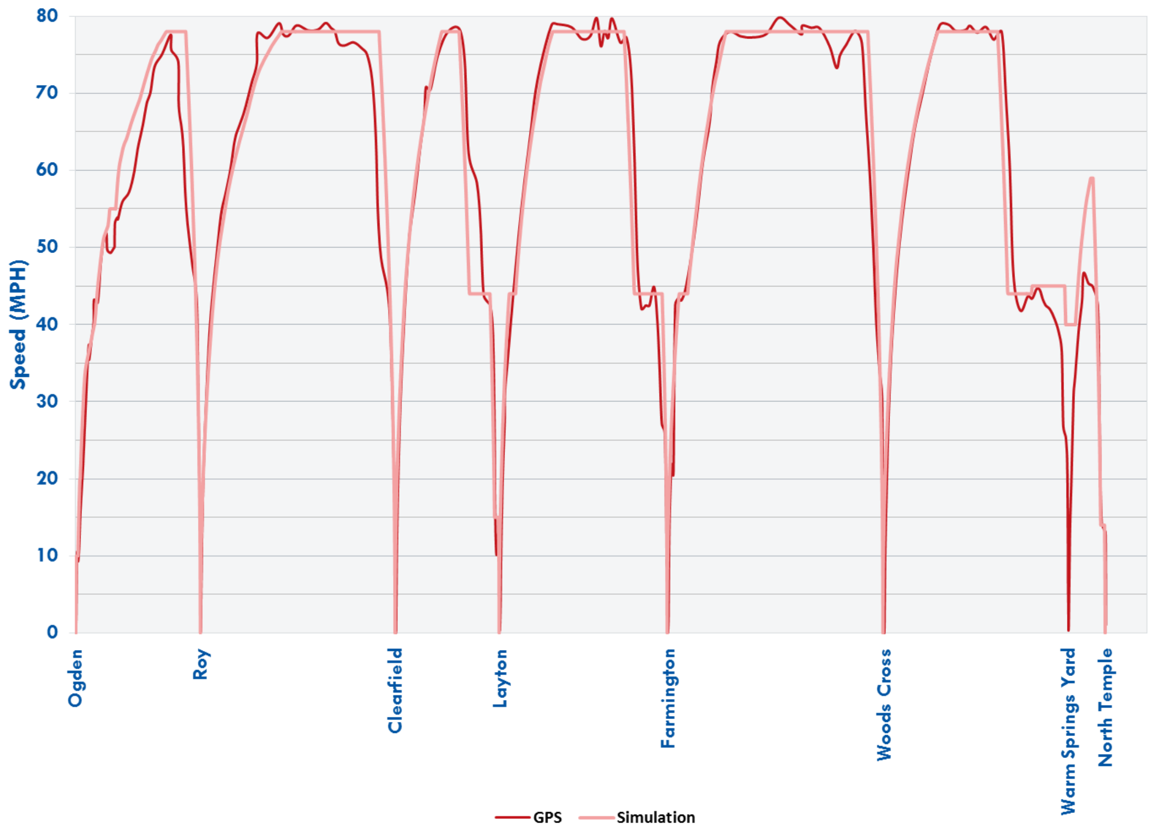


Figure 3-9: Existing Baseline Trip Graph – Ogden to North Temple (Southbound)

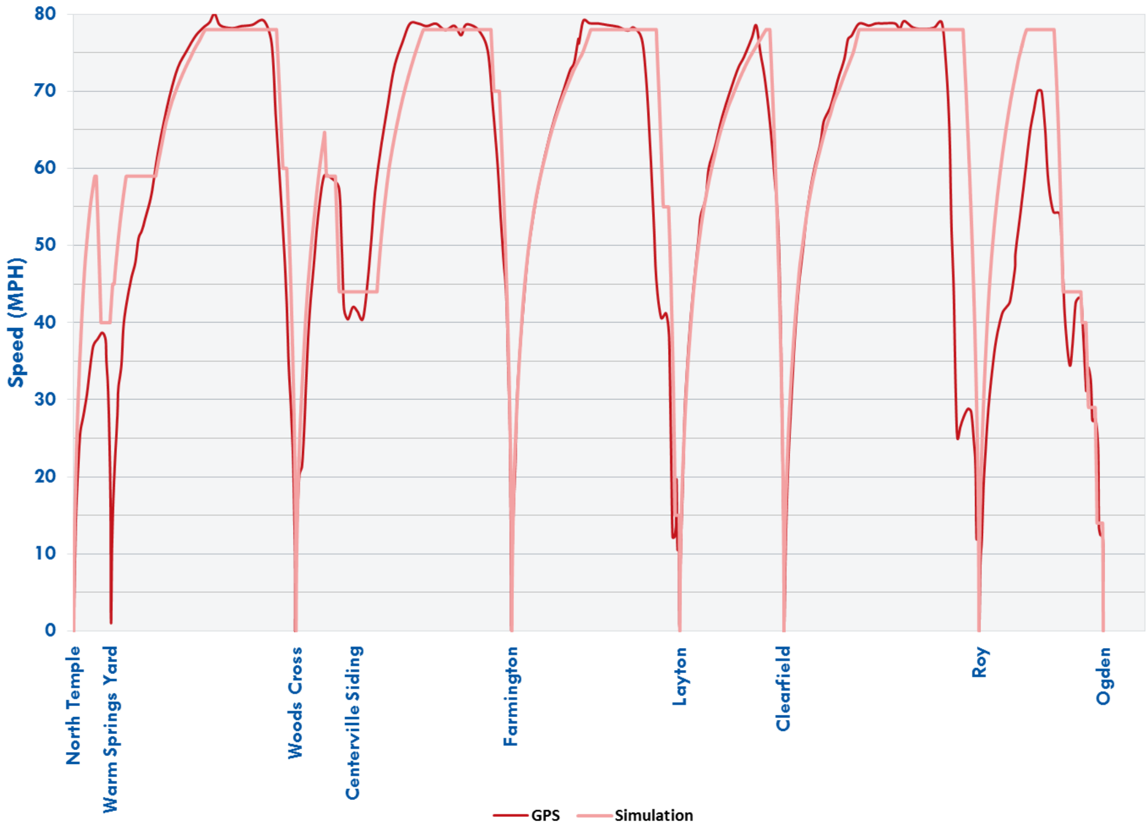


Figure 3-10: Existing Baseline Trip Graph – North Temple to Ogden (Northbound)

UTA also provided extensive Automatic Passenger Counter (APC) data that records station-to-station travel times using on-board sensors and GPS for 303 trips. A synthesis of this data for northbound FrontRunner trips is shown in Table 21 while a synthesis of southbound FrontRunner trips is shown in Table 22. The tables show both minimum and average trip time from the APC data, comparing them with "Golden Run" TrainOps results (0% schedule margin). The effective schedule margin is computed for each station to station pair with an overall schedule margin shown at the bottom. It should be noted that these travel times include en route delays such as extended wait times at sidings. The northbound analysis (shown in Table 21) has individual average schedule margins ranging from -12.5% to 9.6%. The computed overall average schedule margin is 1.0%, meaning that the trains in the simulation without any schedule margin included run 1% faster than the trains in the APC data. The southbound analysis (shown in Table 22) has individual average schedule margins ranging from -8.1% to 15.3%. The computed overall schedule margin is -0.4%, meaning that the simulation takes 0.4% longer on average than the trains represented in the APC data.

The overall average schedule margins for both northbound and southbound trips were averaged together and a 0.3% schedule margin was applied to all trips in the simulation. This results in a very slight reduction in FrontRunner train performance (acceleration, maintaining speed, braking, station dwells) versus no schedule margin being included in the model.

Table 21 - Existing Baseline Station to Station Travel Time Summary - Northbound

From	To	Average UTA	Minimum UTA	Simulation 0%	Margin (Avg.)	Margin (Min.)	Note
Provo Central	Orem Central	0:05:59	0:05:33	0:06:04	-1.4%	-8.5%	
Orem Central	American Fork	0:08:29	0:07:32	0:08:07	4.5%	-7.2%	
American Fork	Lehi	0:06:43	0:06:00	0:06:24	4.9%	-6.3%	
Lehi	Draper	0:07:48	0:07:20	0:07:51	-0.6%	-6.6%	
Draper	South Jordan	0:04:28	0:03:44	0:04:34	-2.2%	-18.2%	
South Jordan	Murray Central	0:07:15	0:06:50	0:07:26	-2.5%	-8.1%	
Murray Central	Salt Lake Central	0:08:08	0:07:25	0:08:09	-0.1%	-9.0%	
Salt Lake Central	North Temple Bridge	0:02:22	0:01:50	0:02:42	-12.5%	-32.1%	1
North Temple Bridge	Woods Cross	0:08:54	0:08:29	0:08:18	7.3%	2.2%	
Woods Cross	Farmington	0:08:02	0:06:34	0:07:20	9.6%	-10.5%	2
Farmington	Layton	0:06:37	0:05:47	0:06:42	-1.3%	-13.7%	
Layton	Clearfield	0:04:23	0:03:41	0:04:32	-3.3%	-18.8%	
Clearfield	Roy	0:06:59	0:06:22	0:07:03	-1.0%	-9.7%	
Roy	Ogden	0:06:14	0:05:08	0:06:16	-0.6%	-18.1%	3
	Overall	**1:32:21**	**1:22:15**	**1:31:28**	**1.0%**	**-10.1%**	

Notes:
1. Short station to station travel time
2. Meets on Centerville Siding
3. Some trains clear Ogden North Signal

Table 22 - Existing Baseline Station to Station Travel Time Summary - Southbound

From	To	Average UTA	Minimum UTA	Simulation 0%	Margin (Avg.)	Margin (Min.)	Note
Ogden	Roy	0:06:29	0:05:02	0:05:37	15.3%	-10.4%	
Roy	Clearfield	0:07:03	0:06:20	0:07:03	-0.1%	-10.2%	
Clearfield	Layton	0:04:35	0:03:56	0:04:40	-1.9%	-15.7%	
Layton	Farmington	0:06:29	0:05:54	0:06:31	-0.6%	-9.5%	
Farmington	Woods Cross	0:08:13	0:07:02	0:07:33	8.8%	-6.8%	1
Woods Cross	North Temple Bridge	0:09:34	0:08:51	0:09:42	-1.3%	-8.8%	
North Temple Bridge	Salt Lake Central	0:02:26	0:01:57	0:02:34	-5.3%	-24.0%	2
Salt Lake Central	Murray Central	0:08:41	0:07:40	0:08:19	4.5%	-7.8%	
Murray Central	South Jordan	0:07:23	0:06:38	0:07:43	-4.4%	-14.0%	
South Jordan	Draper	0:04:04	0:03:35	0:04:13	-3.7%	-15.0%	
Draper	Lehi	0:08:21	0:07:37	0:08:37	-3.1%	-11.6%	
Lehi	American Fork	0:06:25	0:05:58	0:06:32	-1.7%	-8.7%	
American Fork	Orem Central	0:08:55	0:07:36	0:09:42	-8.1%	-21.6%	3
Orem Central	Provo Central	0:06:31	0:05:50	0:06:46	-3.8%	-13.8%	
	Overall	**1:35:07**	**1:23:56**	**1:35:32**	**-0.4%**	**-12.1%**	

Notes:
1. Most trains use Centerville siding
2. Short station to station travel time
3. Most trains use Vineyard siding

4 Study Modeling Tools

This section addresses the two modeling tools used in the Future of FrontRunner Study – the WFRC/MAG Regional Travel Demand Model and the TrainOps Operations Simulation Model.

4.1 Regional Travel Demand Model

One of the key goals of the Future of FrontRunner study is to understand the potential to increase ridership on the system. To measure the ridership effects of the different Future of FrontRunner 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 future transportation demand for both transit and highway systems in the region. The model includes Utah, Salt Lake, Davis, and Weber Counties, representing the primary UTA service area.

The model estimates the travel patterns of people based on land use, demographic characteristics, and available transportation networks. The model forecasts where people are likely to travel and what mode they may take based on the distribution of households and employment and assigns these trips onto facilities that represent the best route for each trip. The model is one of the key tools used for developing the long-range regional transportation plans (RTPs) for both WFRC and MAG. It is also used in almost every major highway and transit project development process, including the FrontRunner North and FrontRunner South projects.

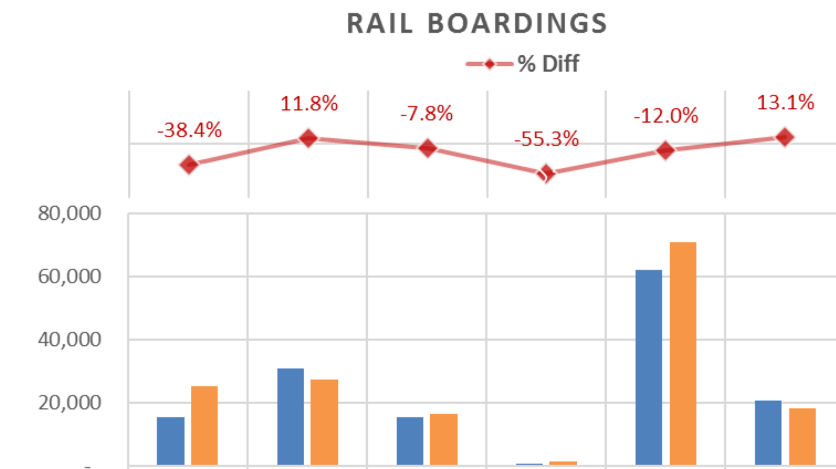
4.2 Travel Demand Model Version Selection

Version 8.3beta of the WFRC/MAG Regional Travel Demand Model was used to develop ridership forecasts for the Future of FrontRunner project. While this model version was still under development during this project, it was determined by WFRC, UTA, and the consultant team that it would be suitable to use for planning study purposes. Several key benefits of using this model version compared to previous model versions include:

- The geographic area was expanded to include portions of Box Elder County, which enables the team to evaluate FrontRunner service to Brigham City.
- Version 8.3beta utilizes a more refined TAZ structure in Utah County, allowing for better representation of current and future land use.
- Draft demographic and land use datasets are based on the 2017 Gardner Policy Institute county control totals and utilized the Real Estate Market Model (REMM) to develop future 2050 horizon year socio-economic forecasts. These data sets are sourced from the best available information and analytic tools.
- Speeds from LTK's Baseline Operations Model were used for calibration of the commuter rail element in the model.
- The previous model base year of development was 2011 which was prior to the opening of the southern segment of FrontRunner to Provo. Version 8.3beta used a 2015 baseline year and was calibrated using observed ridership data.
- Model 8.3beta was being actively used by WFRC to identify a preferred scenario for the 2019 long-range transportation plan update process, so the model results will be

based on assumptions consistent with other ongoing planning efforts. However, it should be noted that the model has continued to be updated during the course of this study and that the model version was dated on August 31, 2017.

- Initial transit validation of the model was determined to be reasonable. Baseline model boardings are within +/-20% of observed, which is the industry standard. Modeled FrontRunner boardings were 13% higher than observed boardings. (See Figure 4-1)[1]



	Blue Line	Red Line	Green Line	Sugar-house	All LRT	Commuter Rail
Model	15,576	30,684	15,317	587	62,165	20,742
Observed	25,301	27,443	16,609	1,315	70,668	18,342

Source: WFRC, Utah Model Advisory Committee August 31, 2017 V8.3 – 2017 -08-31.pptx

Figure 4-1: Transit Ridership Validation 8.3 Beta

4.3 Travel Demand Modeling Assumptions

The project team determined that land use, highway, and transit network assumptions would remain static in all Future of FrontRunner scenarios and that only modifications to the FrontRunner system itself would be made between the scenarios. This was done to isolate the ridership impacts of operational changes and capital projects directly related to FrontRunner. The project team also determined that a consistent horizon year should be used for all travel demand modeling and analysis. The intent was to provide an “apples to apples” comparison between scenarios. Through coordination with WFRC, 2050 was selected as the appropriate horizon year, and land use, demographics, highway, and transit networks used for each Future of FrontRunner Scenario are consistent with WFRC’s draft 2050 S1 scenario.

For scenarios where extensions of the FrontRunner system were introduced, they were coded into the model as separate transit lines. This was done to allow the extensions to have different peak and off-peak headway assumptions consistent with the operations modeling. This is similar to the methodology used for modeling the former FrontRunner service to Pleasant View which ended operation on August 10, 2018.

[1] Transit validation was shared at the August 31st, 2017 Utah Model Advisory Committee

4.4 Travel Demand Model QA/QC Process and Methodology

WFRC staff coded the scenario model runs and ran the model based on direction from the project team. This included updating link level speeds based on 5-day average speeds produced by the simulation modeling for each scenario. Completed scenario model inputs and results were then shared with Fehr & Peers to review the model set up and summarize results. This allowed for a second check of model inputs and results, allowing coding errors and other issues to be found and resolved more quickly.

Checks included the following:

- Headway assumptions for the FrontRunner system were consistent with the scenario.
- The number and location of FrontRunner stations were consistent with the scenario and that they included the correct park-and-ride assumptions and fare zone information.
- Station walk buffers were updated based on the stations assumed in the scenario.
- Average speeds from LTK's operations modeling for each scenario were correctly transferred to the model network rail links.
- A consistent 2050 socio-economic dataset was used for all scenarios (se2050s1.dbf)
- A consistent 2050 highway network was used for all scenarios, with the exception of changes to FrontRunner link average speeds (Master_120517_PTCSpeeds.net)
- A consistent transit network was used for all scenarios, with the exception of changes to the FrontRunner system.
- A seamless transfer was assumed at the Provo FrontRunner station for all scenarios that included an extension south. It should be noted that the Ogden FrontRunner station was already coded as having a seamless transfer to represent existing service to Pleasant View.

4.5 Travel Demand Model Metrics

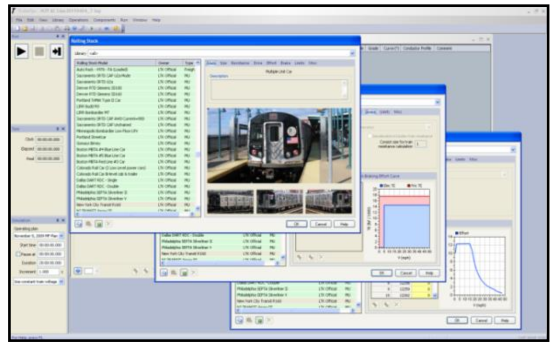
Using version 8.3beta of the WFRC/MAG Regional Travel Demand Model, LTK Team member Fehr & Peers selected several key ridership related metrics for reporting and comparing scenarios. This included:

- ***FrontRunner Daily Boardings:*** The total number of boardings at all FrontRunner stations on an average weekday. This metric was used to understand the difference in ridership on the FrontRunner system between each scenario.
- ***Daily Transit Trips:*** The total number of transit trips taken across the model region (Utah, Salt Lake, Davis, Weber, and a portion of Box Elder County). This metric was used to understand the difference in total transit system ridership between each scenario. This helps to isolate if new transit trips are being added, or if trips are shifting from another transit mode to FrontRunner.
- ***Stop Level FrontRunner Daily Boardings:*** The total number of boardings at individual FrontRunner stations on an average weekday. While the model reports station level boardings for all stations it is not calibrated and validated at a stop level. However, in order to estimate ridership effects from adding infill stations, stop level boardings were assessed for infill stations by combining infill station and adjacent station boardings together.

The results of the modeling are reported in Sections 8.3 (Future Baseline with PTC), 11.3 Low Investment Scenario), 12.3 (Medium Investment Scenario), 13.4 (High Investment Scenario) and 14.3 (High Investment Scenario with Infill Stations) of this report.

4.6 Rail Operations Simulation Model Description

TrainOps is the proprietary LTK operations simulation software used for modeling current, future baseline and future investment scenarios of the Future of FrontRunner Study. Developed and continually enhanced by a team of in-house software engineers, TrainOps is written in the C++ language and targeted for operation on high-performance 64-bit Windows computers.

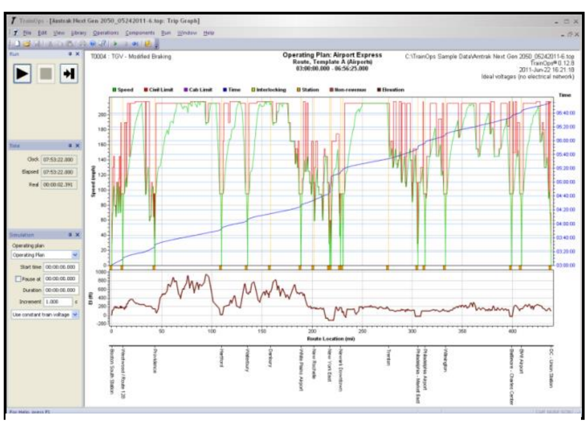


TrainOps features detailed rolling stock libraries (as well as the ability to add customized models), organized into locomotive, multiple unit, freight car and passenger coach categories.

Each TrainOps release is subject to quality testing by an independent TrainOps Quality Assurance Team. TrainOps testing includes user interface, functional, computational accuracy, processing efficiency, output reporting and many other tests – more than 8,000 in all. In addition, TrainOps' train performance and electrical network simulation algorithms are regularly validated through successful calibration to existing "real world" rail systems.

4.6.1 Typical TrainOps Applications

Optimizing Rolling Stock Selection and Performance: Many rail systems are interested in determining the optimal trade-off of train weight and power, as well as understanding if rolling stock under consideration can satisfy existing or planned trip times. For locomotive-hauled passenger trains, future capacity growth in the form of longer trains can have adverse performance impacts. TrainOps' comprehensive rolling stock library and user flexibility in creating and editing new rolling stock models support these analyses.



Very high speed rail simulation showing maximum authorized speed (red), simulated velocity (green) and trip time (blue).

Optimizing New Rail Alignments and Layouts: TrainOps' capabilities include the ability to toggle on and off specific alignment combinations within the same database supports analysis of the best trip times and most energy-efficient operation.

Analyzing Existing and Proposed Operating Plans: TrainOps supports the assessment of future operating plans in terms of on-time performance predictions, energy usage, rolling stock requirements, and the ability of the traction power system to support the proposed train level under "normal" and "contingency" operations.

Supporting the Alternatives Analysis and Environmental Impact Statement Process: Alternative Analyses and Environmental Impact Statements need detailed train operations information. TrainOps supports these wide-ranging analytical needs, including outputs that can support:

- Operations and maintenance cost models,
- Noise and vibration studies,
- Rail-highway at-grade crossing gate down time predictions for vehicular traffic studies,
- Energy usage analyses,
- Fossil fuel emissions levels,
- “Before” and “after” trip time and throughput generation for ridership modeling purposes.

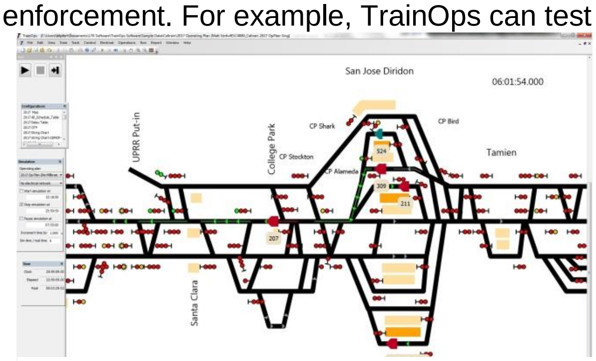
Evaluating Capacity Benefits of New Train Control Designs: TrainOps’ “signal wake” function quantifies minimum supportable headways (signal system capacities) for any alignment, using defined train consists, stopping patterns, dwell times and signal system parameters. This capability can be used to identify the hierarchy of capacity-constraining (most constraining to least constraining) and to evaluate the capacity benefits of small-scale changes such as signal relocations, speed changes and signal control line changes. TrainOps can also be used to evaluate trade-offs in complete signal system redesigns, including such architectures as:

- Wayside signals,
- Wayside signals with cab signal overlay,
- Cab signals
- Target-based cab signals with profiling
- Wayside signals with Positive Train Control (PTC) overlay,
- Communications-based train control.

TrainOps supports the analysis of Positive Train Control systems both in terms of stand-alone systems or systems overlaid on conventional signaling systems. The software supports different brake rates for the same train consist and for multiple consists, depending on the type of train control system and type of enforcement. For example, TrainOps can test the benefits of PTC with different enforced brake rates for civil speed restrictions versus stop signal enforcement.

4.6.2 TrainOps Database Development

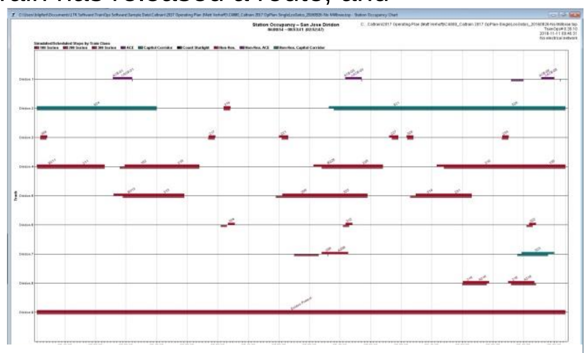
TrainOps is developed using modern software technologies and development methods. There is no inherent software limit on the size of the rail network, the complexity of the traction power system (if modeled), the number of trains that can be simulated, or the duration of simulation. In short, it can model any rail network of any size.



TrainOps run-time graphics show the status of each interlocking route, including green (route established), red (stacked route – route requested but occupied by another train, purple (route requested but not yet established) and gray (route being released).

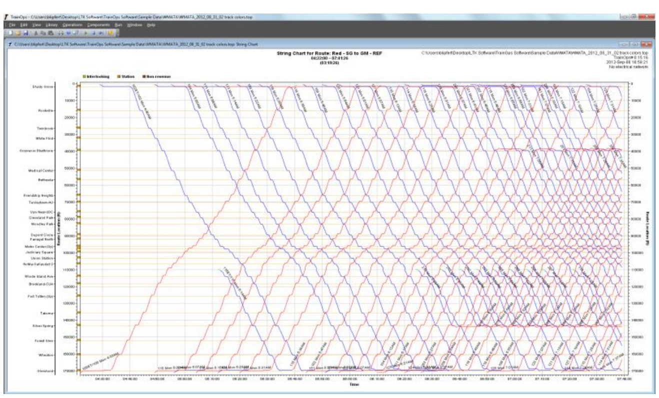
TrainOps was specifically developed to enable comprehensive modeling and studies of AC and DC-electrified railroad and transit train operation, as well as operations of fossil fuel-powered trains. The program provides user-friendly inputs (including the ability to “cut and paste” from spreadsheets) for all relevant system and rolling characteristics, including:

- Route alignment data, including track gradients, horizontal alignment and speed restrictions (which can differ by train class),
- Passenger station locations,
- Train data, including weight, dimensions, propulsion system characteristics, and braking system parameters,
- System train control data, including wayside signaling, cab signaling and Positive Train Control inputs (optional) with user-friendly “point and click” control line data entry (optional),
- Operations data, such as train consist sizes, train consist manipulations at terminals/yards, operating plan (timetable) inputs, passenger station stopping pattern, train loadings and station dwell times,
- Dispatching data, such as route request points (or dispatcher route establishment goals ahead of each train as a function of train class), routing preferences and route establishment times after a conflicting train has released a route, and
- Variability data, such as dispatch uncertainty (for trains leaving yards or arriving from external locations), schedule margin, schedule holds at stations, interlocking route establishment times (dispatcher attentiveness), street signal (intersection) hold times and probabilities of a red signal, tractive effort and brake application rate (optional).



Terminal track occupancy diagram showing simulated times (above the line) and scheduled times (below the line) with train classes distinguished by color.

TrainOps Operations Simulation Algorithms

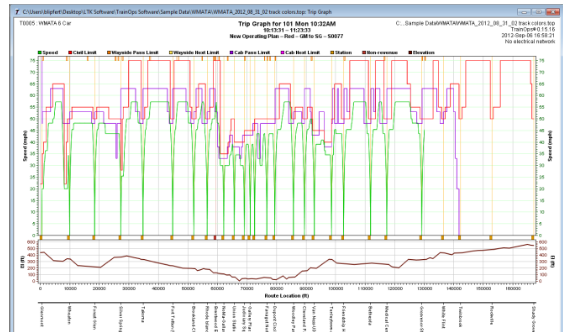


TrainOps time-distance string chart for rapid transit service ramp-up, including color coding by track and representation of midline turnback locations.

TrainOps provides full dynamic routing capability, ranging from selection of alternative tracks at a transit terminal to meet/pass planning on single/multiple track railroad to full network optimization where there may be completely different routes to travel from one city to another. This dynamic routing capability is fully user-configurable on a site-specific location, with the ability to specify different “decision strengths” at each interlocking where a routing choice is available. For large rail networks where individual interlockings are controlled by different railroads’ dispatchers, preferences can be specified on how specific train classes (which may represent the trains of one railroad versus another) are expedited.

TrainOps’ dispatch algorithms work as the simulation runs, providing transparency in how the rail network is being dispatched.

TrainOps Modeling Flexibility



TrainOps trip graph for an ATC cab signal system with civil speed enforcement. Graphs are dynamically updated while the simulation runs (note the right end of the green plot shows the current location of the train; the right end of the purple plot shows the limit of dispatcher route establishment for this train trip).

TrainOps supports rail network modeling with all system components represented individually in the model. A typical simulation may include the following variations in rail network infrastructure and operational attributes:

- Changes in gradients, curvature and speed restrictions (including different speeds for different train classes) as function of individual track or route,
- Different vehicles and train make-ups (as multiple units or locomotive-hauled trains), including homogeneous and heterogeneous consists,
- Different passenger station stopping patterns for each train trip, such as express, local and skip-stop train service,
- Different passenger station dwell times for each station and train,
- User-selectable time step, ranging from coarse computations for rapid-response planning studies to fine computations for sophisticated engineering analyses.

4.7 Rail Operations Simulation Model Metrics

The primary TrainOps metrics used for evaluating the Future of FrontRunner alternatives are end-to-end average travel time and OTP. In addition, TrainOps produces fleet requirement statistics that serve as an input to the study's capital cost estimates. TrainOps also produces station-to-station average travel times for use in the ridership model, as described in Section 4.2.

The TrainOps OTP tables report the percentage of FrontRunner stops considered to be "on time" based on four different lateness tolerances:

- 0 minutes, 0 seconds
- 3 minutes, 0 seconds
- 4 minutes, 59 seconds (the official UTA lateness tolerance for FrontRunner)
- 10 minutes, 0 seconds.

The tables also include an "All Trains" column which is generally identical to the 10 minute lateness tolerance results. The OTP tables are sub-divided into seven rows:

- Ideal Day Simulation
- Typical Day ("Perturbed") Simulation – Day 1
- Typical Day ("Perturbed") Simulation – Day 2
- Typical Day ("Perturbed") Simulation – Day 3
- Typical Day ("Perturbed") Simulation – Day 4
- Typical Day ("Perturbed") Simulation – Day 5
- Average Typical Day ("Perturbed") Simulation Results

Unlike many commuter rail operators, UTA computes OTP at all revenue stations. As an example, 10 FrontRunner trips making 10 stops (in-line and terminal) would yield 100 data points. If individual trips departed later than the 4:59 lateness threshold at a total of 6 station departures, the OTP would be reported as 94% (100-6). UTA tabulates early station departures (even trips departing only a few seconds early) as “late” for OTP tabulation purposes. This typically occurs several times per day but is not a significant driver of OTP results. TrainOps was coded to not permit early departures at any revenue station locations so this never occurs in the simulation and, therefore, early train departures never affect simulated OTP.

TrainOps produces time-distance (“string”) charts and station occupancy charts providing visual comparisons between scheduled and simulated results. These graphics are voluminous as they were produced for the 24-hour ideal day simulation and the five days of perturbed simulations for each of the FrontRunner investment scenarios.

Station occupancy charts for each simulation indicate the train’s scheduled arrival below the horizontal line corresponding to a track and the train’s actual arrival time above the horizontal line. The trains are numbered with the equipment cycle number followed by a dash and then the trip number for that day. A single number over the bar indicates a through train and a second number paired with the first indicates a train that changes direction at the station. Figure 4-2 explains how to identify early and late trains within the station track occupancy charts.

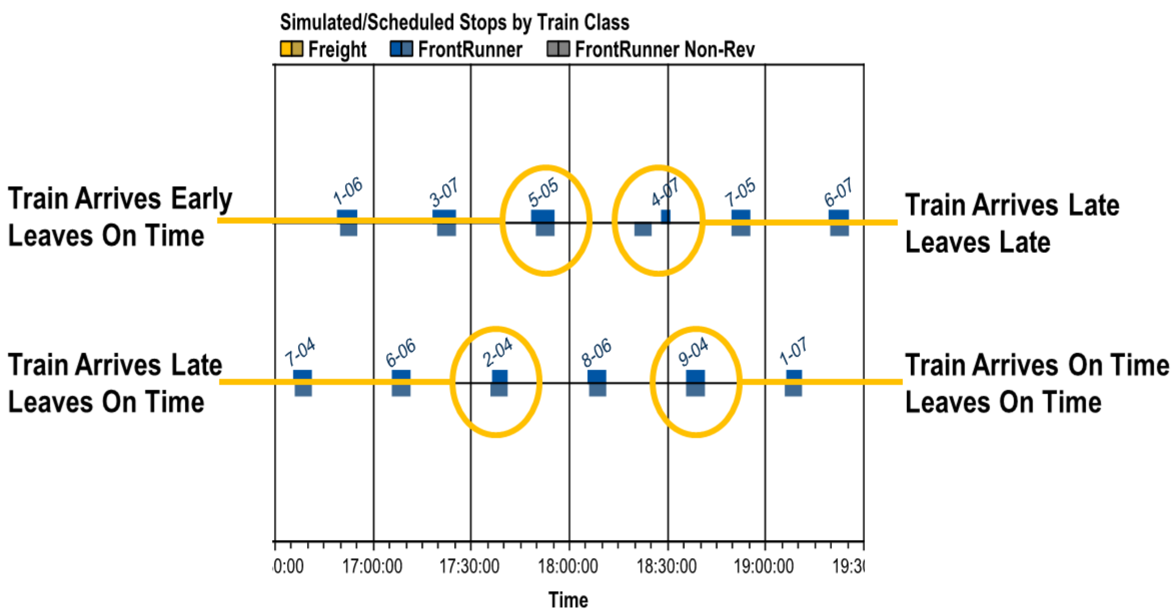


Figure 4-2: Interpreting the Station Track Occupancy Charts (Not Actual Results)

The TrainOps time-distance (“string”) charts, an example of which is shown in Figure 4-4, represent the simulated day broken into four 6-hour periods. The left axis shows the stations in orange while the location along the route as measured in feet from Pleasant View station is show on the right axis. The time-distance (“string”) charts use dashed lines to show the scheduled activity for the trains and solid lines colored by track for the simulated traces of train trips, as follows:

- Blue for main track
- Red for sidings and yards
- Yellow for non-UTA and freight tracks

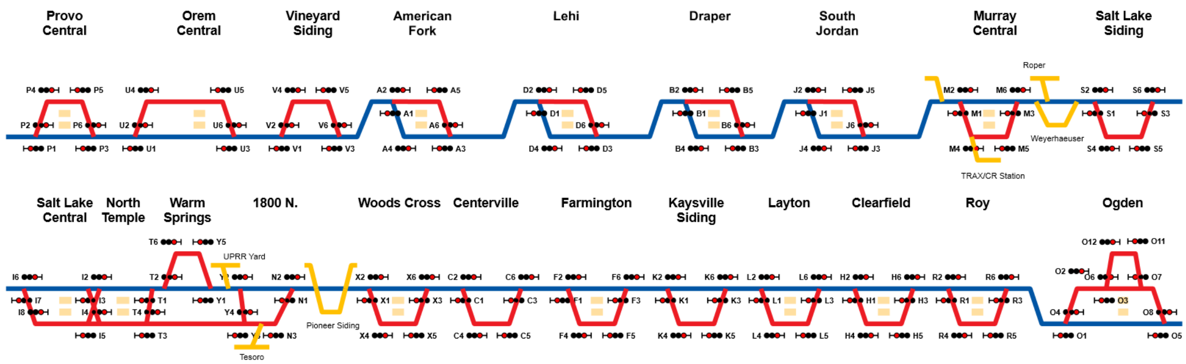


Figure 4-3: Interpreting the track colors on the Time-Distance String Charts

Station dwells and stopped delays in the string chart appear as horizontal portions of the string lines. Changes in train speed due to delays or temporary speed restrictions are seen by lines that become less steep than those for typical trips. The string charts show the late night and overnight freight train movements crossing the FrontRunner Corridor as short "strings" in the vicinity of the Weyerhaeuser, Tesoro and other industry sidings.

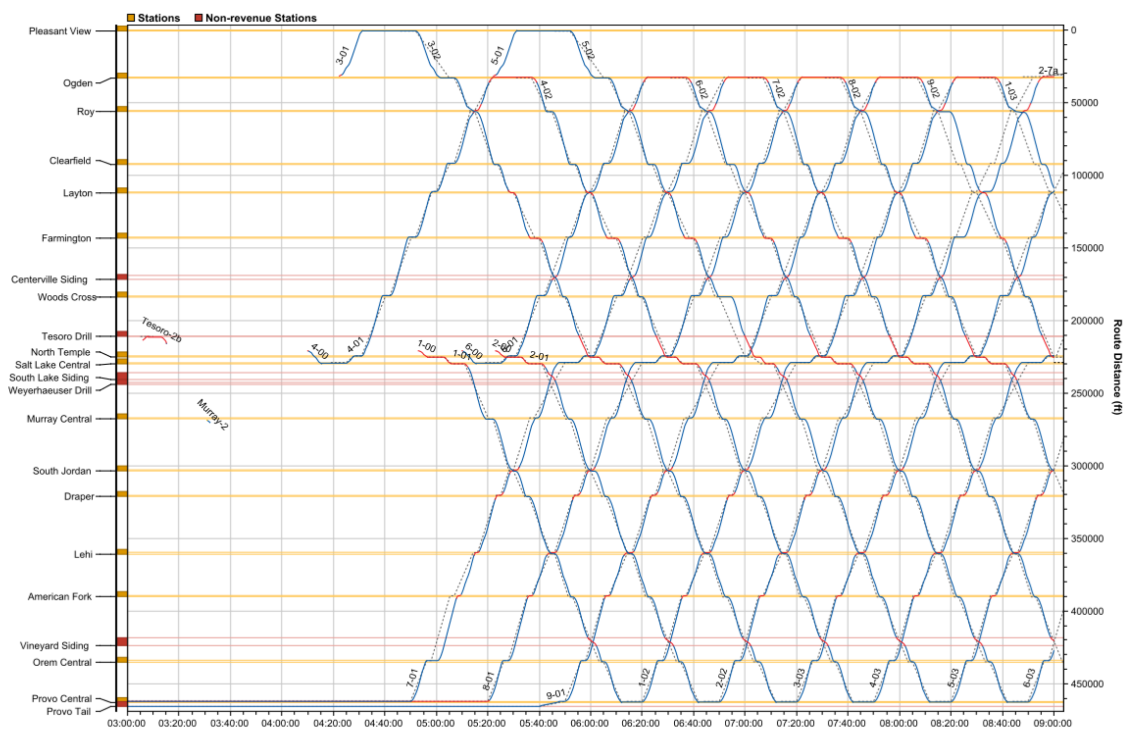


Figure 4-4: Typical FrontRunner Time-Distance "String" Chart showing Provo at bottom, Ogden at top and color-coded simulated train plots between them.

TrainOps produces detailed time-distance string charts for the FrontRunner network. Delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones (solid strings to the right of dashed strings indicate train lateness). The trains run very close to on-time in the No Added Perturbations run. In addition, the solid strings are color-coded to show track usage with blue representing main track and red representing sidings and second main tracks.

5 Transit Reliability and Ridership

The purpose of this chapter is to provide a summary of literature focused on the relationship between transit reliability and ridership. In addition, this section provides an overview of regression analysis conducted on UTA ridership and reliability data to determine if additional adjustments should be made to travel demand model outputs for the Future of FrontRunner Study.

For the baseline case of this study, UTA FrontRunner had an average daily on time performance (OTP) of 87%[2]. This is lower than both the UTA system average OTP of 90% and the OTP of the TRAX light rail system of 94%, suggesting that FrontRunner is less reliable than other UTA services, particularly the other mode which operates in an exclusive right-of-way. In addition, there have been days when reliability of FrontRunner has significantly dipped, in some cases to as low as 50%. There has been little analysis to understand if these current reliability issues have had a measurable effect on FrontRunner ridership.

5.1 Literature Review

A review of available national peer-reviewed research was conducted to determine the extent to which a relationship between transit reliability and ridership has been quantified, along with possible methods for integrating reliability into travel demand model processes. Sources that exclusively looked at reliability effects on ridership are limited and only those that provided quantifiable analysis were included in this review.

5.1.1 Akram Nour, J. C. (2010). An Anxiety-Based Formulation to Estimate the Generalized Cost of Transit Travel Time. Transportation Research Board

This article explores the effect of unreliable transit service on perceived costs, with the intent to improve mode choice models. Using the Waterloo, Ontario bus system as a test case, the authors developed a simulation to estimate a generalized cost formulation that accounts for reliability through adjustments to in-vehicle trip times. This was accomplished using an anxiety measure that depends upon a traveler's ability to assess the likelihood of being late from a given point to their destination. In the test case, travelers were classified into three groups – risk averse, moderately risk averse, or risk neutral. The test case simulated 10,000 peak hour trips between two origin and destination pairs.

The results suggest that unreliability in transit service can produce high generalized costs that can dissuade travelers from using transit, particularly for those who are risk averse. However, in most cases, reliability anxiety accounted for only 10% of the total generalized cost. The authors also note that there is little basis for the relative weights for anxiety assumed in the modeling. While the article makes a compelling argument that assuming a higher in-vehicle trip time to better account for poor reliability could improve modeling accuracy, additional research is needed to truly identify specific adjustments to be made to real or perceived in-vehicle trip times.

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[2] Based on reliability data provided by UTA for 2015 and the first three months of 2016.

5.1.2 National Center for Transit Research Center for Urban Transportation Research. (2008). Transit Reliability, Ridership, and Retention. Tampa, FL: State of Florida Department of Transportation

This report explores several components that affect transit ridership, including transit reliability, rider cessation, and infrequent rider characteristics. Although the report notes that the cost of unreliable service may be higher than the cost of travel for some users, it acknowledges that there is little transit specific research in this area. In addition, improvements to reliability typically coincide with implementation of other major changes to a route such as increased frequency, a reduction in the number of stops, and the addition of other amenities. This makes it difficult to determine if ridership increases are caused by improved travel time reliability or by these other improvements.

The report includes analysis of raw data from on-board surveys, customer satisfaction surveys, household travel surveys, and a comprehensive Puget Sound Transportation Panel. Based on this data, it was found that reliability is cited as very important for current transit riders and is often among the most-requested service improvement. However, both current transit users and non-transit users agreed that delays had less impact if accurate real-time destination information was available. In a sense, real-time information served as a proxy for reliability. In addition, the analysis suggests that poor reliability is not typically the root cause for people to stop using transit. Data from household travel surveys in Washington, D.C. and Pinellas County, Florida, indicated that users stop using transit when they gain access to a car, change jobs, or move. Smaller percentages of respondents indicated dissatisfaction with transit service characteristics as their reason for ceasing transit usage.

Ultimately the report found that the nature of the relationship between reliability and ridership growth was unclear. However, the data does show that reliability is a critical component in increasing and maintaining good customer satisfaction.

5.1.3 Transit Cooperative Research Program. (2014). TCRP Report 166: Characteristics of Premium Transit Services that Affect Choice of Mode. Washington D.C.: Transportation Research Board

This report focused on identifying and quantifying impacts of characteristics of premium transit services as well as methods for integrating these into travel forecasting tools. In total, 20 service attributes were analyzed, including reliability. Data on transit attributes, traveler attitudes and awareness were collected and analyzed in Chicago, Charlotte, and Salt Lake City. Using a maximum difference (MaxDiff) scaling methodology from surveys, the value of each service attribute was expressed as an equivalent of in- vehicle travel time (IVTT). The 20 service attributes, when combined, were valued at a maximum of between 13 and 29 minutes of reduction in IVTT, depending on the location (Charlotte, Chicago) and trip purpose (commute, non-commute). Table 23 highlights the results of the IVTT reduction associated solely with the reliability service attribute.

Table 23 - Reliability Value in 'In Vehicle Trip Time' Results (Minutes)

Attribute	Commute Trips			Non-commute Trips		
	Charlotte	Salt Lake City	Chicago	Charlotte	Salt Lake City	Chicago
Reliability	4.59	0.44***	5.64	-	0.29***	4.63

***The reliability measure was redefined in the survey for Chicago and Charlotte, so this value is not comparable to the value for Salt Lake City.

Unfortunately, the reliability measure was redefined and survey questions were updated for Chicago and Charlotte. Therefore, the IVTT reduction value for Salt Lake City is not comparable with the value for the other two cities.

A previous version of the WFRC/MAG model in the Salt Lake City area was selected as the test case for integrating premium service attributes into the path-building step of the modeling process. For each service attribute, the IVTT minutes were developed by averaging the Chicago and Charlotte survey responses for commute trips. Salt Lake City Survey results were not used as the Chicago and Charlotte surveys had better information from a methodological standpoint. Since the Salt Lake City system only included 11 of the possible 20 premium service attributes, these values were scaled up to represent the potential full benefit gained from premium services. Table 23 summarizes the values used for reliability.

5.1.4 Literature Review Conclusion

Based on the literature review there is not a well-documented clear link between transit reliability and ridership effects. Intuitively, poor reliability should reduce ridership and improved reliability should add riders. However, few studies have been conducted to evaluate these impacts. Doing so is often challenging because typically changes to reliability are often implemented with other modifications to service frequency, span, and the addition of other amenities.

However, there have been several efforts to incorporate reliability into modeling applications. Typically this is accomplished by adding to or decreasing IVTT. The most comprehensive study used survey data to estimate that good reliability is valued at approximately 5 minutes. Yet, this change did not improve commuter rail ridership estimation compared to a model that did not factor in reliability.

5.2 FrontRunner Reliability and Ridership Analysis

Since there is little research related to transit reliability and ridership effects, the project team chose to investigate historic UTA reliability and ridership data (January 2015-March 2016) to see if there was measurable correlation between reliability and ridership. Figure 5-1 summarizes the data for this time period.

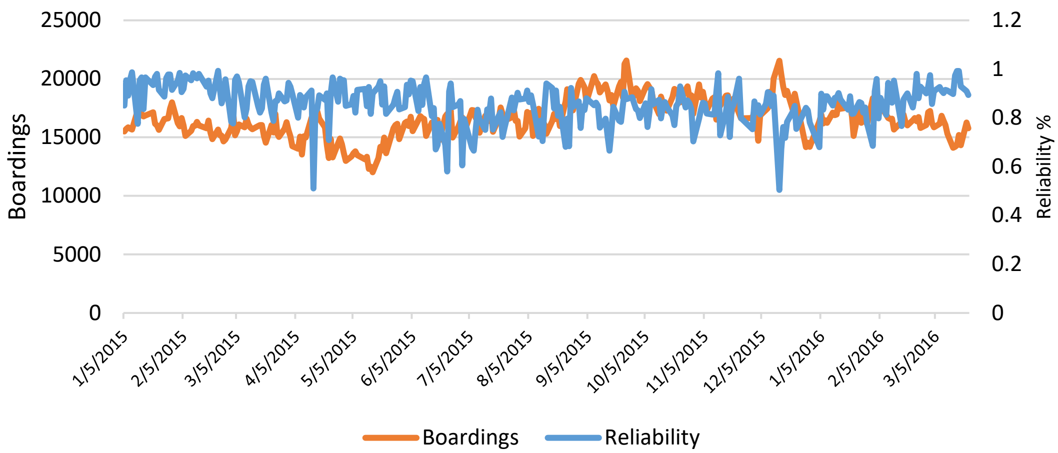


Figure 5-1: FrontRunner Boardings and Reliability (2015 – March 2016)

Regression analysis was conducted to try to estimate the effect of reliability on ridership. The units of this analysis were weeks, and the dependent variable was each week's average weekday boardings, excluding Saturdays and holidays. Some days prior to and following major holidays were also removed from the analysis, as ridership was lower due to the proximity to the holiday rather than service reliability. Several regressions were performed to investigate the relationship between past reliability and ridership, using time horizons of one week, two weeks, and one month. The following figures (Figure 5-2, Figure 5-3, Figure 5-4) provide a graphic representation of these regression models.

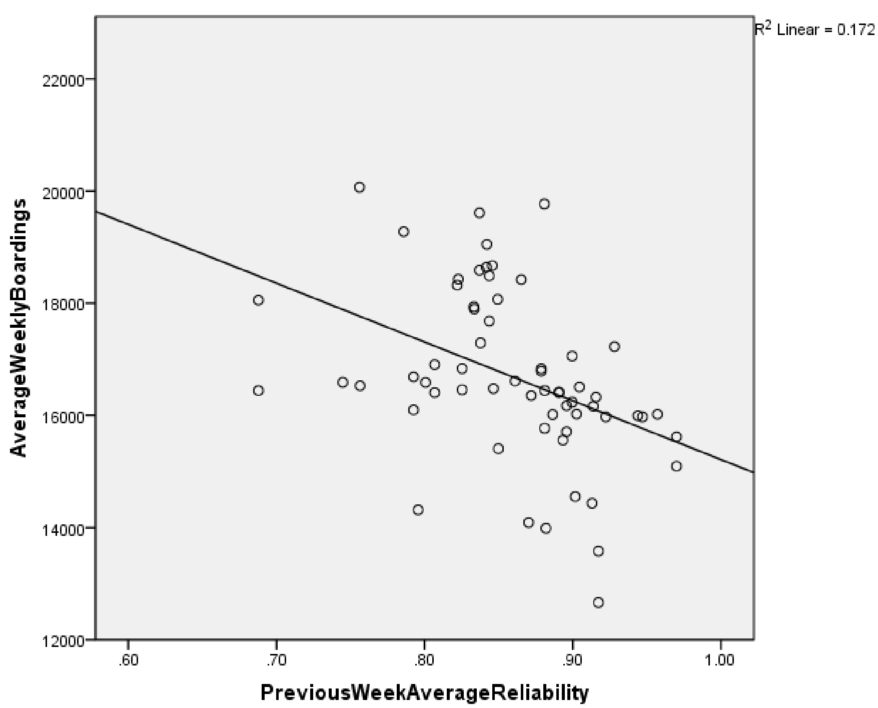


Figure 5-2: Regression 1 - Average Week Boardings and Average Week Reliability

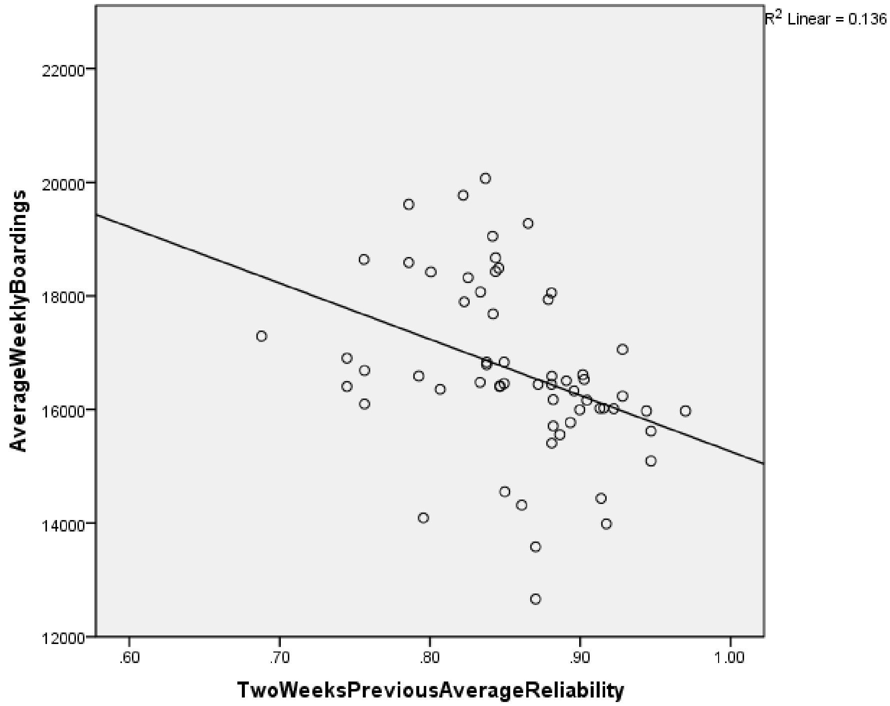


Figure 5-3: Regression 2 - Average Week Boardings and Average Reliability Two Weeks Prior

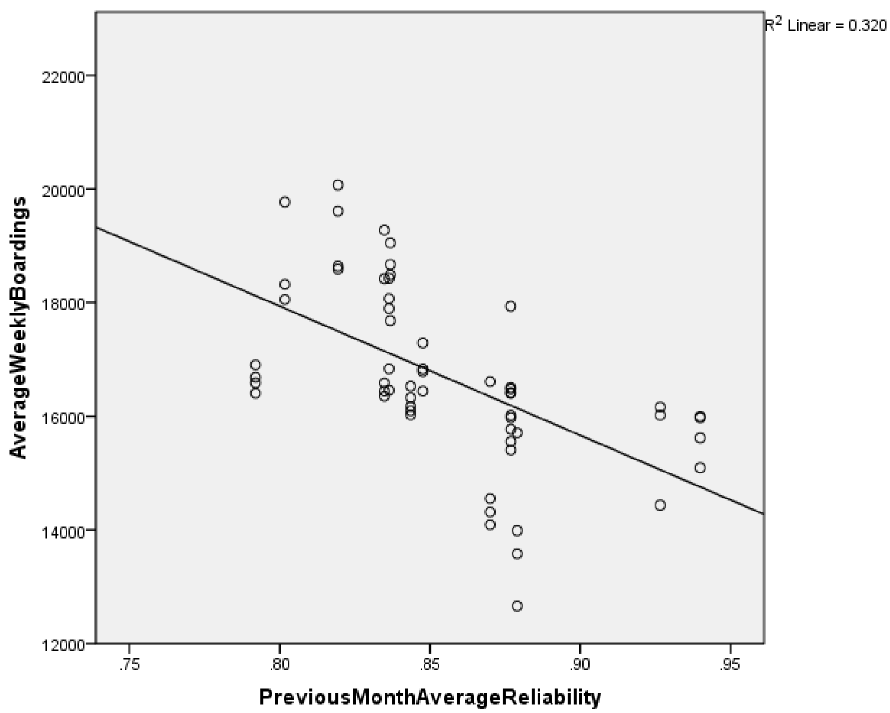


Figure 5-4: Regression 3 - Average Week Boardings and Average Reliability One Month Prior

These linear regression results indicate that the relationship between ridership and reliability is quite weak and that there does not appear to be a statistically significant correlation between poor reliability and lower ridership. The R^2 measure of statistical correlation is well below 1, indicating that these models explain little of the variability in average weekday boardings.

Following this first evaluation, additional regression analyses were conducted to control for seasonal variations. Based on observations of FrontRunner ridership data, season seems to be influential in ridership patterns (see Figure 5-5).

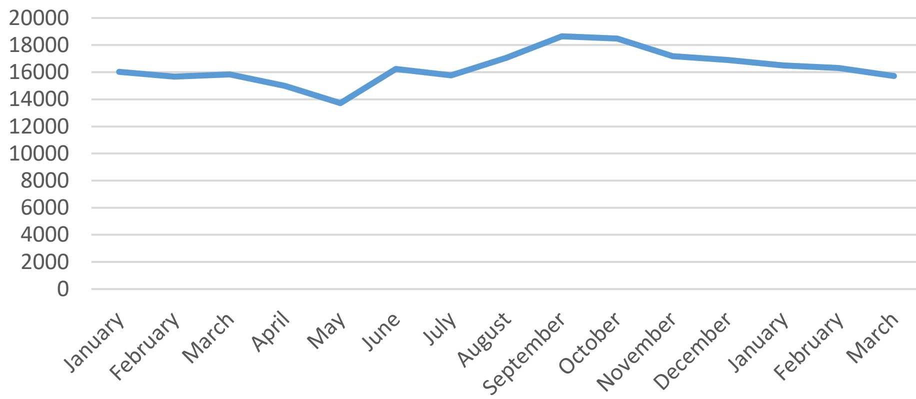


Figure 5-5: FrontRunner Average Monthly Boardings by Month (2015 - March 2016 Weekday)

For these analyses, the dependent variable selected was the difference between each week's average weekday boardings and the seasonal average boardings. The following figures (Figure 5-6, Figure 5-7, Figure 5-8) provide a graphic representation of these regression models.

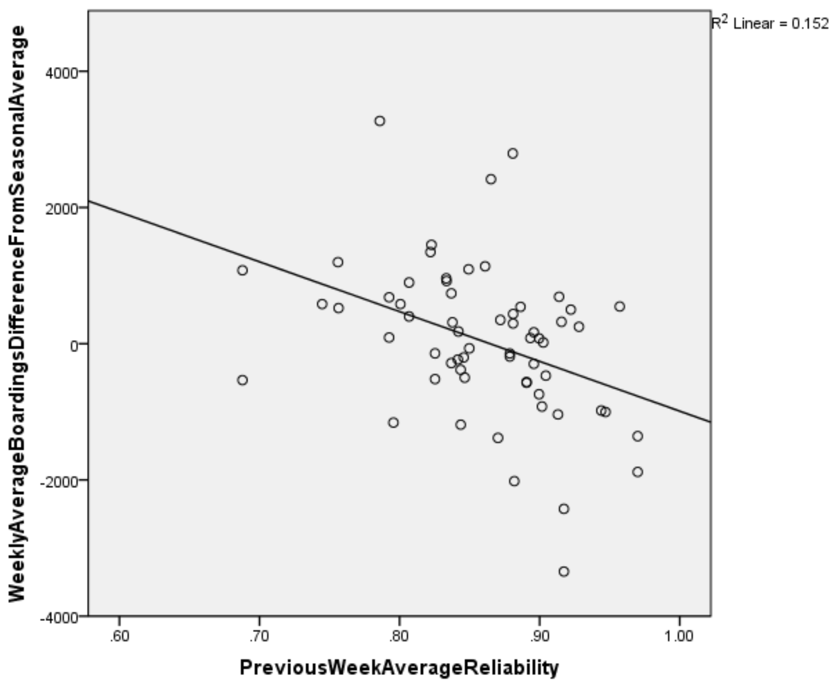


Figure 5-6: Regression 4 - Average Week Boardings Difference from Seasonal Average and Average Reliability One Week Prior

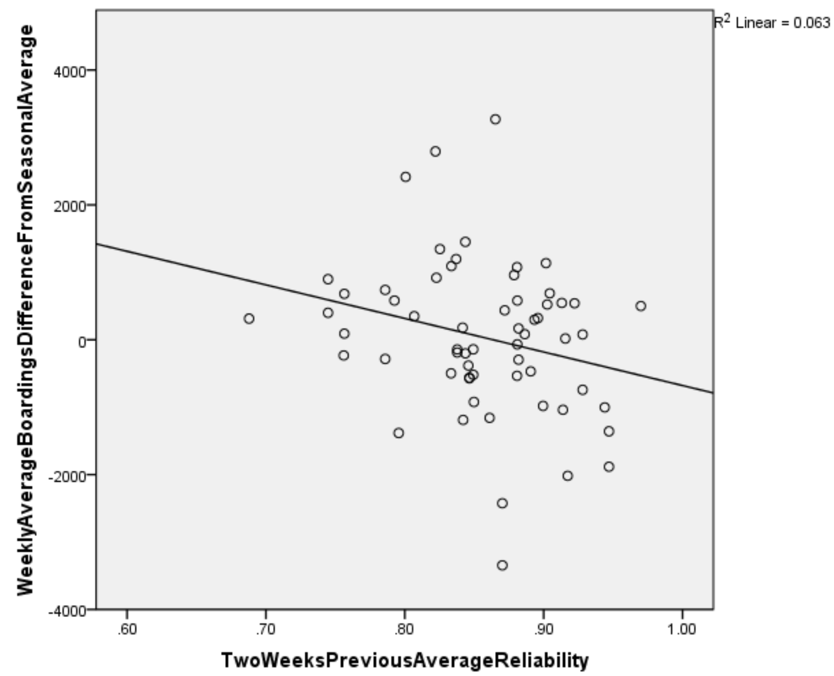


Figure 5-7: Regression 4 - Average Week Boardings Difference from Seasonal Average and Average Reliability Two Weeks Prior

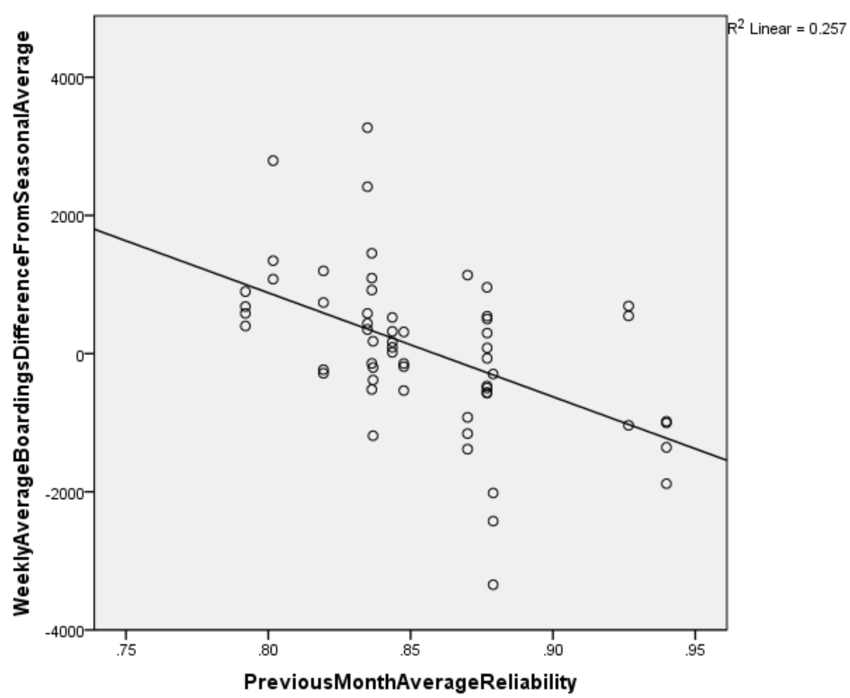


Figure 5-8: Regression 5 - Average Week Boardings Difference from Seasonal Average an Average Reliability One Month Prior

As before, the R^2 measure of statistical correlation is well below 1, indicating that these models also explain little of the variability in average weekday ridership.

5.2.1 FrontRunner Reliability and Ridership Analysis Conclusions

Based on this analysis, there does not appear to be a clear relationship between reliability and FrontRunner ridership. Ridership has remained relatively steady outside of seasonal variations during the timeframe analyzed. This suggests that either the effect of reliability on ridership is quite small, or it occurs on a much longer-term basis. Other theories surmised by the project team include:

- FrontRunner travel times are already uncompetitive compared to using a private automobile for most trips. Therefore, those using the system have already made a choice to use FrontRunner for other reasons (air quality, transit dependency, ability to work while in transit, etc.). Some disruptions in on-time performance and reliability are not enough to cause shifts in user behavior.
- While there are significant dips in reliability, overall the service is approximately 87% reliable. Simply stated, the service quality may not be poor enough to have a measurable effect on ridership. FrontRunner riders have a level of tolerance, or a forgiveness factor, for the current reliability issues.
- While some riders may no longer use the system after experiencing poor reliability, they are being replaced by new riders. This could explain why ridership on the system has remained relatively flat.

Given the results of this analysis, post-processing or changes to the travel demand model to reflect changes in FrontRunner reliability were not recommended for the Future of FrontRunner study. While literature supports a methodology to change IVTT to factor in reliability, local data analysis does not suggest a clear relationship between reliability and ridership on the system. While it is possible that improved reliability would improve ridership, the impact may be limited. Instead, the benefits of improved reliability should be measured using other metrics, such as higher customer satisfaction or a reduction in reliability related complaints from riders.

6 Sunday Service Ridership Estimation

The purpose of this chapter is to summarize the methodology and results of estimating ridership for Sunday service on the UTA FrontRunner commuter rail system. Currently, the FrontRunner system does not operate on Sundays. However, there is interest in better understanding the potential ridership from Sunday service.

UTA FrontRunner Maintenance of Way managers have noted that most major FrontRunner maintenance activities, especially those requiring track outages, are presently conducted on Sundays. The implementation of Sunday service would require such activities to be shifted to overnight hours during the course of the week. As a result, individual maintenance work windows would be reduced in length, reducing maintenance efficiency and increasing overall FrontRunner maintenance costs. Changes in maintenance costs as a result of Sunday service are not addressed in this memo.

6.1 Methodology

While the FrontRunner system does not currently operate on Sundays, the TRAX light rail system does. For the purpose of this analysis, ridership on the three TRAX routes was analyzed as a proxy for Sunday ridership on FrontRunner. Additionally, differences in ridership between weekdays and Saturdays were analyzed for both the FrontRunner and TRAX systems.

UTA provided Fehr & Peers with 2015 data on annual revenue hours and annual riders for each TRAX route and the FrontRunner system broken out by weekday, Saturday, and Sunday service. A regression analysis to determine statistical correlation among these variables was then performed. Observed annual ridership served as the dependent variable. Annual revenue hours and the day of week type (weekday, Saturday, and Sunday) served as the independent variables. This resulted in a regression model with an adjusted R2 of .975 with a value of 1.000 representing perfect correlation. This suggests that the regression model is well fit to the observed data.

The model uses the following regression equation:

$$Y = a + b1 * X1 + b2 * X2 + b3 * X3$$

Where:

Y = Boardings
a = Constant
b1 = Revenue Hours Coefficient
X1 = Revenue Hours
b2 = Saturday Dummy Coefficient
X2 = Saturday Dummy Variable
b3 = Sunday Dummy Coefficient
X3 = Sunday Dummy Variable

Figure 6-1 compares estimated boardings from the regression model to observed ridership on each TRAX route and the FrontRunner system for weekday, Saturday, and Sunday in 2015.

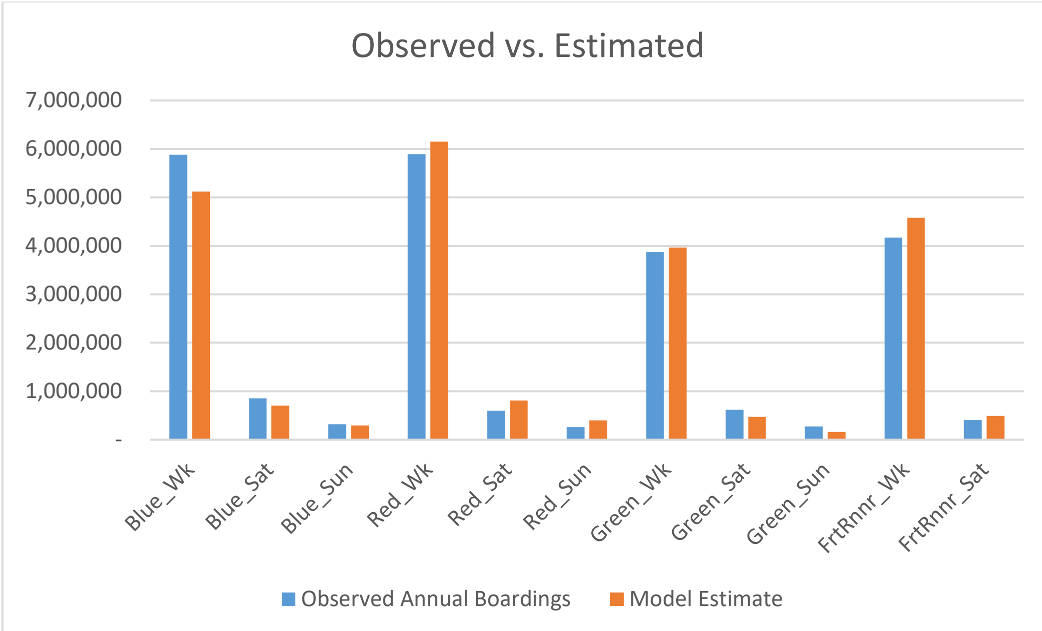


Figure 6-1: Comparison of Estimated Boardings from the Regression Model to Observed Ridership on each TRAX Light Rail Route and the FrontRunner system for 2015 Weekdays, Saturdays, and Sundays.

In order to provide a Sunday ridership range as opposed to a specific number, a second methodology was used to develop an additional estimate. For this estimate, riders per revenue hour on the TRAX system was used. Analysts looked at the ratio of riders per revenue hour on Saturday versus Sunday, shown in Table 24.

Table 24 - Annual Riders per Revenue Hour (2015) Ratios

Route/ Day	Annual Boardings (rounded)	Annual Revenue Hours	Riders/Revenue Hour (Annual)	Ratio (TRAX Sat/Sun)
TRAX Blue Line Saturday	852,000	4,865	175	
TRAX Blue Line Sunday	320,000	3,543	90	**1.9**
TRAX Red Line Saturday	598,000	5,313	113	
TRAX Red Line Sunday	261,000	4,030	65	**1.7**
TRAX Green Line Saturday	620,000	3,823	162	
TRAX Green Line Sunday	275,000	2,955	93	**1.7**
FrontRunner Saturday	404,000	3,912	103	

The average ratio of 1.8 was then applied to the FrontRunner system, as shown in the equation below.

Annual Saturday FrontRunner Riders per Revenue Hour / Average Ratio of TRAX Riders per Revenue Hour between Saturday and Sunday = Sunday Riders/per Revenue Hour:

$$\frac{103}{1.8} = 57$$

6.2 Sunday Ridership Estimates

Using these two methodologies, two estimates of Sunday FrontRunner ridership were developed. For this analysis it was assumed that the reduction in annual revenue hours between Saturdays and Sundays observed from TRAX data provided by UTA would be the same reduction instituted for FrontRunner. Table 25 provides a summary of the annual service hours by day type, as well as the assumed annual service hours used for FrontRunner Sunday service analysis.

Table 25 - Annual Revenue Hours

Mode Type	Weekday Annual Revenue Hours	Saturday Annual Revenue Hours	Sunday Annual Revenue Hours
TRAX	94,212	14,001	10,528
FrontRunner	29,187	3,912	**2,942***

* Calculated using average reduction between Saturday revenue service hours and Sunday service hours observed on TRAX system.

Using the regression model described previously, annual Sunday ridership on FrontRunner was estimated at 158,000. This number was then divided by 52 weeks to provide a daily estimate of 3,038. This is approximately 81% less than the average weekday ridership (2015) on FrontRunner and 61% less than the average Saturday ridership.

Using the riders per revenue hour ratio methodology, annual Sunday ridership on FrontRunner was estimated at 168,000. This number was then divided by 52 weeks to provide a daily estimate of 3,231. This is approximately 80% less than the average weekday ridership on the system and 58% less than the average Saturday ridership. Table 26 summarizes the final estimates.

Table 26 - Final FrontRunner Sunday Ridership Estimates

Estimate Methodology	Annual Boardings	Daily Boardings
Ratio	168,000	3,231
Regression Model	158,000	3,038

6.3 Other Sunday Service Considerations

Ridership on the FrontRunner system is largely commuter based. Nearly 80% of riders are using FrontRunner for either journey to work or journey to school trips according to data from the 2015 on-board survey. On the entire UTA system, these purposes make up 60% of riders.

There are also unique cultural aspects associated with the Church of Jesus Christ of Latter-day Saints that should also be considered when analyzing Sunday service. The faith emphasizes Sunday as a Sabbath. Religious activities at places of worship usually make up three or more hours. In addition, members are also strongly encouraged to spend Sundays with family, refraining from activities that would require themselves or others to work. This reduces demand for Sunday transit service, especially in more suburban areas where the majority of FrontRunner stations are located. Based on data collected by the *Salt Lake*

Tribune, the counties that FrontRunner serves have significant Church of Jesus Christ of Latter-day Saints populations. [3]

- Utah County – 82%
- Davis County – 71%
- Weber County – 54%
- Salt Lake County – 51%

While it cannot be assumed that this population as a whole would not use Sunday service, this unique factor must be considered in developing reasonable ridership estimates.

6.4 Sunday Ridership Conclusions

Based on this analysis, it is estimated that annual boardings from instituting Sunday service would be between 158,000 and 168,000. This would roughly equate to between 3,038 and 3,231 boardings per day. It should be noted that these estimates were derived using TRAX service data as a proxy. This service is focused in Salt Lake County which has the lowest Church of Jesus Christ of Latter-day Saints population percentage compared to the other counties served by FrontRunner. Therefore, Sunday ridership on FrontRunner is likely to be at the lower end of the range presented given that much of the service provided would be in areas with higher Church populations. Additionally, the current ridership market is much more commuter based, which would also suggest lower utilization for non-commute trips on Sundays.

If there is continued interest in adding Sunday service, UTA should complete a cost/benefit analysis to fully understand the cost implications (including additional Maintenance of Way costs) of adding this service compared to the benefit of additional riders. Additional operating scenarios that assume differing levels of annual revenue hours could also be analyzed using both the ratio and regression models presented above but with new revenue hour assumptions.

[3] Mormon Populace Picks Up the Pace in Utah, Salt Lake Tribune, November 30, 2014. http://www.sltrib.com/news/1842825-155/mormon-populace-picks-up-the-pace Accessed 11/30/2016.

7 Baseline Simulation Results

The weekday FrontRunner operating plans are based on the UTA "Schedules and Headways" document from April 2015. These operating plans serve as the baseline for operations simulation model calibration only. A later operating plan serves as the Future Baseline with PTC scenario's train schedule and forms the comparative baseline for the four future scenarios. The baseline simulation TrainOps model configuration is shown in Figure 2-1.

There are four locations where freight trains operate on FrontRunner on a regular basis – three to five nights per week. All of these locations are short crossing moves, rather than long "road" type moves. The freight window is technically midnight to 4 AM though freight crews will start calling in the 9 PM to 10 PM timeframe to see if they might get an early move. Normally, freight operations have no impact on FrontRunner operations. However, future FrontRunner scenarios may include higher frequency late night service; it is important to include freight operations so that any future scenarios with longer or more intense passenger train operation periods correctly reflect freight operating requirements. The freight locations with potential mainline impacts are:

- UPRR Tesoro Refinery at Warm Springs;
- Murray (Sampler), which involves crossing FrontRunner to operate on TRAX light rail trackage after TRAX revenue trains are off the line;
- Pioneer (Silver Eagle), where there are two switches on the east side of the main that have companion switches on the west side that essentially form diamond crossings of FrontRunner; and
- Roper (Weyerhaeuser).

One weeknight freight trip was added in each direction to the simulation for each of the five simulation days at the four locations mentioned above.

Operating challenges were discussed with the dispatchers during LTK's observations at the FrontRunner Dispatch Office. Ridership at Murray Station is strong and it is difficult for northbound morning peak period trains to recover from FrontRunner South delays given that there can be 3-4 minute dwells there. Minor delays in the system can cascade to major delays given the precision of the meets. Minor delays are typically caused by a "stop and protect" grade crossing order (even one on the parallel UP line), an engine issue that requires a reboot or walk-around, and door issues that require the engineer to cut out a door. The Comet cars are viewed as having much less reliable doors than the Bombardier coaches.

With statistically-randomized dwell times at all stations and a universal (non-randomized) 0.3% schedule margin applied, the baseline simulation model yielded an "ideal day" OTP result of about 97%. This reflects an individual FrontRunner operating day with high OTP but is not representative of recent overall FrontRunner OTP. Additional model inputs, described below, were used to bring simulated FrontRunner OTP into conformance with recent overall reported performance.

In order for the simulation to more closely match operating conditions experienced on FrontRunner, two perturbations were added to each of the five randomized operating plans. These perturbations, shown in Table 27, were chosen based on data LTK received showing daily reports of delays on FrontRunner. A cautious engineer operating at a maximum speed of 65 MPH for one train cycle (multiple trips representing typical daily hours on duty) was included for each of the five days.

Table 27 – Simulated Perturbations

Day 1	Door Failure – 7-minute extended dwell at 1 station
	TRAX Connection Delay – 5-minute delay for 1 NB train at North Temple
Day 2	Crossing Failure/Broken Gate – 2 hr. 15 MPH speed restriction through grade crossing
	TRAX Connection Delay – 5-minute delay for 1 NB train at North Temple
Day 3	Locomotive Failure – 1 train stops 10-minutes while train is reset
	Door Failure – 7-minute extended dwell at 1 station
Day 4	Door Failure – 7-minute extended dwell at 1 station
	Crossing Failure/Broken Gate – 2 hr. 15 MPH speed restriction through grade crossing
Day 5	TRAX Connection Delay – 5-minute delay for 1 NB train at North Temple
	Locomotive Failure – 1 train stops 10-minutes while train is reset

7.1 Baseline Simulation Results without Perturbations (Ideal Day)

Initially the FrontRunner operating plan was run with randomized dwell times but without any included perturbations. The simulation resulted in on time performance of more than 97% which is typical of the best performing weekdays at FrontRunner.

Figure 7-1 represents TrainOps simulation results for the morning peak period from 3:00 a.m. to 9:00 a.m. Solid lines represent simulation results while dotted lines represent FrontRunner scheduled times that are input to the simulation model. The figure shows that train 7-01 is randomly assigned a long dwell at Orem. Overall, this string chart shows excellent schedule adherence with simulated strings very close to the scheduled strings.

Appendix C contains a complete set of time-distance string charts for the Existing Baseline (pre-PTC) scenario, including “ideal day” and “perturbed” results that comprise six 24-hour simulations.

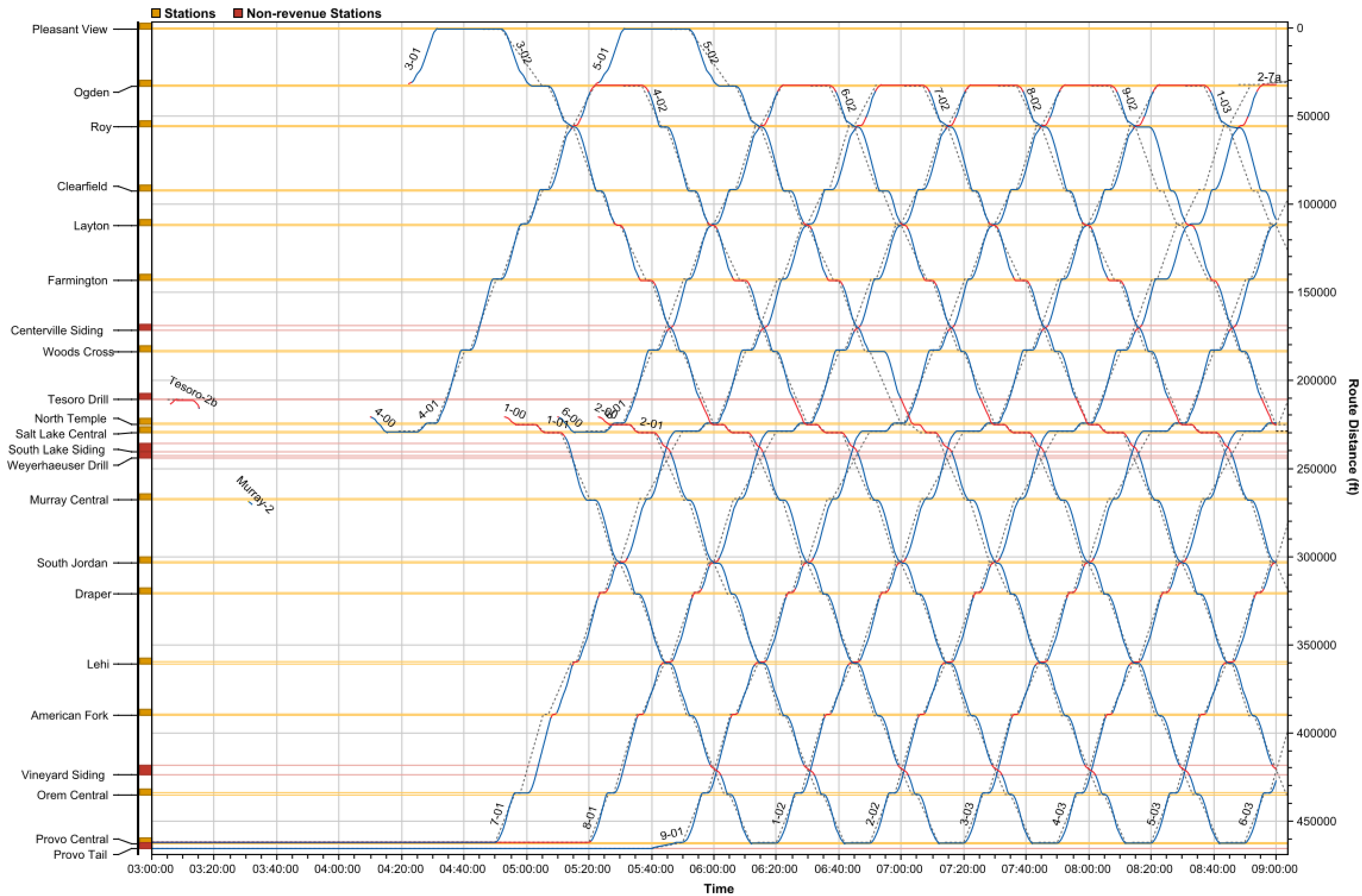


Figure 7-1: Existing Baseline Time-Distance ("String") Chart – 3 AM – 9 AM – No Added Perturbations

7.2 Discussion of Existing Baseline Operations Simulation Results

The goal of the baseline modeling effort was to produce a five day set of simulations with an average OTP of 90% at the 4 minute and 59 second lateness threshold. This was done using five days with perturbations as shown in Table 28 to capture the real world variability present in the UTA data. Table 28 shows the number of simulated events making up the OTP percentage as the number of station stops; the “All Stops” column on the right simply totals up all of the scheduled events in a given simulation run.

The resulting five day OTP of 91.34% is deemed to be acceptably close to the 90% goal. The day-to-day variation in OTP is between 89.86% and 93.63%. The poorest performing of the five simulated days was Day 2 which included both a crossing failure/broken gate and a TRAX connection delay. As was seen in the FrontRunner dispatch data, the area most prone to delays in the simulation is FrontRunner South.

Table 28 - Simulated On-Time Performance - Existing Baseline Scenario

Lateness Threshold	00:00:00		00:03:00		00:04:59		00:10:00		All Stops	
	Stops	Pct (%)	Stops	Pct (%)	Stops	Pct (%)	Stops	Pct (%)	Stops	Pct (%)
Average Ideal Day (no Perturbations)	**474**	**55.85**	**809**	**95.42**	**836**	**98.56**	**847**	**99.88**	**848**	**100**
FrontRunner-Day 1	390	45.99	737	86.91	780	91.98	834	98.35	848	100
FrontRunner-Day 2	376	44.34	657	77.48	762	89.86	847	99.88	848	100
FrontRunner-Day 3	402	47.41	715	84.32	774	91.27	834	98.35	848	100
FrontRunner-Day 4	421	49.65	721	85.02	763	89.98	831	98.00	848	100
FrontRunner-Day 5	390	45.99	748	88.21	794	93.63	829	97.76	848	100
Average Typical Day (with Perturbations)	**396**	**46.67**	**716**	**84.39**	**775**	**91.34**	**835**	**98.47**	**848**	**100**

Note: OTP is computed at all stations, not just at the terminals

8 Future Baseline with PTC Simulation Results

UTA is implementing PTC consistent with the Rail Safety Improvement Act of 2008, a federal law enacted by Congress to improve railroad safety. The law mandated PTC on most passenger rail networks by December 31, 2015, a deadline that was extended to December 31, 2018. FrontRunner is on track to meet this deadline, reporting that all 40 on-board units (locomotive and cab car) have been installed as of June 30, 2018, as have all 103 wayside locations.

UTA's PTC architecture uses its existing E-ATC train control system to provide additional enforcement required under the FRA's interpretation of the Rail Safety Improvement Act. UTA provided design-build PTC drawings showing changes in E-ATC control line logic, as shown below (LTK utilized a version of FrontRunner North PTC control lines with LTK review comments but did not receive confirming PTC plans from the UTA).

FrontRunner North -	FRN_Aspect Charts_IFC_20170926-wLTK Comments_20171114.pdf Weber County to Salt Lake City Commuter Rail – Aspect Charts Last Revision: 09/26/2017 IFC REV 0 9-26-17 REB/ISIS UT-14-17TH
FrontRunner South -	FRS_TCTRL_NORTH_IFR_05-01-17-Resized.pdf Front Runner South Commuter Rail – Following Train Control Lines – Northbound Last Revision: 08/10/2017 IFR REV. 0 05-01-17 RHW/UNITED RAIL UT-14-17TH  FRS_TCTRL_SOUTH_IFR_05-01-17-Resized Front Runner South Commuter Rail – Following Train Control Lines – Southbound Last Revision: 08/10/2017 IFR REV. 0 05-01-17 RHW/UNITED RAIL UT-14-17TH 

Where possible, UTA modified curves or pursued engineering design waivers to improve E-ATC speeds under PTC. But, in the vast majority of changed locations, the E-ATC control lines were changed to be more restrictive, resulting in modest FrontRunner travel time increases. In addition, speed restrictions as a result of malfunctioning or failed grade crossings must now be enforced with E-ATC, leading to a significant increase in travel time under PTC when such a malfunction or failure occurs.

The Future Baseline with PTC Scenario TrainOps model configuration is the same as the Baseline Scenario shown in Figure 2-1. Only the underlying E-ATC signal control lines and maximum authorized speeds were changed. These changes are not visible in the TrainOps schematic though they are present in the underlying simulation input data.

After iterating through multiple Future Baseline with PTC simulation scenarios, the scheduled one-way travel times changed for the PTC simulation with an additional minute added to the southbound travel times (resulting in a scheduled end-to-end travel time of two hours and six minutes) and five additional minutes added to the northbound travel times (resulting in a scheduled end-to-end travel time of two hours and seven minutes).

As was done in the Baseline Calibration simulation, two perturbations and a cautious engineer operating at a maximum speed of 65 MPH for one train cycle were added to each of the five randomized operating plan days in order for the simulation to more closely match operating conditions experienced on FrontRunner. These perturbations, shown in Table 27 were chosen based on data LTK received showing daily reports of delays on FrontRunner.

For grade crossing failures, it was assumed that the FrontRunner Dispatcher would communicate the reason for the cab signal step-downs, providing the engineer with the confidence to operate at the upper range of the 0 speed command (14 MPH in the simulation). This is in contrast with end-of-track and controlled siding 0 speed command operation, where trains are capped at 4 MPH in this condition in the simulation. The north of Murray failure has a more profound operational impact because the approaching PTC signal control lines are longer than for the grade crossing north of South Jordan. Both crossings were selected at random (though the selection was focused on single track crossings for maximum operational impact) as part of the baseline calibration work, then retained for the PTC analysis.

8.1 Future Baseline with PTC Simulation Results without Perturbations (Ideal Day)

Initially the FrontRunner operating plan was run with randomized dwell times but without any additional perturbations. The simulation was run five times (using a different random seed number resulting in different randomized dwells) in order to get a more realistic average ideal day value. The resulting on time performance is just over 95%, almost 3.5% lower than when the Baseline simulation is run using the same method.

Delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones. The trains, on FrontRunner North, run very close to on-time in the No Added Perturbations run. Figure 8-1 shows a number of late FrontRunner South trains, such as Train 6-02 in the second half of the string chart. This can be seen visually as the solid (simulated) strings are to the right of the dotted (scheduled) strings. A tenth trainset has been introduced to FrontRunner in peak periods to account for shorter “turn” times at Provo. Rather than needing to turn in approximately 3 minutes (a time that provides no schedule recovery), an extra headway has been introduced so that turns are scheduled to turn in approximately 33 minutes. The cascading delays shown in Figure 8-1 are notably limited to FrontRunner South as the trains heading north are able to recover and get back on schedule between Salt Lake Central and North Temple.

Appendix D contains a complete set of time-distance string charts for the Future Baseline with PTC scenario, including “ideal day” and “perturbed” results that comprise six 24-hour simulations.

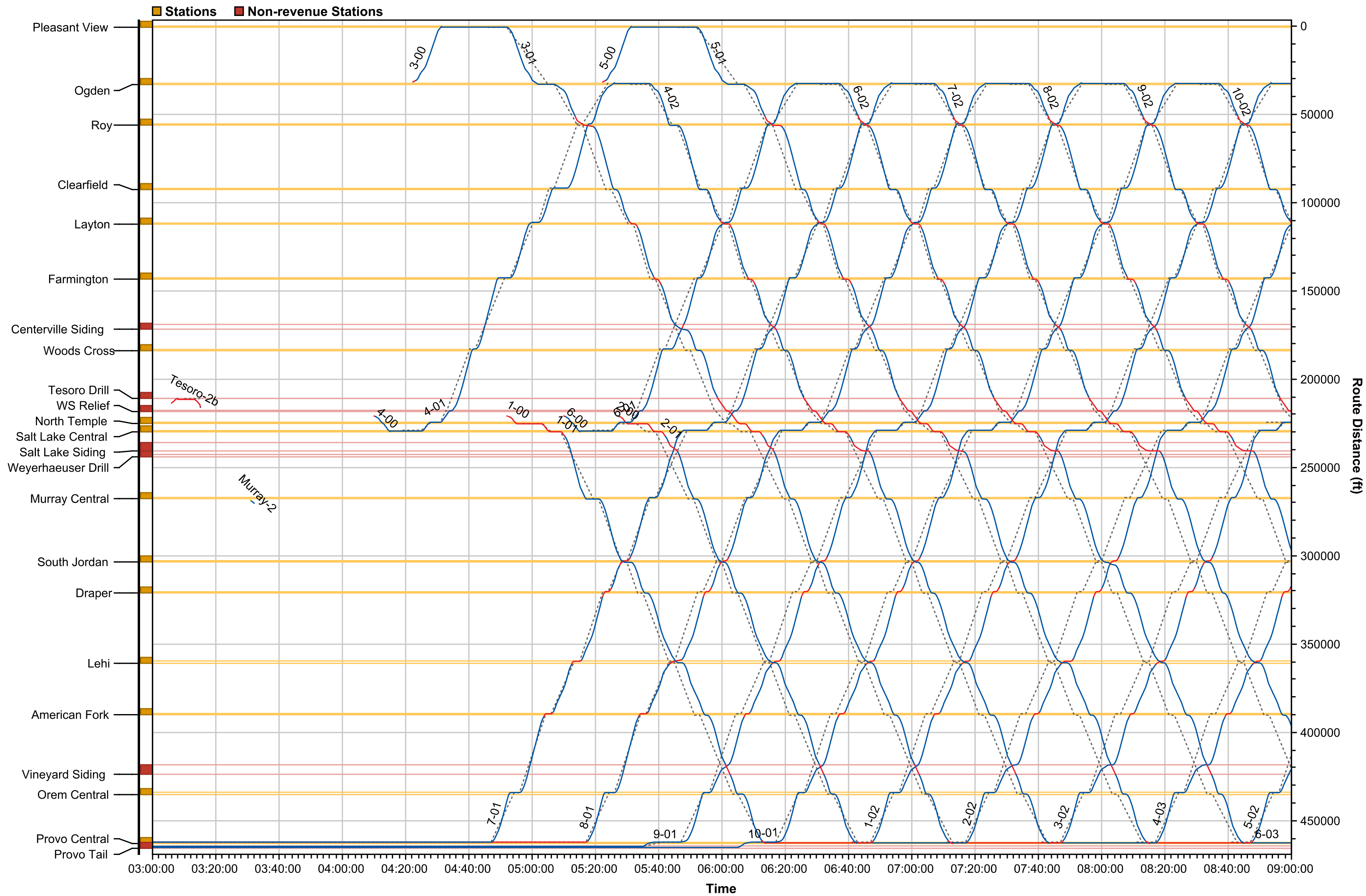


Figure 8-1: Future Baseline with PTC Time-Distance ("String") Chart – 3 AM – 9 AM – No Added Perturbations

8.2 Discussion of Future Baseline with PTC Results

The Future with PTC simulation resulted in a five-day (with perturbations) OTP of 88.14% at the 4 minute and 59 second lateness threshold. This reflects the simulation of five days with perturbations as shown in Table 29 to capture the real world variability present in the UTA data. This reflects the addition of a tenth trainset to peak FrontRunner operations in order to support reliable terminal operations at Provo.

The day-to-day variation in OTP is between 79.25% and 92.15%. Two of the five days include two-hour grade crossing failures (north of Murray on Day 2, north of South Jordan in Day 4, both in single track), consistent with the calibration baseline. The grade crossing failures, especially the failure north of Murray, have significant effects on OTP given the PTC-related signal control enforcement of Restricted Speed over the crossing and the enforced speed-stops in approach.

Table 29 - Simulated On-Time Performance - Future with PTC

Lateness Threshold	00:00:00		00:03:00		00:04:59		00:10:00		All Stops	
	Stops	Pct (%)	Stops	Pct (%)	Stops	Pct (%)	Stops	Pct (%)	Stops	Pct (%)
Average Ideal Day (no Perturbations)	**359**	**42.11**	**689**	**80.82**	**811**	**95.12**	**851**	**99.72**	**853**	**100**
FrontRunner-Day 1	335	39.27	642	75.26	772	90.50	841	98.59	853	100
FrontRunner-Day 2	327	38.34	563	66.00	676	79.25	795	93.20	853	100
FrontRunner-Day 3	371	43.49	664	77.84	786	92.15	843	98.83	853	100
FrontRunner-Day 4	369	43.26	686	80.42	766	89.80	843	98.83	853	100
FrontRunner-Day 5	344	40.33	631	73.97	759	88.98	843	98.83	853	100
Average Typical Day (with Perturbations)	**349**	**40.94**	**637**	**74.70**	**752**	**88.14**	**833**	**97.66**	**853**	**100**

Note: OTP is computed at all stations, not just at the terminals
With selected grade crossing failures, 0 commands at crossing locations capped at 14 MPH

Table 30 - Simulated On-Time Performance - Existing vs. Future with PTC (Summary)

Lateness Threshold	00:00:00		00:03:00		00:04:59		00:10:00		All Stops	
	Stops	Pct (%)	Stops	Pct (%)	Stops	Pct (%)	Stops	Pct (%)	Stops	Pct (%)
Existing (Baseline Calibration)										
Average Ideal Day (no Perturbations)	474	55.85	809	95.42	**836**	**98.56**	847	99.88	848	100
Average Typical Day (with Perturbations)	396	46.67	716	84.39	**775**	**91.34**	835	98.47	848	100
Future with PTC										
Average Ideal Day (no Perturbations)	359	42.11	689	80.82	**811**	**95.12**	851	99.72	853	100
Average Typical Day (with Perturbations)	349	40.94	637	74.70	**752**	**88.14**	833	97.66	853	100

Note: OTP is computed at all stations, not just at the terminals

8.3 Discussion of Future Baseline Ridership Modeling Results

The operating assumptions for the Future Baseline ridership model run match the assumptions used in the operations model. In this scenario, there are no changes to headways, no additional stations, and no extensions added to the system. The five day average speeds for each station pair in the simulation model were used to update link level speeds of the FrontRunner system, reflecting the average speeds when positive train control (PTC) is fully implemented. This model run essentially represents a future no-build condition. Table 31 summarizes the total daily boardings for the FrontRunner system and by station. Table 32 summarizes the total daily regional auto and transit trips.

Table 31 - Future Baseline with PTC Daily FrontRunner Boardings by Station - 2050

Stop Name	Future Baseline with PTC
Pleasant View	67
Ogden (transfer)	67
Ogden	3,311
Roy	1,144
Clearfield	2,061
Layton	1,649
Farmington	1,104
Woods Cross	2,208
North Temple	2,237
Salt Lake	9,730
Murray	3,775
South Jordan	1,239
Draper	465
Lehi	1,184
American Fork	1,283
Orem	2,229
Provo	1,807
TOTAL	35,561

Table 32 - Future Baseline with PTC Total Daily Regional Auto and Transit Trips

Trips	Future Baseline with PTC
Auto	13,217,138
Transit	294,638

Total FrontRunner ridership in this scenario is approximately 35,600 and transit trips make up approximately 294,600 of the total regional trips

9 FrontRunner Double Track Feasibility

As part of the Future of FrontRunner Study, a double track feasibility workshop was held at the UTA offices to identify a hierarchy of physically feasible double track zones between Provo, Salt Lake City and Ogden. The workshop included representatives of UTA Planning, UTA Capital Development, UTA Environmental, UTA Real Estate, UTA Rail Planning, UTA Maintenance of Way and UTA Rail Operations (FrontRunner management). The workshop was led by LTK Team member Jacobs Engineering and was supported by LTK and LTK Team member Fehr & Peers. The group discussed every mile of corridor from the various perspectives represented and agreed to assign one of five color codes to identify the relative ease or difficulty to obtain the necessary land to build a second track.

Jacobs Engineering prepared Google Earth *.kmz files as an aid to the multi-day workshop discussions. These files include as-builts of FrontRunner and Utah Automated Geographic Reference Center (AGRC) data layers. Wetlands come from two sources – corridor delineation from the as-builts and AGRC data. The as-builts are more accurate but the AGRC data provides off-corridor detail where ROW acquisition is contemplated. It was noted during the workshop that there are no critical habitat delineations anywhere within FrontRunner North or FrontRunner South.

Given that UPRR tracks parallel much of the FrontRunner corridor, the workshop discussed the feasibility of relocating UP tracks. Assuming property is available, it was agreed that UP track relocation should be considered anywhere along the corridor. UP traffic is more intense in the north than in the south. During the original FrontRunner North negotiations, UP was operating about 65 daily trains in this segment; that volume has declined in the last 10 years but still far exceeds what operates south of Salt Lake City.

The desirability of double tracking the tail track at Provo was discussed. Three trainsets are stored there overnight at present. Service growth may necessitate storage of a fourth consist in the future. There were divergent opinions on whether two tail tracks would allow better speeds into the station from the north, due to increased signal system "overrun" distance. Two constraints must be analyzed – signal design braking distance and diverging switch speed constraints.

The workshop described the "pinch point protection" system in place where UP and FrontRunner track centers are closer than 25 feet. There are bollards placed every 200 feet or so that would be knocked over in the event of a derailment on either railroad. These bollards contain break-away cables that are interfaced with the vital signal circuits, turning all applicable signals to stop in the event of a break. It was noted that UP's negotiation in any follow-on track relocation would start with a demand for 50 foot track center minimums and no pinch point protection. For planning purposes, it was agreed that 25 foot separation with pinch point protection is a reasonable assumption.

The definitions of the five double track feasibility colors were clarified during the workshop. Modified definitions, as applied during the workshop, are as follows:

- Purple: Double track already in place
- Blue: Double Track can be obtained with minimal difficulty (no ROW acquisition, simple grading, no obvious utility relocations, no UP relocation, no wetlands mitigation, no new structures other than culverts)

- Green: Double Track can be obtained with moderate difficulty (no ROW acquisition except for possible UP ROW acquisition with no associated track relocation, simple to moderate grading, possible utility relocations, no UP relocation, possible minor to moderate wetlands mitigation, no new structures other than culverts and simple short bridge spans)
- Yellow: Double Track can be obtained with difficulty (possible ROW acquisition except for major taking of active industrial facilities or multiple residences, possible UP ROW acquisition with associated track relocation, possible major grading including new minor to major retaining walls, possible utility relocations, possible minor to major wetlands mitigation, possible new bridge structures including multiple span structures but excluding major new rail viaducts/flyovers or complete reconstruction of major (interstate or other major arterial) overgrade structures)
- Orange: Double Track can be obtained with major difficulty (possible ROW acquisition including taking of active industrial facilities or multiple residences, possible UP ROW acquisition with associated track relocation including major relocation of multiple main or yard tracks, possible major grading including new minor to major retaining walls, possible utility relocations, possible minor to major wetlands mitigation, possible new bridge structures including multiple span structures but excluding major new rail viaducts/flyovers or complete reconstruction of major (interstate or other major arterial) overgrade structures, possible major reconstruction of stations include new ADA-compliant elevator towers for cross-track access)
- Red: Double Track can be obtained with extreme difficultly and expense or is physically impossible (possible ROW acquisition including taking of active industrial facilities or multiple residences, possible UP ROW acquisition with associated track relocation including relocation of multiple main or yard tracks, possible major grading including new minor to major retaining walls, possible utility relocations, possible minor to major wetlands mitigation, possible environmental impact to publicly-owned lands, including public parks, adjacent to ROW, possible destruction or alteration of significant cultural resources adjacent to ROW, possible required relocation of waterbodies such as rivers and canals, possible new bridge structures including multiple span structures and possibly including major new rail viaducts/flyovers or complete reconstruction of major (interstate or other major arterial) overgrade structures, possible major reconstruction of stations include new ADA-compliant elevator towers for cross-track access)

The results of the workshop are shown graphically in Appendix E. This includes color-coding of all FrontRunner track with respect to double track feasibility. The workshop identified six “red zones” where FrontRunner double track can be obtained only with extreme difficulty. These are shown in Table 33.

Table 33 - Summary of Double Track Feasibility Red Zones (Double Track Can be Obtained Only with Extreme Difficultly)

FrontRunner MP	UP MP	Station-Station Location	Double Tracking Constraints
S28.4 - S27.8	716.7 - 717.3	American Fork - Lehi	UP on east side, constricted ROW, Lehi Round-Up Rodeo Grounds and numerous houses to west
S23.4 - S23.2	721.6 - 721.8	Lehi - Draper	River very close on west, constricted ROW, Jordan Narrows geographic constraints
S13.1 – S12.8	731.9 – 732.2	South Jordan – Murray	FrontRunner flyover over UP, constricted ROW, Jordan Gateway Complex on west
S4.7 – S4.6	740.3 – 740.4	Murray – Salt Lake Central	I-15 bridge overhead, complex skewed angle column placement
S1.1 – S0.6	744.0 – 744.5	Murray – Salt Lake Central	Narrow ROW, I-15 bridge overhead, complex skewed angle column placement
N11.6 – N11.9	793.4 – 793.7	Woods Cross to Farmington	Constricted ROW, no room to relocate adjacent UP (2 mainline tracks), need to construct new I-15 interchange

10 FrontRunner Capital Cost Estimates

LTK and UTA developed unit capital cost estimates for all proposed FrontRunner infrastructure improvements, including electrification and rail vehicle maintenance facilities associated with an electric vehicle fleet. In addition, UTA and LTK developed unit capital cost estimates for FrontRunner diesel fleet expansion as well as fleet replacement by electric vehicles. All unit costs were developed in 2018 dollars.

Unit costs were developed exclusive of design, bonding, construction management and other “soft” costs, as well as no right-of-way estimates were performed. The scenario capital cost estimates presented in Section 1 add a 30 percent unallocated contingency to all infrastructure and fleet capital costs for such “soft” costs as well as to compensate for the high level nature of the cost estimates.

Table 34 presents the infrastructure unit capital costs, including train control, electrification and maintenance facility unit costs. The New Light Maintenance Shop and Yard is meant to serve as an interim EMU Service & Inspection (S&I) facility during the early years of electrified operation. During this time period, it is assumed that the existing Warm Springs Maintenance Facility would be upgraded to serve as the permanent EMU shop with the S&I facility or facilities remaining to supplement Warm Springs. The S&I facility or facilities would ideally be located at one or both ends of electrification (Ogden and/or Provo) rather than in the middle of the FrontRunner network.

The S&I unit cost is built up from the following assumptions:

- 37,500 SF building (50 x 750 feet, two tracks) designed to support bridge crane;
- Service pit and steel service platforms;
- Drop table and wheel truing facility;
- Train wash;
- Approximately 16,500 LF of track and electrification;
- $5,250,000 in site development costs; and
- $1,050,000 in land purchase costs.

Table 35 presents the supplemental and replacement FrontRunner fleet unit costs.

Table 34 - Infrastructure Capital Cost Estimate Units

Capital Unit	Construction Adjacent to Live Rail?	Units	Unit Cost (2018 $)	Unit Cost Source and Assumptions
Station Side Platform	Y	Per Platform	$ 1,500,000	UTA, assumes one side of track only.
Station Center Island Platform	Y	Per Platform	$ 2,500,000	UTA
Raise existing low platform to high platform height - Center	Y	Per platform	$ 250,000	UTA
Raise existing low platform to high platform height - Side	Y	Per platform	$ 150,000	UTA
Extend Existing Platform - on existing foundation (south)	Y	Per car length req'd per platform	$ 350,000	Extend Existing Platform - on existing foundation (south)
Extend Existing Platform - new foundation (north)	Y	Per car length req'd per platform	$ 500,000	Extend Existing Platform - new foundation (north)
Station Parking Lot	N.A.	Per Parking Lot	$ 4,000,000	UTA
Relocated Switch (Freight/Yard)	Y	Per Switch	$ 100,000	UTA, assumes moving switch/signal stuff/insulated joints. Does not assume new switch purchase.
Relocated Main Track	Y	Per LF of Track (not LF of Rail)	$ 865	UTA
Additional Main Track (Without Signals)	Y	Per LF of Track (not LF of Rail)	$ 1,150	UTA
Interlocking (Single Switch)	Y	Per Interlocking	$ 3,500,000	UTA, includes track installation, signals, office controls.
Signal Location (Non-Interlocking)	Y	Per Location	$ 250,000	UTA, applies to automatic E-ATC cab signal locations only, assuming approximately 50% of locations will be able to use an existing CIH and 50% of locations will require a new CIH.
Grade Crossing – Single Track (Signalized)	Y	Per Crossing	$ 1,500,000	UTA, assumes new crossing install, signal connections to UDOT and Back Office, IJ's, gate mechanisms, new house.
Grade Crossing - Double Track (Signalized)	N	Per Crossing	$ 2,000,000	UTA, assumes utility relocations, corridor preparation, new equipment purchases.
Grade Crossing - Double Track (Signalized)	Y	Per Crossing	$ 1,750,000	UTA, assumes new crossing install, signal connections to UDOT and Back Office, IJ's, gate mechanisms, new house.
Undergrade Bridge - Single Track (LF)	Y	Per LF	$ 186,500	UTA
Electrification (Single Track)	Y	Per Mile of Track	$ 2,500,000	LTK
Electrification (Double Track)	Y	Per Mile of Track	$ 2,450,000	LTK
New Light Maintenance Shop and Yard	Y	Per Facility	$ 72,000,000	LTK
Existing Maintenance Shop and Yard Improvements	Y	Per Facility	$ 50,000,000	LTK

Table 35 - Fleet Capital Cost Estimate Units

Capital Unit	Cost Basis	Unit Cost (2018)	Unit Cost Source and Assumptions
Diesel Loco	Per Unit	$ 6,750,000	UTA
Bi-Level Coach	Per Unit	$ 3,400,000	UTA
Bi-Level Cab Car	Per Unit	$ 3,800,000	UTA
Electric Multiple Unit Car	Per Unit	$ 5,740,000	LTK
Replace existing fleet	Lump sum	$ 311,000,000	UTA
Electric Loco	Per Unit	$ 8,849,000	LTK. Not assumed in study.

11 Future Low Investment Scenario Simulation Results

The Future Low Investment Scenario includes additional infrastructure to extend service and increase reliability while maintaining diesel operation at existing headways. The current E-ATC PTC architecture is assumed to remain with PTC applied to the additional infrastructure. Specific infrastructure projects assumed in this scenario include:

- Extension south from Provo to Payson with intermediate stations at Springville and Spanish Fork (consistent with TransPlan 40, the Regional Transportation Plan for MAG from 2015-2040);
- Infill station at Vineyard, between Orem Central and American Fork;
- Additional double track totaling approximately 10 miles to provide operational flexibility and schedule recovery from service disruptions; and
- Changing the American Fork Siding from a “lap” siding to a traditional siding.

The Payson extension required an operating plan to determine which FrontRunner trips are extended to begin or end at Payson and the impact to the total number of trains required for peak operations. The operating plan assumes four peak-direction trips (four inbound AM peak trips and four outbound PM peak trips) running on an hourly headway and two train consists that layover at Payson every night. The specific trip times are based on the existing UTA Route 821 service to allow commuters to arrive downtown Salt Lake City between 7-10 AM and depart downtown between 3:30-6:30 PM. Preliminary running times were developed based on the track distance between the planned Payson Station and Provo Central Station and a 40 MPH average running speed. From these assumptions, peak operations can run with 11 train consists, utilizing a passing siding near the Spanish Fork Station and approximately 35 minutes of layover time at Payson for the return trips.

Using the distances developed in the Payson extension operating plan, the TrainOps model was updated to include the extension and refine the operations and running time. Speed steps were added to represent PTC-enforced speeds for curves. The running time between Provo and Payson in the model is 25 minutes northbound and 26 minutes southbound, which includes one minute of pad time northbound into Provo and two minutes of pad time southbound into Payson.

The optimal location of the siding at Spanish Fork was found to be just north of Highway 147 (6400 South) based on simulation modeling. This is very near the Spanish Fork Station location shown in the MAG RTP for 2015-2040.

Additional double track between Provo and Ogden included in the simulation was chosen using full day simulations with perturbations and analyzing these results against the Double Tracking Feasibility Workshop in October 2016. A list of locations was created and then ranked according to the effectiveness that each one would have on improving reliability; this is shown in Table 36. Two locations were not considered due to their level of difficulty (Centerville Siding) or lower effectiveness (Layton Station to Kaysville Siding). The remaining double track extensions total 9.66 miles and are included in the Low Investment Scenario simulation.

Table 36 - Double Track Priority Analysis

<table>
<tr><th>Rank</th><th>Segment</th><th>From MP</th><th>To MP</th><th>Dist.</th><th>Level of Difficulty</th></tr>
<tr><td>1a</td><td>Vineyard Siding - North</td><td>35.70</td><td>35.20</td><td>0.50</td><td>Minimal difficulty</td></tr>
<tr><td>1b</td><td>Vineyard Siding - Further North</td><td>35.20</td><td>33.60</td><td>1.60</td><td>Difficulty</td></tr>
<tr><td>2</td><td>1700 South (Salt Lake Siding) - South</td><td>3.66</td><td>2.14</td><td>1.52</td><td>Major difficulty</td></tr>
<tr><td>3</td><td>Centerville Siding - North</td><td>12.00</td><td>11.51</td><td>0.49</td><td>Extreme difficulty</td></tr>
<tr><td rowspan="4">4</td><td rowspan="4">Woods Cross to Centerville</td><td rowspan="4">10.99</td><td rowspan="4">8.98</td><td rowspan="4">2.01</td><td>Major difficulty</td></tr>
<tr><td>Minimal difficulty</td></tr>
<tr><td>Moderate difficulty</td></tr>
<tr><td>Difficulty</td></tr>
<tr><td rowspan="4">5</td><td rowspan="4">South Jordan - Draper</td><td rowspan="4">16.78</td><td rowspan="4">14.31</td><td rowspan="4">2.47</td><td>Difficulty</td></tr>
<tr><td>Moderate difficulty</td></tr>
<tr><td>Major difficulty</td></tr>
<tr><td>Difficulty</td></tr>
<tr><td>6</td><td>Lehi – North</td><td>24.50</td><td>23.42</td><td>1.08</td><td>Major difficulty</td></tr>
<tr><td>7</td><td>Lehi – South</td><td>25.45</td><td>24.97</td><td>0.48</td><td>Difficulty</td></tr>
<tr><td>8</td><td>Layton Station - Kaysville Siding</td><td>22.00</td><td>20.27</td><td>1.73</td><td>Major difficulty</td></tr>
</table>

A combination of running time and schedule adjustments were made to the operating plan to further increase reliability of the simulation with perturbations. The revised schedule is shown in Appendix A. This involved testing several options and the best performance included these adjustments:

- Revised scheduled running times between adjacent stations with scheduled departure time adjustments northbound at Orem, Lehi, Salt Lake Central, and Temple; southbound at Woods Cross, Salt Lake Central, Murray, South Jordan, Lehi, and Vineyard,
- Departing Ogden earlier, arriving Provo later: 2:10 Ogden to Provo,
- Departing Provo earlier, arriving Ogden later: 2:09 Provo to Ogden,
- Departing Provo earlier, arriving Pleasant View later: 2:22 Provo to Pleasant View,
- Departing Ogden earlier, arriving Payson later: 2:35 Ogden to Payson, and
- Less dwell time at Salt Lake Central: 3 minutes southbound, 5 minutes northbound.

As was done in the Baseline Calibration and Future Baseline with PTC simulations, two perturbations were added to each of the five randomized operating plan days in order for the simulation to more closely match operating conditions experienced on FrontRunner. A cautious engineer operating at a maximum speed of 65 MPH for one train cycle was included for each of the five days.

In addition, the FrontRunner train consist for the Low Investment Scenario was changed from three Bombardier Bi-Level VII cars and one single level Pullman Standard Comet I car to five (5) Bi-Level cars. This reflects future plans to accommodate growing ridership.

Most routing stays the same in this scenario versus the Future Baseline. In this scenario, American Fork was changed from a lap siding to a traditional siding. This is largely because there are no meets at American Fork in normal circumstances in this scenario; the change allows trains to pass through the switch before and after the station at full speed in each direction.

The 1800 South (Salt Lake) Siding has been extended south through the Weyerhaeuser area, which results in access to Roper Yard from Track 1 and access to Weyerhaeuser from Track 2. Table 37 summarizes the inputs to the Low Investment Scenario capital cost estimate. These capital costs do not include “state of good repair” infrastructure costs or recurring fleet replacement costs.

For grade crossing failures, it was assumed that the FrontRunner Dispatcher would communicate the reason for the cab signal step-downs, providing the engineer with the confidence to operate at the upper range of the 0 speed command (14 MPH in the simulation). This is in contrast with end-of-track and controlled siding 0 speed command operation, where trains are capped at 4 MPH in this condition in the simulation. The north of Murray failure has a more profound operational impact because the approaching PTC signal control lines are longer than for the grade crossing north of South Jordan. Both crossings were selected at random (though the selection was focused on single track crossings for maximum operational impact) as part of the baseline calibration work, then retained for all subsequent simulation scenarios.

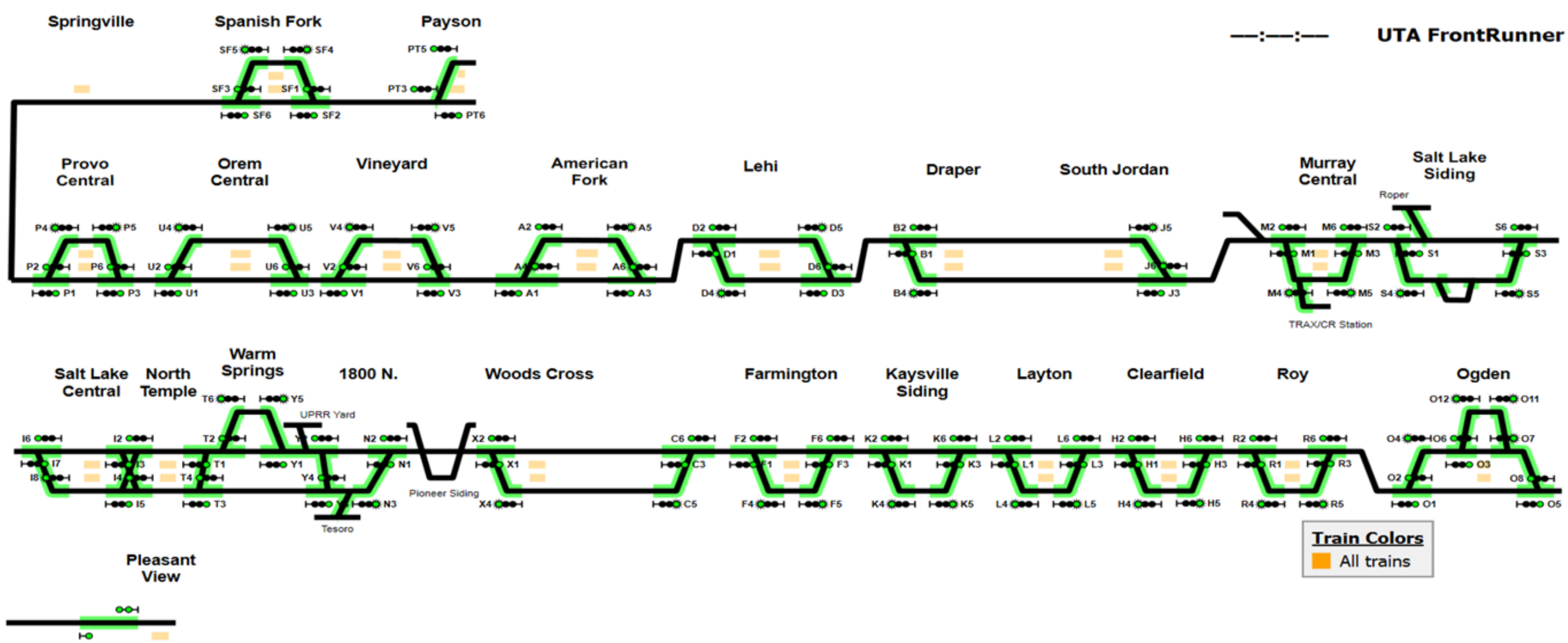


Figure 11-1: TrainOps Track Schematic of Low Investment Scenario Simulation

11.1 Low Investment Scenario Simulation Results without Perturbations (Ideal Day)

Table 37 - Low Investment Scenario Capital Cost Estimate Units

Capital Unit	Construction Adjacent to Live Rail?	Units	Unit Cost (2018 $)*	Low Investment Scenario Quantities	Notes
Station Side Platform	Y	Per Platform	$ 200,000	1	Springville Station platform.
Station Center Island Platform	Y	Per Platform	$ 250,000	3	Vineyard, Spanish Fork, and Payson Station platforms.
Raise existing low platform to high platform height - Center	Y	Per car length req'd per platform	$ 250,000	30	Per car length, need 2 car lengths for all stations. No PV
Raise existing low platform to high platform height - Side	Y	Per car length req'd per platform	$ 150,000	6	Provo, SLCtrl, Farmington - 2 car lengths
Extend Existing Platform - on existing foundation (south)	Y	Per car length req'd per platform	$ 350,000	0	
Extend Existing Platform - new foundation (north)	Y	Per car length req'd per platform	$ 500,000	0	
Station Parking Lot	N.A.	Per Parking Lot	$ 4,000,000	4	Parking lots at all four new stations. Assumed 500ft x 500ft area (250,000 sq. ft. @ $16.00 per sq. ft.) that includes space for bus turnaround, sidewalks, curb and gutter, and landscaping.
Relocated Main Track	Y	Per LF of Track (not LF of Rail)	$ 865	18,500	Relocate/consolidate UP track for South Jordan, Salt Lake, and Centerville siding extensions.
Additional Main Track (Without Signals)	Y	Per LF of Track (not LF of Rail)	$ 1,150	141,300	50,700 feet additional track for siding extensions; 86,300 feet additional track for Payson extension; 4,300 feet for Spanish Fork Siding.
Interlocking (Single Switch)	Y	Per Interlocking	$ 3,500,000	3	Add 3 new interlocking signals for siding extensions and 9 new interlocking signals for Payson extension.
Signal Location (Non-Interlocking)	Y	Per Location	$ 250,000	8	Relocate 8 signals from interlocking to non-interlocking.
Grade Crossing – Single Track (Signalized)	Y	Per Crossing	$ 1,500,000	0	
Grade Crossing – Double Track (Signalized)	N	Per Crossing	$ 2,000,000	0	
Grade Crossing – Double Track (Signalized)	Y	Per Crossing	$ 1,750,000	2	Jordan Gateway crossing 3 tracks, 1600 North crossing 4 tracks.
Undergrade Bridge - Single Track (LF)	Y	Per LF	$ 186,500	215	Road bridge (400 North in Woods Cross) may need to be rebuilt over UTA and UP.
Electrification (Single Track)	Y	Per Mile of Track	$ 2,500,000	0	
Electrification (Double Track)	Y	Per Mile of Track	$ 2,450,000	0	Little per-track-mile savings for double track versus single track.
New Light Maintenance Shop and Yard	Y	Per Facility	$ 72,000,000	0	
Existing Maintenance Shop and Yard Improvements	Y	Per Facility	$ 50,000,000	0	

Table 37 - Low Investment Scenario Capital Cost Estimate Units

Capital Unit	Construction Adjacent to Live Rail?	Units	Unit Cost (2018 $)*	Low Investment Scenario Quantities	Notes
Diesel Loco	N.A.	Per Unit	$ 6,750,000	1	For 11th train. UTA already has a spare
Bi-Level Coach	N.A.	Per Unit	$ 3,400,000	27	Four cars for 11th train and 20 cars to increase to 5-car bi-level trains, plus 20% spares (shared with cab cars).
Bi-Level Cab Car	N.A.	Per Unit	$ 3,800,000	4	For 11th train, plus spare (shared with coach cars).
Electric Multiple Unit Car	N.A.	Per Unit	$ 5,740,000	0	
Replace existing fleet	N.A.	Lump sum	$ 311,000,000	1	

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

The simulated “ideal day” OTP without perturbations was 99.79%. Delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones. The trains run very close to on-time in the No Added Perturbations run. With the extended double track sections, there are no cascading delays, unlike the Future Baseline with PTC scenario.

Appendix F contains a complete set of time-distance string charts for the Low Investment scenario, including “ideal day” and “perturbed” results that comprise six 24-hour simulations.

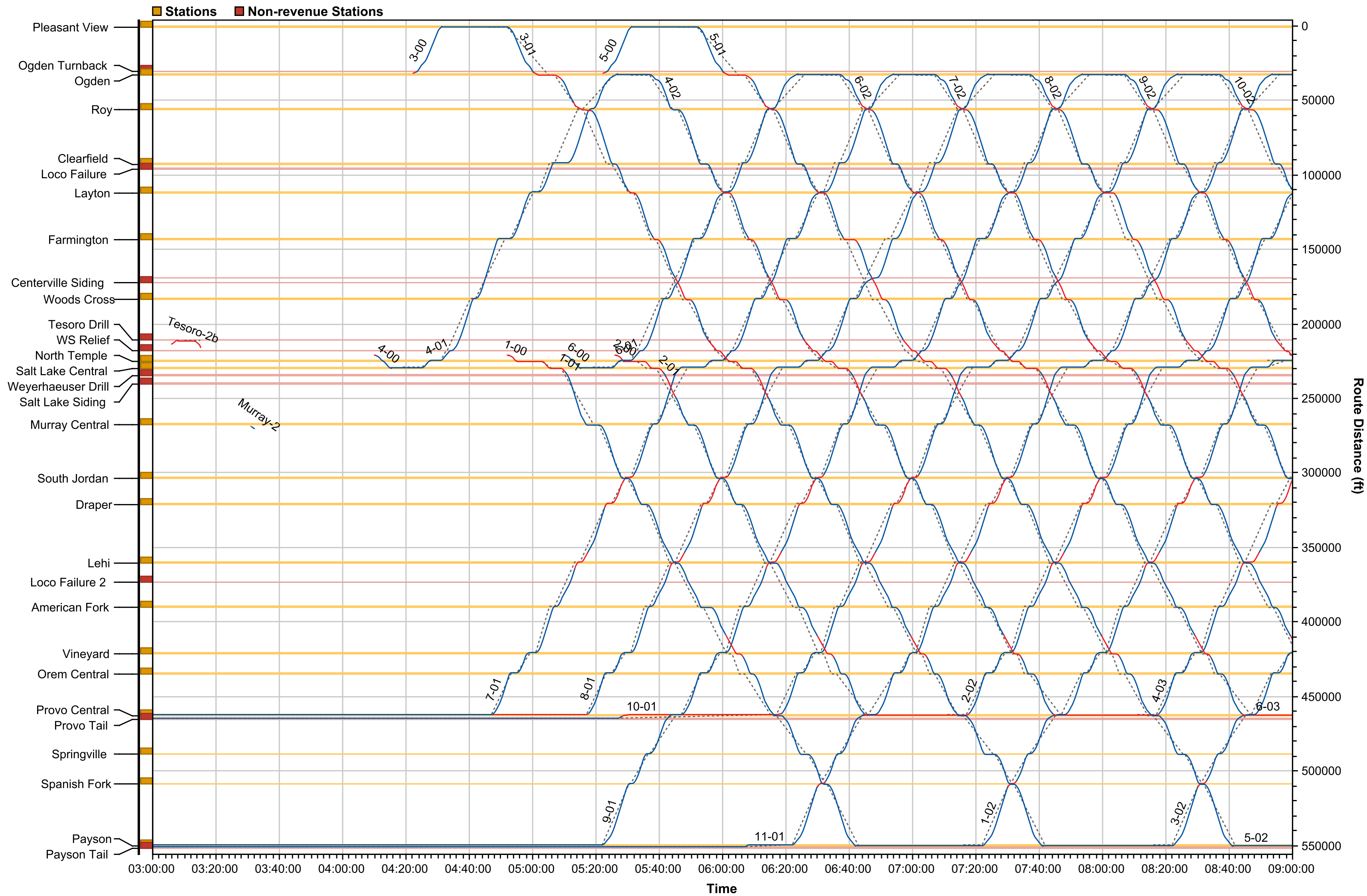


Figure 11-2: Low Investment Scenario Time-Distance ("String") Chart – 3 AM – 9 AM – No Added Perturbations

11.2 Low Investment Scenario Discussion of Results

The Low Investment Scenario simulation resulted in a five-day (with perturbations) OTP of 85.74% at the 4 minute and 59 second lateness threshold. This was done using five days with perturbations as shown in Table 38 to capture the real world variability present in the UTA data. The day-to-day variation in OTP is between 79.48% and 91.62%. With the change from a 4-car train consist using three bi-levels and one single-level car to four bi-levels, OTP declines significantly. The original consist with three bi-levels and one single-level car simulation resulted in a five-day (with perturbations) OTP of 93.91%.

Two of the five days include two-hour grade crossing failures (north of Murray on Day 2, north of South Jordan in Day 4, both in single track), consistent with the calibration baseline. The grade crossing failures, especially the failure north of Murray, have significant effects on OTP given the PTC-related signal control enforcement of Restricted Speed over the crossing and the enforced speed-stops in approach. The other operating perturbations such as one cautious train engineer that were assumed in the Future Baseline with PTC Scenario were carried forward to the Low Investment Scenario.

Table 38 - Simulated On-Time Performance - Low Investment Scenario

Lateness Threshold	**0:00:00**		**0:03:00**		**0:04:59**		**0:10:00**		**All Stops**	
Train Class	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**
Average Ideal Day (no Perturbations)	**393**	**41.15**	**874**	**91.52**	**946**	**99.06**	**955**	**100.00**	**955**	**100**
FrontRunner-Day 1	335	35.08	719	75.29	832	87.12	946	99.06	955	100
FrontRunner-Day 2	315	32.98	729	76.34	825	86.39	915	95.81	955	100
FrontRunner-Day 3	348	36.44	783	81.99	875	91.62	939	98.32	955	100
FrontRunner-Day 4	340	35.60	720	75.39	803	84.08	912	95.50	955	100
FrontRunner-Day 5	264	27.64	625	65.45	759	79.48	891	93.30	955	100
Average Typical Day (with Perturbations)	**320**	**33.55**	**715**	**74.89**	**819**	**85.74**	**921**	**96.40**	**955**	**100**

The Low Investment Scenario reflects timetable running time adjustments between stations northbound at Orem, Lehi, Salt Lake Central, North Temple, Layton, and Clearview; southbound at Clearfield, Woods Cross, Salt Lake Central, Murray, South Jordan, Lehi, and Vineyard. Additional end-to-end run time was also added, with trains departing Ogden earlier and arriving Provo later with an overall scheduled time of 2:12 Ogden to Provo. This is a 6 minute increase versus the Future Baseline with PTC Scenario.

In the northbound direction, trains are scheduled to depart Provo earlier and arriving at Ogden later with an overall 2:09 scheduled run time. This is a 2 minute increase versus the Future Baseline with PTC Scenario. The Low Investment Scenario features reduced scheduled dwell time/recovery at Salt Lake Central: 2 minutes southbound, 4 minutes northbound. This is a reduction of 1 minute southbound and 2 minutes northbound versus the Future Baseline with PTC Scenario. The full schedule is shown in Appendix A.

11.3 Discussion of Low Investment Scenario Ridership Modeling Results

The ridership model network and transit files were updated to reflect the addition of the infill station at Vineyard as part of this scenario. The scenario also includes a southern extension of FrontRunner to Payson, along with intermediate stations at Springville and Spanish Fork. A separate commuter rail line was coded with a peak headway of 60 minutes and no off-peak headway to reflect the limited service assumed in the operations modeling. This same headway was assumed for service between Pleasant View and Ogden. The main line FrontRunner route headway was unchanged, assuming a 30 minute peak headway and 60 minute off-peak headway (Provo to Ogden).

The five day average speeds for each station-station pair from the corresponding scenario operations model was used to update link level speeds. Table 39 summarizes the total daily boardings for the FrontRunner system and by station. Table 40 summarizes the total daily regional auto and transit trips.

Table 39 - Low Investment Scenario Daily FrontRunner Boardings by Station

Stop Name	Future Baseline with PTC
Pleasant View	100
Ogden (transfer)	100
Ogden	3,338
Roy	1,151
Clearfield	2,060
Layton	1,649
Farmington	1,129
Woods Cross	2,233
North Temple	2,391
Salt Lake	9,920
Murray	3,921
South Jordan	1,269
Draper	484
Lehi	1,166
American Fork	1,133
Vineyard	601
Orem	2,706
Provo	3,502
Provo (transfer)	367
Springville	148
Spanish Fork	142
Payson	91
TOTAL	39,600

Table 40 - Low Investment Scenario Total Daily Regional Auto and Transit Trips

Trips	Future Baseline with PTC
Auto	13,213,642
Transit	298,075

Total FrontRunner ridership in this scenario is approximately 39,600, which is an 11% increase from the Future Baseline model run. Approximately 1,300 of these boardings occur at the Vineyard Station and the southern extensions stations (Springville, Spanish Fork, Payson).

Transit trip shares also increase under this scenario making up approximately 298,000 of the total regional trips. However, this is only a 1% increase from the Future Baseline model run and demonstrates a net increase of approximately 3,437 new transit trips due to changes to the FrontRunner system in this scenario.

A sensitivity test was conducted using this model run to better understand ridership for the southern extension to Payson. In this test, the FrontRunner main line was extended south to the Springville, Spanish Fork, and Payson stations with 30 minute peak headways and 60 minute off-peak headways rather than using a separate transit line file with different headway assumptions. Table 41 and Table 42 provide a summary of results.

Table 41 - Low Investment Scenario Sensitivity Test Daily FrontRunner Boardings by Station

Stop Name	Future Baseline with PTC
Pleasant View	100
Ogden (transfer)	100
Ogden	3,338
Roy	1,143
Clearfield	2,060
Layton	1,641
Farmington	1,132
Woods Cross	2,229
North Temple	2,426
Salt Lake	10,074
Murray	4,071
South Jordan	1,283
Draper	488
Lehi	1,188
American Fork	1,152
Vineyard	618
Orem	3,225
Provo	3,993
Springville	572
Spanish Fork	726
Payson	627
TOTAL	42,080

Table 42 - Low Investment Scenario Sensitivity Test Total Daily Regional Auto and Transit Trips

Trips	Future Baseline with PTC
Auto	13,210,752
Transit	301,079

While this sensitivity test demonstrates that ridership would increase if the main line was extended to the south rather than operating a separate shuttle route, the increase would be limited. There were approximately 1,200 more boardings at the three southern extension stations in the sensitivity test model run compared with the Low Investment Scenario. Ultimately, the project team determined that this level of ridership did not support full service and that extensions would be modeled as separate shuttle routes.

12 Future Medium Investment Scenario Simulation Results

The Future Medium Investment Scenario includes the same additional infrastructure to expand service and increase reliability as the Low Investment Scenario and builds on this with additional double track capacity to allow increased service for 15-minute peak headways and 30-minute off-peak headways. Specific infrastructure projects modeled in this scenario include:

- Extension south from Provo to Payson with intermediate stations at Springville and Spanish Fork (same as the Low Investment Scenario),
- Infill station at Vineyard, between Orem Central and American Fork (same as the Low Investment Scenario), and
- Additional double track totaling approximately 46 miles for the new meets created by the 15-minute peak headways and to help with meets during service disruptions (an additional 36 miles plus the 10 miles from the Low Investment Scenario).

The Payson extension service in the Medium Investment Scenario is approximately the same as in the Low Investment Scenario with four peak-direction trips every hour. Schedule times were changed slightly to smooth the turnbacks at Provo Central with the new 15-minute peak headways. In addition, a siding was added at Springville to help with the new meets there as a result of the adjusted schedules and the Spanish Fork siding helps with meets created by perturbations.

Six-car trains (five bi-level coaches and one bi-level cab car) are assumed for this scenario in order to meet the projected peak ridership demand. These train consists, operating with the same single MP36 diesel locomotive, considerably slow the deceleration and acceleration in and out of stations and at interlockings versus Existing or Future Baseline train performance. Therefore, it becomes more difficult to keep up with the schedule, especially in the perturbed scenarios. More information on the impacts of the longer diesel-hauled trains are detailed below. Signal circuit lengths were checked for accepting the longer trains in the system, with the Ogden turnback being the only one that required replacement.

Additional double track to model in the simulation was chosen using full day simulations with perturbations and analyzing these results against the Double Tracking Feasibility Workshop from October 2016. A list of locations was created and then ranked according to the effectiveness that each one would have on improving reliability; this is shown in Table 43.

The locations were created as a result of a test “alternate meet” 30-minute headway operating plan – these are the locations where the additional trains would make routine passes. After running the draft 15-minute operating plan in the no perturbation simulation, the double track sections were analyzed again and more locations with “super sidings” (extending double track to connect sidings) were added to increase OTP. Table 45 summarizes the inputs to the Medium Investment Scenario capital cost estimate. These capital costs do not include “state of good repair” infrastructure costs or recurring fleet replacement costs.

After adding the initially-planned double track sections, OTP in the scenario without perturbations was at 74.2%, still well below the 95% goal. Before adding even more double track, it was decided to revise the operating plan by adding one additional train consist in the cycle and adjusting the meets on FrontRunner South, which is where trains were having the most difficulty staying on schedule and making their meets. This is based on an analysis of traversal times between double track interlockings, which confirmed they are at levels that accommodate 15-minute headways. The revision to the operating plan allowed trains to better meet their schedule by giving a longer running time south of Salt Lake Central and a better chance to meet their passing window by revising the meet locations. With the resulting improvement in OTP, it was decided to not add more double track locations. The schedule is shown in Appendix A.

Table 43 - Double Track Priority Analysis

Rank	Segment	From MP	To MP	Dist.	Level of Difficulty
1	Draper Siding – South	20.60	17.70	2.90	Major difficulty
					Difficulty
					Minimal difficulty
2	1800 North Siding – North	6.37	3.65	2.72	Minimal difficulty
					Moderate difficulty
3	Murray Central – South	8.77	7.40	1.37	Major difficulty
					Difficulty
4	American Fork – North	30.07	28.78	1.29	Difficulty
					Major difficulty
5	Clearfield – North	27.40	26.30	1.10	Difficulty
					Major difficulty
					Minimal difficulty
6	Farmington – North	18.90	16.70	2.20	Difficulty
					Major difficulty
					Minimal difficulty
					Moderate difficulty
7	Ogden - Roy Super Siding	36.75	33.90	2.85	Difficulty
	(requires crossover south of Ogden)				Moderate difficulty
					Major difficulty
					Minimal difficulty
8	Provo - Orem Super Siding	43.91	43.13	0.78	Major difficulty
					Difficulty
9	Vineyard-American Fork	33.60	30.53	3.07	Moderate difficulty
					Difficulty
10	Orem-Vineyard	38.59	36.69	1.90	Difficulty
11	Clearfield-Roy	32.80	27.40	5.40	Major difficulty
					Moderate difficulty
					Minimal difficulty
					Difficulty
12	Layton-Clearfield	25.91	22.58	3.33	Major difficulty
					Moderate difficulty
					Minimal difficulty

As more cars are added in a consist with the same motive power (an MP36 diesel locomotive, in this case), the train becomes slower to accelerate and decelerate in and out of stations and interlockings. Additionally, a train may not be able to reach the top speed of 79 MPH in between some stations that it could with a shorter consist. This reality is reflected in the simulations as the consist size grows from the current 4-car trains (three bi-levels with one single level car) to 5-car bi-level trains in the Low Investment Scenario and then to 6-car bi-level trains in the Medium Investment Scenario. Alternately, electric consists were tested to compare a similar consist size of a train that will be used in the High Investment Scenario simulations (Stadler 8-car EMU trains, similar to those on order by Caltrain). These results are presented in the velocity graph shown in Figure 12-1.

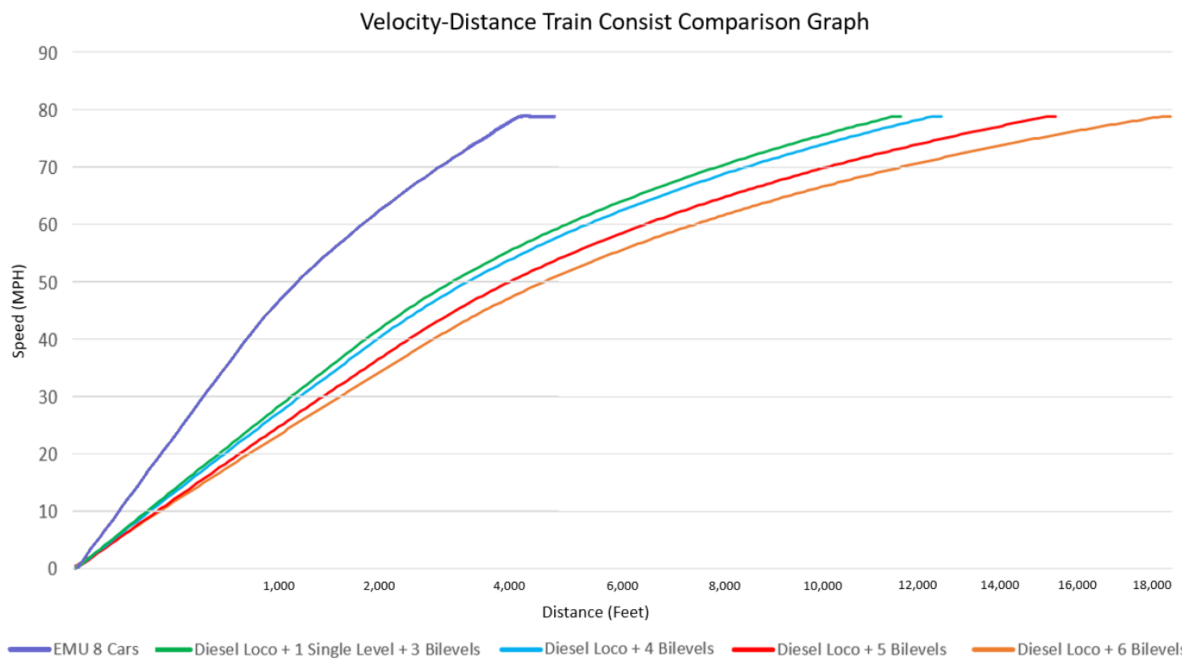


Figure 12-1: Velocity-Distance Train Consist Comparison Graph

UTA's special Hill Air Force Base's Warriors Over the Wasatch Air and Space Show service on June 23 and 24, 2018 provided an opportunity to verify the reduced acceleration of longer trains under "real world" conditions. On those days, UTA operated five-car bi-level trainsets, rather than the current 3 bi-levels and one single level coach. UTA Field Supervisors recorded "time to 79 MPH" data for the five-car train trips, comparing it with the analogous times for the existing train consists.

Using this data and ignoring the two station-to-station pairs where the "real world" five-car train got to 79 mph faster than the existing FrontRunner consist (deemed statistical flukes and shown in red in Table 44), the "real world" data shows acceleration times increasing by 25 to 56 seconds, depending on location. The TrainOps simulation results show 23 to 46 seconds, again depending on location. The "real world" and TrainOps simulation results are deemed sufficiently close to confirm that the simulation is accurately predicting the travel time impacts of longer FrontRunner trains in the future.

A combination of running time and schedule adjustments were made to the operating plan to further increase reliability of the simulation with perturbations. This involved testing several options and the best performance included these adjustments:

- Interstation adjustments northbound at Orem, Lehi, Salt Lake Central, Temple, Layton, and Clearview; southbound at Clearfield, Woods Cross, Salt Lake Central, Murray, South Jordan, Lehi, and Vineyard
- Departing Ogden earlier, arriving Provo later: 2:21 Ogden to Provo (2:12 Low Investment, 2:06 Future with PTC)
- Departing Provo earlier, arriving Ogden later: 2:19 Provo to Ogden (2:09 Low Investment, 2:07 in Future with PTC)
- Departing Provo earlier, arriving Pleasant View later: 2:34 Provo to Pleasant View (2:23 Low Investment, 2:20 Future with PTC)

- Departing Ogden earlier, arriving Payson later: 2:49 Ogden to Payson (2:39 Low Investment, 2:34 PTC Future with PTC)

As was done in the previous simulations, in order for the simulation to more closely match operating conditions experienced on FrontRunner, two perturbations were added to each of the five randomized operating plan days. A cautious engineer operating at a maximum speed of 65 MPH for one train cycle was included for each of the five days.

Table 44 - 5-car Bi-Level Train vs. Current 4-Car Train

Station		Demonstration Time to 79 MPH			Simulation Time to 79 MPH			Notes Reference
From	**To**	**5 Cars**	**3/1 Cars**	**Difference**	**5 Cars**	**3/1 Cars**	**Difference**	
Provo	Orem	0:05:34	0:04:48	0:00:46	0:04:40	0:03:54	0:00:46	
Orem	American Fork	0:03:09	0:07:48	0:04:39	0:03:15	0:02:36	0:00:39	
American Fork	Lehi	-	0:05:34	-	-	0:05:20	-	
Lehi	Draper	0:06:24	0:05:54	0:00:30	0:05:28	0:04:51	0:00:37	
Draper	South Jordan	-	0:02:33	-	0:03:09	0:02:32	0:00:37	See Note 1
South Jordan	Murray Central	0:04:00	0:03:07	0:00:53	0:03:32	0:03:07	0:00:25	
Murray Central	Salt Lake Central	0:03:32	0:02:37	0:00:55	0:03:40	0:03:14	0:00:26	
Salt Lake Central	North Temple	-	-	-	-	-	-	
North Temple	Woods Cross	0:06:50	0:07:42	0:00:52	0:07:41	0:07:18	0:00:23	See Note 2
Woods Cross	Farmington	0:03:06	0:02:38	0:00:28	0:02:56	0:02:23	0:00:33	
Farmington	Layton	0:03:45	0:02:49	0:00:56	0:04:08	0:03:22	0:00:46	
Layton	Clearfield	-	-	-	-	0:03:41	-	
Clearfield	Roy	0:03:18	0:02:53	0:00:25	0:04:07	0:03:22	0:00:45	
Roy	Ogden	0:02:48	0:02:02	0:00:46	-	0:02:11	-	See Note 3

Notes:
1. In the simulation 5-car run, the departure from Draper came very close to not reaching 79 MPH.
2. The simulation runs assumed relief stops at Warm Springs to match the demonstration runs.
3. In the simulation 5-car run, the departure from Roy only reached 72 MPH.

For grade crossing failures, it was assumed that the FrontRunner Dispatcher would communicate the reason for the cab signal step-downs, providing the engineer with the confidence to operate at the upper range of the 0 speed command (14 MPH in the simulation). This is in contrast with end-of-track and controlled siding 0 speed command operation, where trains are capped at 4 MPH in this condition in the simulation. The north of Murray failure has a more profound operational impact because the approaching PTC signal control lines are longer than for the grade crossing north of South Jordan.

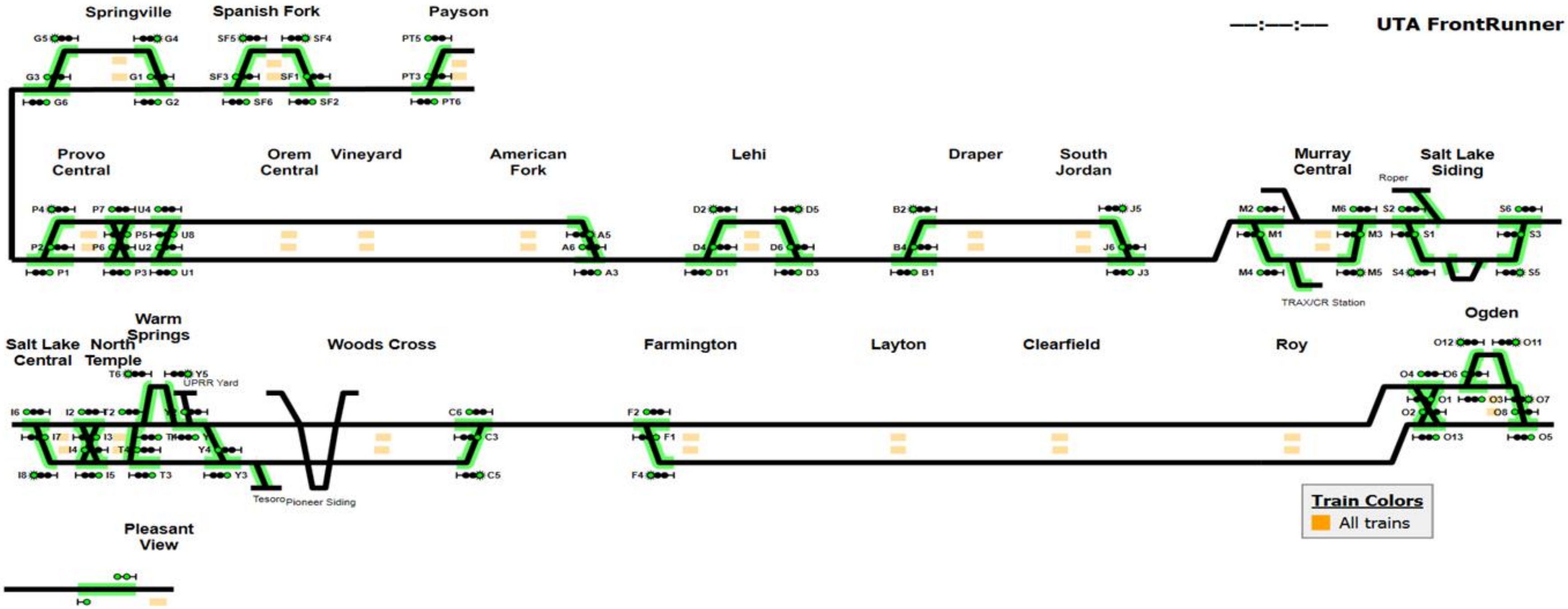


Figure 12-2: TrainOps Track Schematic of Medium Investment Scenario Simulation

Table 45 - Medium Investment Scenario Capital Cost Estimate Units

Capital Unit	Construction Adjacent to Live Rail?	Units	Unit Cost (2018 $)*	Medium Investment Scenario Quantities	Notes
Station Side Platform	Y	Per Platform	$ 200,000	0	
Station Center Island Platform	Y	Per Platform	$ 250,000	4	
Raise existing low platform to high platform height - Center	Y	Per platform	$ 250,000	34	Per car length, need 2 car lengths for all stations. No PV. Plus 4 more -1 each- on long stations in North (Ogden, Layton, Farmington, SLCtrl)
Raise existing low platform to high platform height - Side	Y	Per platform	$ 150,000	8	Provox2, SLCtrlx3, Farmingtonx3 - low platform plus new car length on long platforms
Extend Existing Platform - on existing foundation (south)	Y	Per car length req'd per platform	$ 350,000	8	South Stations, 1 car length + Provo side platform
Extend Existing Platform - new foundation (north)	Y	Per car length req'd per platform	$ 500,000	4	North Stations, 1 car length minus long stations
Station Parking Lot	N.A.	Per Parking Lot	$ 4,000,000	4	
Relocated Main Track	Y	Per LF of Track (not LF of Rail)	$ 865	55,300	Relocate/consolidate UP track for South Jordan, Salt Lake, Centerville, Draper, Murray, American Fork, Ogden, Kaysville, Layton, Roy, and Clearfield siding extensions.
Additional Main Track (Without Signals)	Y	Per LF of Track (not LF of Rail)	$ 1,150	273,300	178,000 feet additional track for siding extensions; 86,300 feet additional track for Payson extension; 9,000 feet for Spanish Fork and Springville Sidings.
Interlocking (Single Switch)	Y	Per Interlocking	$ 3,500,000	9	Add 4 new interlockings for new siding construction and 5 new interlockings for Payson extension.
Signal Location (Non-Interlocking)	Y	Per Location	$ 250,000	147	
Grade Crossing – Single Track (Signalized)	Y	Per Crossing	$ 1,500,000	10	For Payson Extension
Grade Crossing – Double Track (Signalized)	N	Per Crossing	$ 2,000,000	0	
Grade Crossing – Double Track (Signalized)	Y	Per Crossing	$ 1,750,000	20	Jordan Gateway in Jordan; 1600 North in Centerville; S 500 W, S 700 W, and S 900 W in Provo; W 400 S in Orem; W Center, W 1500 S, E 1100 N, and Main Street near Woods Cross, Old Mill Lane near Kaysville; W Gentile St, S 650 W and W Hill Field Rd near Layton; W Gordon Ave and N 2200 W near Clearfield; W 1300 N, W 1800 N, W 2300 N, and W 6000 South near Roy, and W 3300 S near Ogden.
Undergrade Bridge - Single Track (LF)	Y	Per LF	$ 186,500	465	Road bridge (400 North in Woods Cross) may need to be rebuilt over UTA and UP and E 700 S bridge near Clearfield may need to be rebuilt over UTA and UP.
Electrification (Single Track)	Y	Per Mile of Track	$ 2,500,000	0	
Electrification (Double Track)	Y	Per Mile of Track	$ 2,450,000	0	
New Light Maintenance Shop and Yard	Y	Per Facility	$ 72,000,000	0	
Existing Maintenance Shop and Yard Improvements	Y	Per Facility	$ 50,000,000	0	

Table 45 - Medium Investment Scenario Capital Cost Estimate Units

Capital Unit	Construction Adjacent to Live Rail?	Units	Unit Cost (2018 $)*	Medium Investment Scenario Quantities	Notes
Diesel Loco	N.A.	Per Unit	$ 6,750,000	15	12 for additional peak trains plus three spares.
Bi-Level Coach	N.A.	Per Unit	$ 3,400,000	101	Includes coaches for upgrading trains to 6-car bi-level trains, plus coaches for 12 new trains, plus 20% spares.
Bi-Level Cab Car	N.A.	Per Unit	$ 3,800,000	22	12 for new trains plus spares (6 cab cars substituted for coach cars for greater cab car reserve).
Electric Multiple Unit Car	N.A.	Per Unit	$ 5,740,000	0	
Electric Loco	N.A.	Per Unit	$ 8,849,000	0	
Replace existing fleet	N.A.	Lump sum	$ 311,000,000	1	

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

12.1 Medium Investment Scenario Simulation Results without Perturbations (Ideal Day)

After adding the additional 46 miles of double track for the Medium Investment Scenario (36 miles of additional double track above the Low Investment Scenario), the OTP without perturbations increased from the initial model run of 56.5% to 93.9% OTP. With perturbations, OTP was simulated at 84.8% over the five days.

Delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones shown in Figure 12-3. The trains run very close to on-time in the No Added Perturbations run, except for cascading delays at the end of each peak. Even with the extended double track sections, cascading delays begin to develop between American Fork and Draper after the peak service has been running for about an hour. However, due to the availability of some schedule margin in this area, trains generally get back on time before Provo southbound and Salt Lake Central northbound.

Refer to Appendix G for more results.

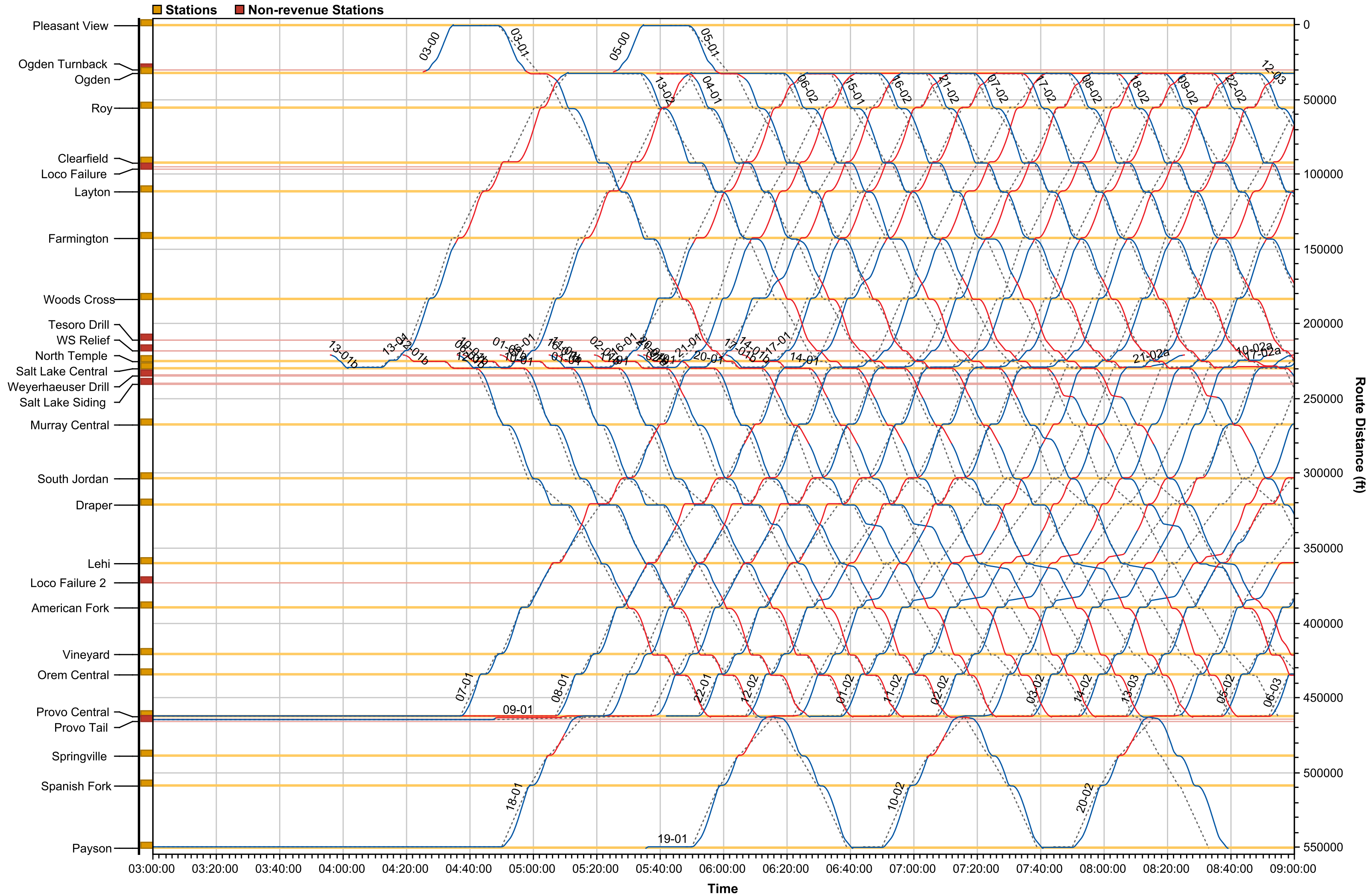


Figure 12-3: Medium Investment Scenario Time-Distance ("String") Chart – 3 AM – 9 AM – No Added Perturbations

12.2 Medium Investment Scenario Discussion of Results

The Medium Investment Scenario simulation resulted in a five-day (with perturbations) OTP of 84.82% at the 4 minute and 59 second lateness threshold. The day-to-day variation in OTP is between 73.05% and 92.14%. With the change to a 6-car bi-level train consist, OTP is substantially lower than the 95% goal despite the significant assumed investment in double track.

Two of the five days include two-hour grade crossing failures (north of Murray on Day 2, north of South Jordan in Day 4, both in single track), consistent with the calibration baseline. The grade crossing failures, especially the failure north of Murray, have significant effects on OTP given the PTC-related signal control enforcement of Restricted Speed over the crossing and the enforced speed-stops in approach, as well as the number of trains being pushed through this area because of the 15-minute headways.

Table 46 - Simulated On-Time Performance - Medium Investment

Lateness Threshold	**0:00:00**		**0:03:00**		**0:04:59**		**0:10:00**		**All Stops**	
Train Class	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**
Ideal Day (no Perturbations)	**793**	**45.47**	**1516**	**86.93**	**1639**	**93.98**	**1728**	**99.08**	**1744**	**100**
FrontRunner-Day 1	705	40.42	1425	81.71	1544	88.53	1662	95.30	1744	100
FrontRunner-Day 2	658	37.73	1307	74.94	1452	83.26	1621	92.95	1744	100
FrontRunner-Day 3	780	44.72	1501	86.07	1607	92.14	1708	97.94	1744	100
FrontRunner-Day 4	593	34.00	1138	65.25	1274	73.05	1414	81.08	1744	100
FrontRunner-Day 5	703	40.68	1354	78.36	1506	87.15	1657	95.89	1728	100
Average Typical Day (with Perturbations)	**688**	**39.51**	**1345**	**77.26**	**1477**	**84.82**	**1612**	**92.62**	**1741**	**100**

12.3 Discussion of Medium Investment Scenario Ridership Modeling Results

As with the Future Low Investment Scenario, this ridership model run included the addition of Vineyard Station and a southern extension of FrontRunner to Payson. However, this scenario also includes changes to both the peak and off-peak headways of the FrontRunner main line. Headways were changed to 15 minutes during the peak and 30 minutes during the off-peak. The southern extension and the FrontRunner line between Pleasant View and Ogden were modeled with a headway of 60 minutes and no off-peak headway to reflect the limited service assumed in the operations modeling.

The five day average speeds for each station-station pair from the corresponding scenario operations model was used to update link level speeds of the system. Table 47 summarizes the total daily boardings for the FrontRunner system and by station. Table 48 summarizes the total daily regional auto and transit trips.

Table 47 - Medium Investment Scenario Test Daily FrontRunner Boardings by Station

Stop Name	Medium Investment Scenario
Pleasant View	105
Ogden	105
Ogden	4,094
Roy	2,031
Clearfield	3,521
Layton	2,554
Farmington	1,719
Woods Cross	3,994
North Temple	4,413
Salt Lake	13,447
Murray	6,951
South Jordan	2,350
Draper	722
Lehi	1,642
American Fork	1,720
Vineyard	807
Orem	3,555
Provo	3,712
Provo	312
Springville	131
Spanish Fork	122
Payson	74
TOTAL	58,082

Table 48 - Medium Investment Scenario Total Daily Regional Auto and Transit Trips

Trips	Medium Investment Scenario
Auto	13,199,489
Transit	312,503

Total FrontRunner ridership in this scenario is approximately 58,000, which is a 63% increase from the Future Baseline model run. Approximately 2,500 of these boardings occur at the Vineyard Station and the southern extensions stations (Springville, Spanish Fork, Payson).

Transit trip shares also increase under this scenario making up approximately 312,500 of the total regional trips. This is a 6% increase from the Future Baseline model run and demonstrates a net increase of approximately 17,900 new transit trips due to changes to the FrontRunner system in this scenario.

13 Future High Investment Scenario Simulation Results

The Future High Investment Scenario includes additional infrastructure to expand service and increase reliability, but more significantly this scenario includes the investment in electric infrastructure and rolling stock. Specific infrastructure projects modeled in this scenario include:

- Extension south from Provo to Payson with intermediate stations at Springville and Spanish Fork (same as in the Low and Medium Investment Scenarios),
- Infill station at Vineyard, between Orem Central and American Fork (same as in the Low and Medium Investment Scenarios),
- Additional double track totaling approximately 34 miles to help with meets during service disruptions (includes 10 miles from the Low Investment Scenario plus an additional 24 miles of double track), and
- Electric infrastructure between Provo and Ogden with either diesel shuttles or dual-mode multiple-units serving the Payson and Pleasant View lines.

The Payson extension service has a similar operating plan as in the Medium Investment Scenario, with four peak-direction trains every hour in the morning and afternoon.

Vehicles used in the High Investment Scenario are Stadler 8-car EMU consists, which are similar to those currently on order by Caltrain. These trains are roughly the same length as the 6-car bi-level with diesel locomotive consists, so no change in signal locations was required to support the EMU consists. Table 49 summarizes the inputs to the High Investment Scenario capital cost estimate. These capital costs do not include “state of good repair” infrastructure costs or recurring fleet replacement costs.

In the High Investment Scenario, the meets performed better than the Medium Investment Scenario because of the faster acceleration and deceleration of the EMUs, which enabled quicker stations stops and faster times through interlockings. This led to an increase in OTP above the Low and Medium Investment Scenarios, as well as reduced travel times.

A combination of running time and schedule adjustments were made to the operating plan to further increase reliability of the simulation with perturbations. This involved testing several options and the overall travel time was reduced from the Medium Investment Scenario and closer to the Low Investment Scenario travel times:

- 2:14 Ogden to Provo,
- 2:10 Provo to Ogden,
- 2:25 Provo to Pleasant View,
- 2:38 Ogden to Payson, and
- Dwell time at Salt Lake Central: 3 minutes southbound, 6 minutes northbound.

Full simulated schedules for all scenarios are shown in Appendix A. As was done in the previous simulations, in order for the simulation to more closely match operating conditions experienced on FrontRunner, two perturbations were added to each of the five randomized operating plan days. These perturbations were chosen based on data LTK received showing daily reports of delays on FrontRunner. A cautious engineer operating at a maximum speed of 65 MPH for one train cycle was included for each of the five days.

For grade crossing failures, it was assumed that the FrontRunner Dispatcher would communicate the reason for the cab signal step-downs, providing the engineer with the confidence to operate at the upper range of the 0 speed command (14 MPH in the simulation). This is in contrast with end-of-track and controlled siding 0 speed command operation, where trains are capped at 4 MPH in this condition in the simulation. The north of Murray failure has a more profound operational impact because the approaching PTC signal control lines are longer than for the grade crossing north of South Jordan. Both crossings were selected at random (though the selection was focused on single track crossings for maximum operational impact) as part of the baseline calibration work, then retained for the PTC analysis.

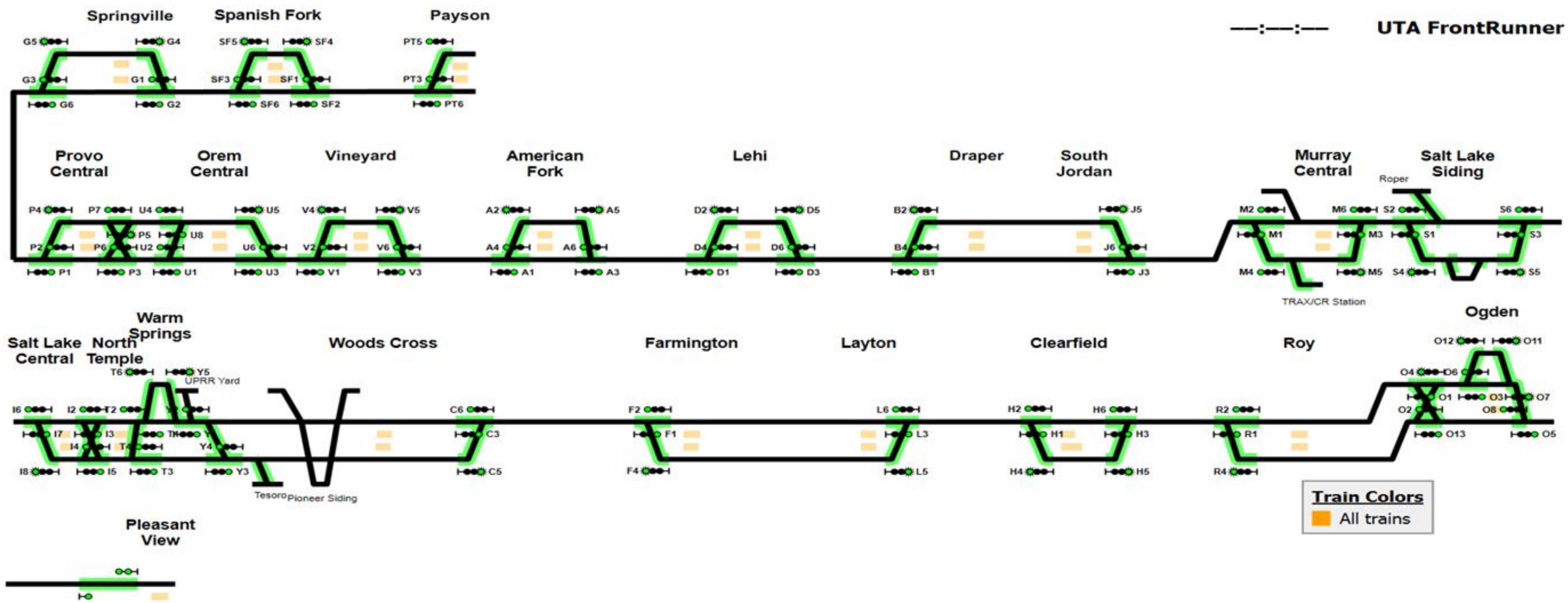


Figure 13-1: TrainOps Track Schematic of High Investment Scenario Simulation

Table 49 - High Investment Scenario Capital Cost Estimate Units

Capital Unit	Construction Adjacent to Live Rail?	Units	Unit Cost (2018 $)*	High Investment Scenario Quantities	Notes
Station Side Platform	Y	Per Platform	$ 200,000	0	
Station Center Island Platform	Y	Per Platform	$ 250,000	4	Vineyard, Spanish Fork, Payson, and Springville Station platforms.
Raise existing low platform to high platform height - Center	Y	Per platform	$ 250,000	38	Per car length, need 2 car lengths for all stations. No PV. Plus 8 more -2 each- on long stations in North (Ogden, Layton, Farmington, SLCtrl)
Raise existing low platform to high platform height - Side	Y	Per platform	$ 150,000	10	Provox2, SLCtrlx4, Farmingtonx4
Extend Existing Platform - on existing foundation (south)	Y	Per car length req'd per platform	$ 350,000	16	South Stations, 2 car length + Provo side platform
Extend Existing Platform - new foundation (north)	Y	Per car length req'd per platform	$ 500,000	8	North Stations minus long stations, 2 car lengths
Station Parking Lot	N.A.	Per Parking Lot	$ 4,000,000	4	Parking lots at all new stations.
Relocated Main Track	Y	Per LF of Track (not LF of Rail)	$ 865	44,200	Relocate/consolidate UP track for South Jordan, Salt Lake, Centerville, Draper, Murray, American Fork, Ogden, Kaysville, and Clearfield siding extensions.
Additional Main Track (Without Signals)	Y	Per LF of Track (not LF of Rail)	$ 1,150	251,000	155,700 feet additional track for siding extensions; 86,300 feet additional track for Payson extension; 9,000 feet for Spanish Fork and Springville Sidings.
Interlocking (Single Switch)	Y	Per Interlocking	$ 3,500,000	9	Add 4 new interlockings for new siding construction and 5 new interlockings for Payson extension.
Signal Location (Non-Interlocking)	Y	Per Location	$ 250,000	114	
Grade Crossing – Single Track (Signalized)	Y	Per Crossing	$ 1,500,000	10	For Payson Extension
Grade Crossing – Double Track (Signalized)	N	Per Crossing	$ 2,000,000		
Grade Crossing – Double Track (Signalized)	Y	Per Crossing	$ 1,750,000	11	S 500 W, S 700 W, and S 900 W in Provo; W Center, W 1500 S, E 1100 N, and Main Street near Woods Cross, Old Mill Lane near Kaysville, and W 3300 S near Ogden.
Undergrade Bridge - Single Track (LF)	Y	Per LF	$ 186,500	465	Road bridge (400 North in Woods Cross) may need to be rebuilt over UTA and UP and E 700 S bridge near Clearfield may need to be rebuilt over UTA and UP.
Electrification (Single Track)	Y	Per Mile of Track	$ 2,500,000	25	
Electrification (Double Track)	Y	Per Mile of Track	$ 2,450,000	115	Little per-track-mile savings for double track versus single track.
New Light Maintenance Shop and Yard	Y	Per Facility	$ 72,000,000	2	Two-track, eight-car EMU service and inspection/light running repair shop.
Existing Maintenance Shop and Yard Improvements	Y	Per Facility	$ 50,000,000	1	Warm Springs lengthening and electrification upgrade.
Diesel Loco	N.A.	Per Unit	$ 6,750,000	0	
Bi-Level Coach	N.A.	Per Unit	$ 3,400,000	0	
Bi-Level Cab Car	N.A.	Per Unit	$ 3,800,000	0	

Table 49 - High Investment Scenario Capital Cost Estimate Units

Capital Unit	Construction Adjacent to Live Rail?	Units	Unit Cost (2018 $)*	High Investment Scenario Quantities	Notes
Electric Multiple Unit Car	N.A.	Per Unit	$ 5,740,000	192	160 EMUs for peak operation (20 8-car trains) plus 32 for 20% spares.
Electric Loco	N.A.	Per Unit	$ 8,849,000	0	

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

13.1 Future Rolling Stock

The two future investment scenarios with an electrified FrontRunner network assume the operation of Electric Multiple Units (EMUs). Unlike locomotive-hauled trains, EMUs have consistent train performance regardless of train length. With most or all axles powered, EMUs have excellent rail-wheel adhesion characteristics that provide excellent acceleration and deceleration.

Table 50 - Specification for Simulation - Electric Multiple Units (EMUs)

	Stadler EMU, 8-Car, 4MT (AW1)
Weight (pounds)	1154468
Length (feet)	680
Number of Axles	32
Passenger Capacity (Seated)	550 (Note 1)
Passenger Capacity (Total)	1000
Maximum Design Speed (mph)	3
Maximum Operating Speed (mph)	3
Auxiliary kW Load (kW)	0
Rotational Mass (percent)	9.015
Service Brake Rate (mph/s)	2.5
Frontal Area (square feet)	140

Note 1: European intercity seating configuration, based on information from Stadler. Commuter rail passenger capacity is higher.

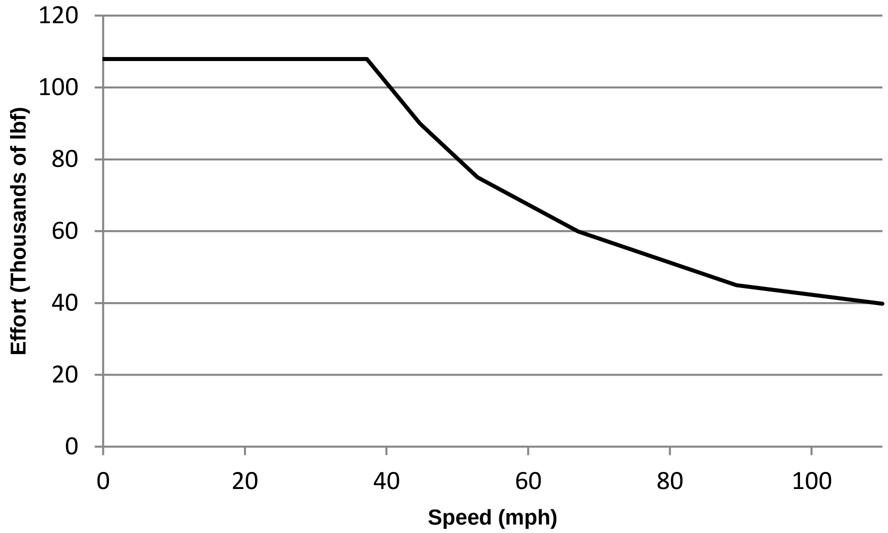


Figure 13-2: Stadler EMU Tractive Effort

13.2 High Investment Scenario Simulation Results without Perturbations (Ideal Day)

The simulated High Investment Scenario OTP without perturbations was 99.83% within the 4:59 lateness threshold.

Referring to the time-distance string chart in Figure 13-3, delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones. The trains run very close to on-time in the No Added Perturbations run. Even with shorter double track sections, there are no cascading delays, unlike the Medium Investment Scenario. This is due to the faster acceleration and deceleration, and the ability to stay at a higher speed longer, with the EMU consists.

Refer to Appendix H for more results.

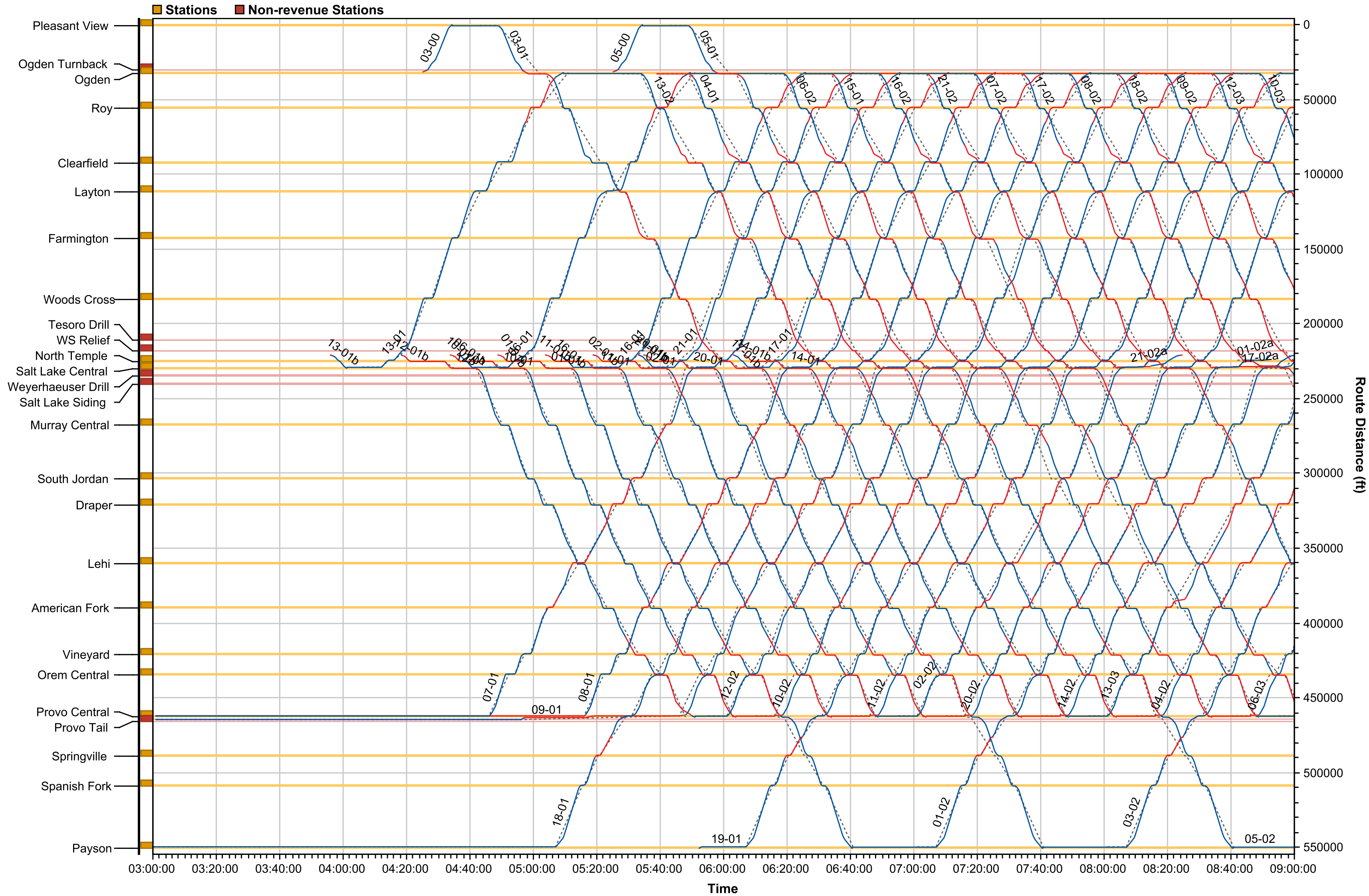


Figure 13-3: High Investment Scenario Time-Distance (“String”) Chart – 3 AM – 9 AM – No Added Perturbations

13.3 High Investment Scenario Discussion of Results

The High Investment Scenario simulation resulted in a five-day (with perturbations) OTP of 93.51% at the 4 minute and 59 second lateness threshold. This was done using five days with perturbations as shown in Table 51 to capture the real world variability present in the UTA data. The day-to-day variation in OTP is between 86.70% and 99.43%. The change to an EMU consist greatly helps improve OTP even with an increase in the number of trains operating on the system.

Two of the five days include two-hour grade crossing failures (north of Murray on Day 2, north of South Jordan in Day 4, both in single track), consistent with the calibration baseline. The grade crossing failures, especially the failure north of Murray, have significant effects on OTP given the PTC-related signal control enforcement of Restricted Speed over the crossing and the enforced speed-stops in approach, especially with the higher amount of trains running through the system with the 15-minute peak headways.

Table 51 - Simulated On-Time Performance - High Investment Scenario

Lateness Threshold	0:00:00		0:03:00		0:04:59		0:10:00		All Stops	
Train Class	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**
Ideal Day (no Perturbations)	**1315**	**75.40**	**1730**	**99.20**	**1741**	**99.83**	**1743**	**99.94**	**1744**	**100**
FrontRunner-Day 1	1202	68.92	1668	95.64	1708	97.94	1737	99.60	1744	100
FrontRunner-Day 2	1018	58.37	1435	82.28	1518	87.04	1614	92.55	1744	100
FrontRunner-Day 3	1266	72.59	1717	98.45	1734	99.43	1743	99.94	1744	100
FrontRunner-Day 4	1017	58.31	1442	82.68	1512	86.70	1585	90.88	1744	100
FrontRunner-Day 5	1217	69.78	1634	93.69	1682	96.44	1725	98.91	1744	100
Average Typical Day (with Perturbations)	**1144**	**65.60**	**1579**	**90.55**	**1631**	**93.51**	**1681**	**96.38**	**1744**	**100**

13.4 Discussion of High Investment Scenario Ridership Modeling Results

Like the Low and Medium scenarios, this model scenario included the addition of Vineyard Station and a southern extension of FrontRunner to Payson. The headway assumptions included 15 minute peak and 30 minute off-peak for the FrontRunner main line. The southern extension and the FrontRunner line between Pleasant View and Ogden were modeled with a headway of 60 minutes and no off-peak headway to reflect the limited service assumed in the operations modeling.

The five day average speeds for each station-station pair from the corresponding scenario operations model was used to update link level speeds of the system. In this scenario these speeds reflect electrification of the system. Table 52 summarizes the total daily boardings for the FrontRunner system and by station. Table 53 summarizes the total daily regional auto and transit trips.

Table 52 - High Investment Scenario Total Daily FrontRunner Boardings by Station

Stop Name	High Investment Scenario
Pleasant View	107
Ogden	107
Ogden	4,215
Roy	2,061
Clearfield	3,681
Layton	2,685
Farmington	1,826
Woods Cross	4,239
North Temple	4,933
Salt Lake	14,528
Murray	7,647
South Jordan	2,625
Draper	832
Lehi	1,919
American Fork	1,867
Vineyard	868
Orem	3,710
Provo	4,036
Provo	339
Springville	139
Spanish Fork	135
Payson	80
TOTAL	62,579

Table 53 - High Investment Scenario Total Daily Regional Auto and Transit Trips

Trips	High Investment Scenario
Auto	13,195,895
Transit	316,320

Total FrontRunner ridership in this scenario is approximately 62,600, which is a 76% increase from the Future Baseline model run. Approximately 1,400 of these boardings occur at the Vineyard Station and the southern extensions stations (Springville, Spanish Fork, Payson).

Transit trip shares also increase under this scenario making up approximately 316,300 of the total regional trips. This is a 7% increase from the Future Baseline model run and demonstrates a net increase of approximately 21,700 new transit trips due to changes to the FrontRunner system in this scenario.

14 Future High Investment Scenario with Infill Stations Simulation Results

The High Investment Scenario with Infill Stations includes additional infrastructure to expand service and increase reliability, electric infrastructure improvements, further extensions to the north and south, and additional stations. Specific infrastructure projects modeled in this scenario include:

- Extension south from Provo to Santaquin (additional station south of Payson),
- Extension north from Ogden to Brigham City (assumes new track built north of Ogden with intermediate stations at Business Depot of Ogden (BDO), Pleasant View and Willard),
- Infill stations at Vineyard, Bluffdale, Centerville, and Sunset,
- Additional double track totaling approximately 34 miles to help with meets during service disruptions (includes 10 miles from the Low Investment Scenario plus an additional 24 miles of double track, matching the Provo-Ogden double track of the High Investment Scenario), and
- Electric infrastructure between Provo and Ogden with either diesel shuttles or dual-mode multiple-units serving the Payson and Pleasant View lines.

The Payson extension service has a similar operating plan as in the Medium Investment Scenario, with four peak-direction trains every hour in the morning and afternoon.

Vehicles used in the High Investment Scenario with Infill Stations are Stadler 8-car EMU consists, which are similar to those currently on order by Caltrain. These trains are roughly the same length as the 6-car bi-level with diesel locomotive consists, so no change in signal locations was required to support the EMU consists. Table 49 Table 54 summarizes the inputs to the High Investment with Infill Stations Scenario capital cost estimate. These capital costs do not include “state of good repair” infrastructure costs or recurring fleet replacement costs.

Additional double track to model in the simulation between Ogden and Provo is identical to the High Investment Scenario. In the High Investment Scenario with Infill Stations, the meets performed similarly as the High Investment Scenario because of the faster acceleration and deceleration of the EMUs, which enabled quicker stations stops and faster times through interlockings. This led to favorable OTP results, similar to the High Investment Scenario, with the same improvement to travel times. Because the OTP was so high and similar to the High Investment Scenario, even with the infill stations, it was decided that including additional double track in this scenario was not warranted.

A combination of running time and schedule adjustments were made to the operating plan to further increase reliability of the simulation with perturbations. This involved testing several options and the overall travel time was still reduced from the Medium Investment Scenario, even though this scenario includes three additional stations between Provo and Ogden (schedule can be found in Appendix A):

- 2:16 Ogden to Provo,
- 2:13 Provo to Ogden,
- 2:43 Provo to Brigham City,
- 2:47 Ogden to Santaquin, and

- Dwell time at Salt Lake Central: 7 minutes southbound, 8 minutes northbound.

As was done in the previous simulations, in order for the simulation to more closely match operating conditions experienced on FrontRunner, two perturbations were added to each of the five randomized operating plan days. These perturbations were chosen based on data LTK received showing daily reports of delays on FrontRunner. A cautious engineer operating at a maximum speed of 65 MPH for one train cycle was included for each of the five days.

For grade crossing failures, it was assumed that the FrontRunner Dispatcher would communicate the reason for the cab signal step-downs, providing the engineer with the confidence to operate at the upper range of the 0 speed command (14 MPH in the simulation). This is in contrast with end-of-track and controlled siding 0 speed command operation, where trains are capped at 4 MPH in this condition in the simulation. The north of Murray failure has a more profound operational impact because the approaching PTC signal control lines are longer than for the grade crossing north of South Jordan. Both crossings were selected at random (though the selection was focused on single track crossings for maximum operational impact) as part of the baseline calibration work, then retained for the PTC analysis.

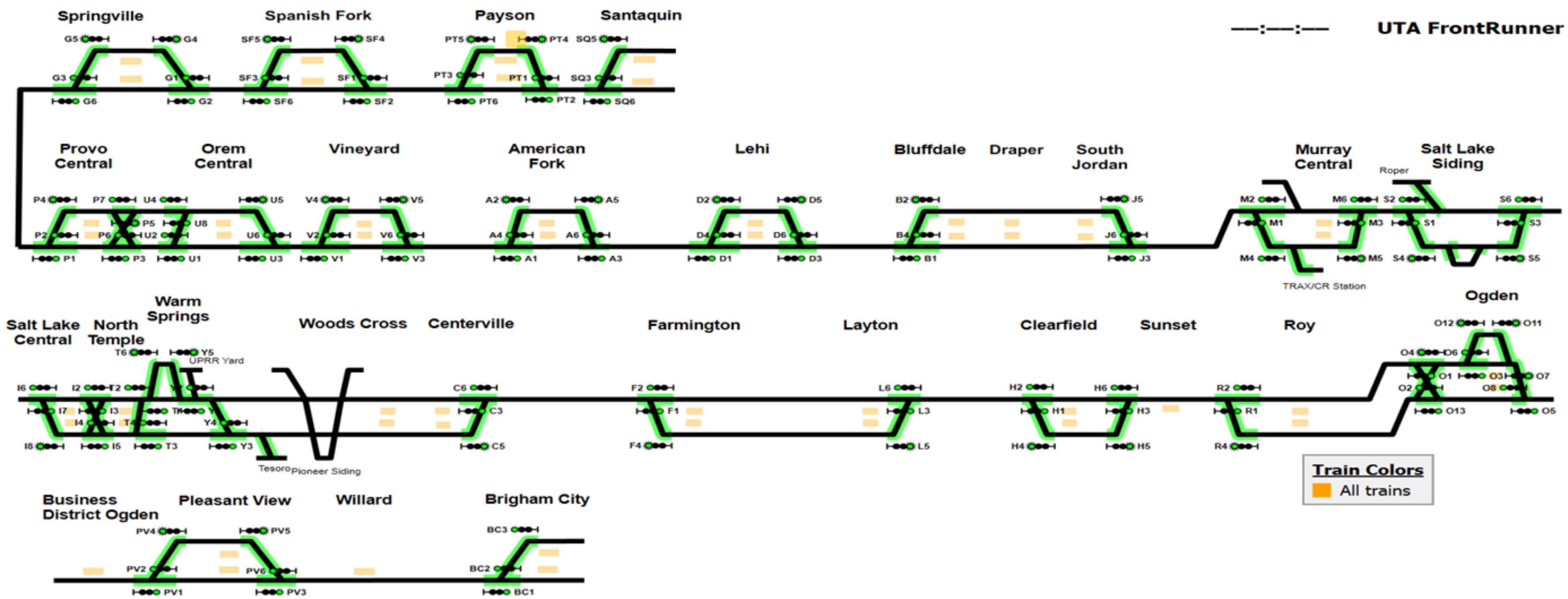


Figure 14-1: TrainOps Track Schematic of High Investment with Infill Stations Scenario Simulation

Table 54 - High Investment with Infill Stations Scenario Capital Cost Estimate Units

Capital Unit	Construction Adjacent to Live Rail?	Units	Unit Cost (2018 $)*	High Investment Scenario with Extensions & Infill Stations Quantities	Notes
Station Side Platform	Y	Per Platform	$ 200,000	3	Sunset, Willard, and Ogden BDO Station platforms.
Station Center Island Platform	Y	Per Platform	$ 250,000	9	Vineyard, Spanish Fork, Payson, Santaquin, Brigham City, Centerville, Bluffdale, Pleasant View, and Springville Station platforms.
Raise existing low platform to high platform height - Center	Y	Per platform	$ 250,000	38	Per car length, need 2 car lengths for all stations. No PV. Plus 8 more -2 each- on long stations in North (Ogden, Layton, Farmington, SLCtrl)
Raise existing low platform to high platform height - Side	Y	Per platform	$ 150,000	10	Provox2, SLCtrlx2, Farmingtonx2
Extend Existing Platform - on existing foundation (south)	Y	Per car length req'd per platform	$ 350,000	16	South Stations, 2 car length + Provo side platform
Extend Existing Platform - new foundation (north)	Y	Per car length req'd per platform	$ 500,000	8	North Stations minus long stations, 2 car lengths
Station Parking Lot	N.A.	Per Parking Lot	$ 4,000,000	12	Parking lots at all new stations.
Relocated Main Track	Y	Per LF of Track (not LF of Rail)	$ 865	44,200	Relocate/consolidate UP track for South Jordan, Salt Lake, Centerville, Draper, Murray, American Fork, Ogden, Kaysville, and Clearfield siding extensions.
Additional Main Track (Without Signals)	Y	Per LF of Track (not LF of Rail)	$ 1,150	338,000	155,700 feet additional track for siding extensions; 86,300 feet additional track for Payson extension; 9,000 feet for Spanish Fork and Springville Sidings; 137,000 feet for Santaquin and Brigham City extensions (including Pleasant View Siding).
Interlocking (Single Switch)	Y	Per Interlocking	$ 3,500,000	12	Add 4 new interlockings for new siding construction, 5 new interlockings for Santaquin extension, and 3 new interlockings for Brigham City extension.
Signal Location (Non-Interlocking)	Y	Per Location	$ 250,000	145	
Grade Crossing – Single Track (Signalized)	Y	Per Crossing	$ 1,500,000	27	For Payson, Santaquin, and Brigham City extensions.
Grade Crossing – Double Track (Signalized)	N	Per Crossing	$ 2,000,000	1	For Brigham City Extension
Grade Crossing – Double Track (Signalized)	Y	Per Crossing	$ 1,750,000	11	S 500 W, S 700 W, and S 900 W in Provo; W Center, W 1500 S, E 1100 N, and Main Street near Woods Cross, Old Mill Lane near Kaysville, and W 3300 S near Ogden.
Undergrade Bridge - Single Track (LF)	Y	Per LF	$ 186,500	465	Road bridge (400 North in Woods Cross) may need to be rebuilt over UTA and UP and E 700 S bridge near Clearfield may need to be rebuilt over UTA and UP.
Electrification (Single Track)	Y	Per Mile of Track	$ 2,500,000	24.6	
Electrification (Double Track)	Y	Per Mile of Track	$ 2,450,000	115.4	Little per-track-mile savings for double track versus single track.

Table 54 - High Investment with Infill Stations Scenario Capital Cost Estimate Units

Capital Unit	Construction Adjacent to Live Rail?	Units	Unit Cost (2018 $)*	High Investment Scenario with Extensions & Infill Stations Quantities	Notes
New Light Maintenance Shop and Yard	Y	Per Facility	$ 72,000,000	2	Two-track, eight-car EMU service and inspection/light running repair shop.
Existing Maintenance Shop and Yard Improvements	Y	Per Facility	$ 50,000,000	1	Warm Springs lengthening and electrification upgrade.
Diesel Loco	N.A.	Per Unit	$ 6,750,000	0	
Bi-Level Coach	N.A.	Per Unit	$ 3,400,000	0	
Bi-Level Cab Car	N.A.	Per Unit	$ 3,800,000	0	
Electric Multiple Unit Car	N.A.	Per Unit	$ 5,740,000	192	160 EMUs for peak operation (20 8-car trains) plus 32 for 20% spares.
Electric Loco	N.A.	Per Unit	$ 8,849,000	0	

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

14.1 High Investment Scenario with Infill Stations Simulation Results without Perturbations (Ideal Day)

The OTP for the High Investment Scenario with Infill Stations Scenario without perturbations was 99.34% within the 4:59 lateness threshold.

Referring to the time-distance (“string”) chart in Figure 14-2, delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones. The trains run very close to on-time in the No Added Perturbations run. Similar to the High Investment Scenario, there are no cascading delays, even with the addition of three infill stations between Provo and Ogden without any compensating additional double track. This is due to the faster acceleration and deceleration, and the ability to stay at a higher speed longer, with the EMU consists.

Refer to Appendix I for more results.

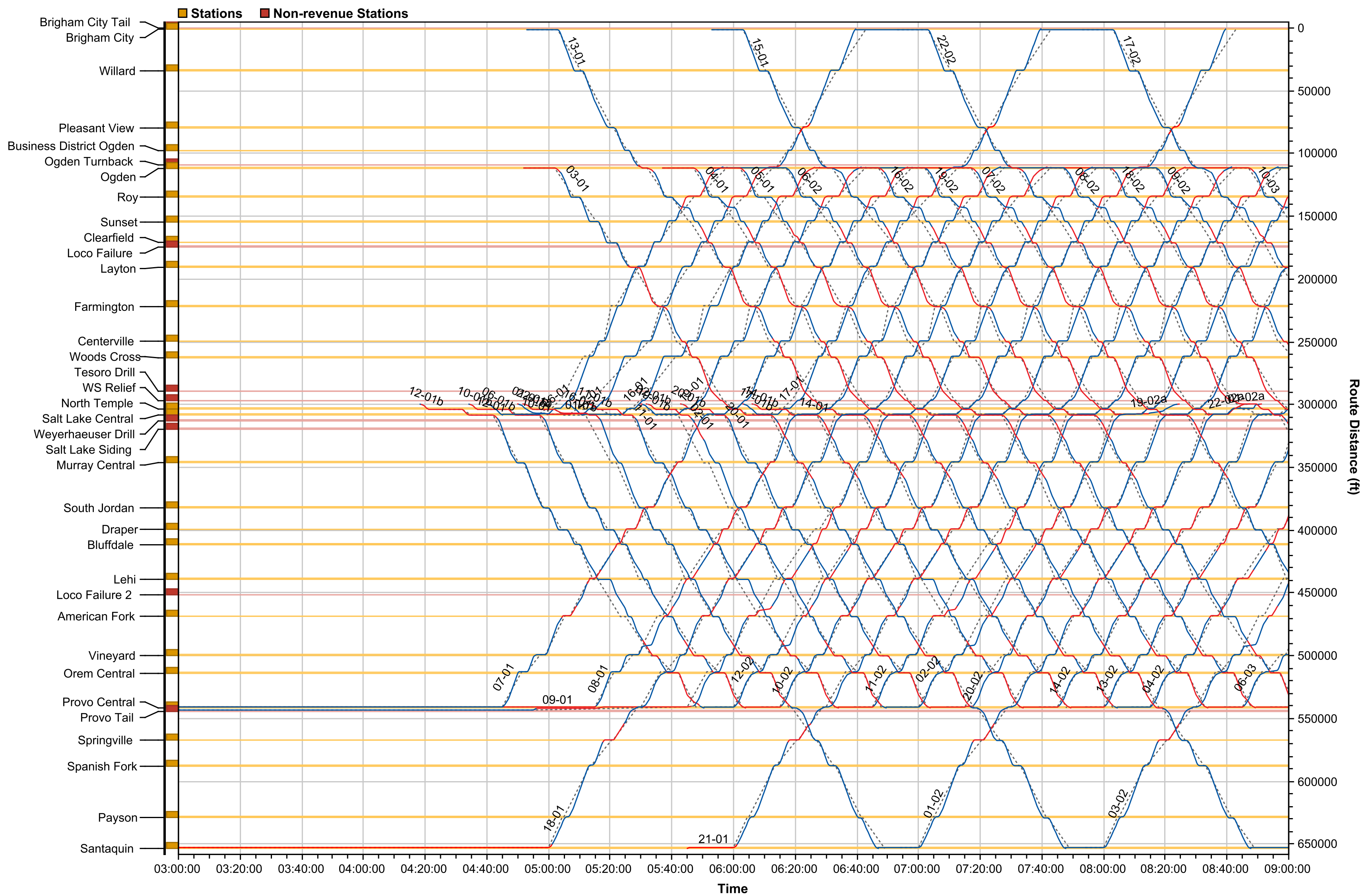


Figure 14-2: High Investment Scenario with Infill Stations Time-Distance ("String")Chart - 3 AM - 9 AM - No Added Perturbations

14.2 High Investment Scenario with Infill Stations Discussion of Results

The High Investment Scenario with Infill Stations simulation resulted in a five-day (with perturbations) OTP of 93.1% at the 4 minute and 59 second lateness threshold. This was done using five days with perturbations as shown in Table 55 to capture the real world variability present in the UTA data. The day-to-day variation in OTP is between 85.88% and 98.68%. The change to an EMU consist greatly helps improve OTP even with an increase in the number of trains operating on the system and the additional infill stations.

Two of the five days include two-hour grade crossing failures (north of Murray on Day 2, north of South Jordan in Day 4, both in single track), consistent with the calibration baseline. The grade crossing failures, especially the failure north of Murray, have significant effects on OTP given the PTC-related signal control enforcement of Restricted Speed over the crossing and the enforced speed-stops in approach, especially with the higher amount of trains running through the system with the 15-minute peak headways.

Table 55 - Simulated On-Time Performance - High Investment Scenario with Infill Stations

Lateness Threshold	0:00:00		0:03:00		0:04:59		0:10:00		All Stops	
Train Class	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**	**Stops**	**Pct (%)**
Ideal Day (no Perturbations)	**1309**	**61.83**	**2062**	**97.40**	**2103**	**99.34**	**2117**	**100.00**	**2117**	**100**
FrontRunner-Day 1	1189	56.16	1954	92.30	2063	97.45	2109	99.62	2117	100
FrontRunner-Day 2	1140	53.85	1778	83.99	1861	87.91	1986	93.81	2117	100
FrontRunner-Day 3	1278	60.37	2028	95.80	2089	98.68	2112	99.76	2117	100
FrontRunner-Day 4	1048	49.50	1724	81.44	1818	85.88	1904	89.94	2117	100
FrontRunner-Day 5	1240	58.57	1933	91.31	2024	95.61	2094	98.91	2117	100
Average Typical Day (with Perturbations)	**1179**	**55.69**	**1883**	**88.97**	**1971**	**93.10**	**2041**	**96.41**	**2117**	**100**

14.3 Discussion of High Investment Scenario with Infill Stations Ridership Modeling Results

Like the Low Medium, and High scenarios, this model scenario included the addition of Vineyard Station and a southern extension of FrontRunner to Payson. It also included the addition of three stations along the existing Ogden-Provo corridor – one located in Bluffdale between the existing FrontRunner stations in Draper and Lehi, one located in Centerville between the existing Woods Cross and Farmington FrontRunner stations, and one located in Sunset between the existing Clearfield and Roy FrontRunner stations.

The southern extension also included an additional station further south in Santaquin. This scenario also includes a northern extension of the FrontRunner system which includes stations at Business Depot Ogden (BDO), Pleasant View (existing), Willard, and Brigham City.

The main line FrontRunner route was modeled with a peak headway of 15 minutes and an off-peak headway of 30 minutes. The extensions, both north and south, were modeled with a headway of 60 minutes and no off-peak headway to reflect the limited service assumed in the operations modeling.

The five day average speeds for each station-station pair from the corresponding scenario operations model was used to update link level speeds of the system. In this scenario these speeds reflect electrification of the system. Table 56 summarizes the total daily boardings for the FrontRunner system and by station. Table 57 summarizes the total daily regional auto and transit trips.

Table 56 - High Investment Scenario with Infill Stations Total Daily FrontRunner Boardings by Station

Stop Name	High Investment with Infill Stations Scenario
Brigham City	58
Willard	20
Pleasant View	108
Ogden BDO	5
Ogden (transfer)	176
Ogden	4,188
Roy	1,775
Sunset	1,497
Clearfield	3,261
Layton	2,618
Farmington	1,713
Centerville	467
Woods Cross	4,160
North Temple	4,777
Salt Lake	14,774
Murray	7,961
South Jordan	2,651
Draper	1,552
Bluffdale	282
Lehi	2,019
American Fork	2,018
Vineyard	881
Orem	3,841
Provo	4,128
Provo	516
Springville	218
Spanish Fork	159
Payson	141
Santaquin	38
TOTAL	66,004

Table 57 - High Investment Scenario with Infill Stations Total Daily Regional Auto and Transit Trips

Trips	High Investment Scenario
Auto	13,193,844
Transit	317,992

Total FrontRunner ridership in this scenario is approximately 63,800, which is a 79% increase from the Future Baseline model run. Approximately 4,000 of these boardings occur at the infill stations (Vineyard, Bluffdale, Centerville, Sunset) and southern and northern extensions (Springville, Spanish Fork, Payson, Santaquin, Ogden BDO, Willard, Brigham City)

Transit trip shares also increase under this scenario making up approximately 318,000 of the total regional trips. This is an 8% increase from the Future Baseline model run and demonstrates a net increase of approximately 23,300 new transit trips due to changes to the FrontRunner system in this scenario.

The introduction of infill stations was not isolated to individual model runs for each station addition. Rather, all infill stations were included in one model run, which also included additional extension stations and modifications to the link level FrontRunner speeds. Therefore, it is difficult to establish the additional ridership associated with each individual station.

Moreover, while the regional travel demand model is a good tool for understanding and forecasting regional travel, calibration of transit occurs at a system and rail route level, not an individual station level. The model does not perform well at establishing stop level boarding forecasts, particularly when stations are located close to one another. Therefore, infill stations were grouped together to better compare ridership effects.

Overall, the High Investment Scenario with Infill Stations has the highest ridership of all the Scenarios. However, when looking at the total station boardings without the extensions to Santaquin and Payson, there is only a net increase of approximately 900 boardings between the High Investment Scenario and the High Investment Scenario with Infill Stations. Figure 14-3 provides a chart comparing these two scenarios at a station boarding level.

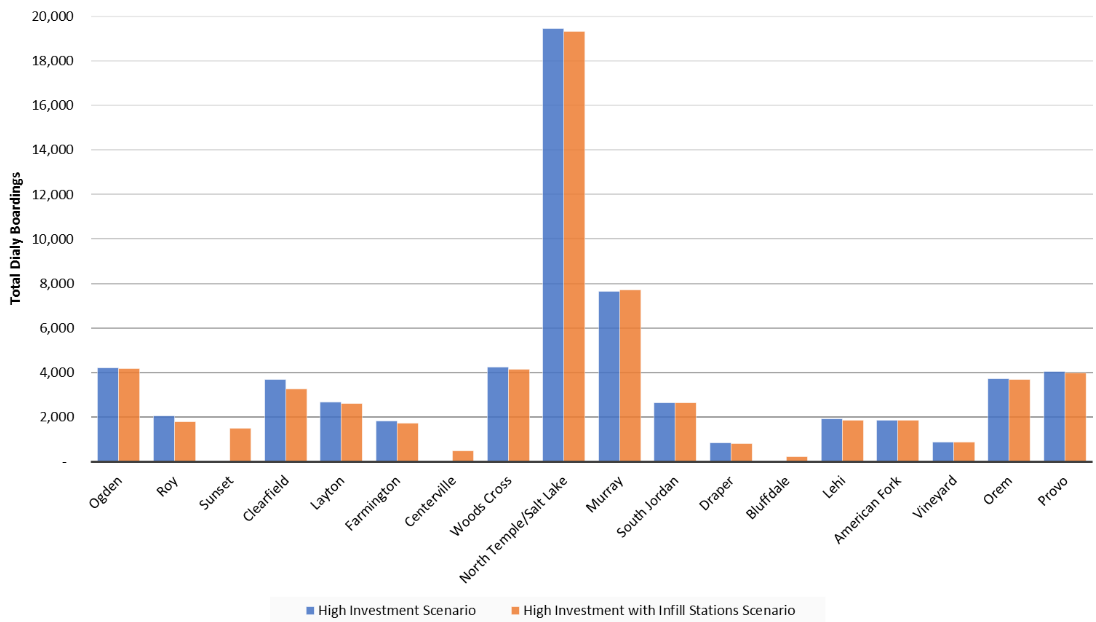


Figure 14-3: High Investment Scenario and High Investment with Infill Stations Ogden to Provo Boardings Comparison

As evident in the figure, boardings 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 the infill stations. In addition, the infill stations divert significant existing ridership from adjacent existing stations.

14.3.1 Infill Station Ridership Analysis - Bluffdale Station

The Bluffdale and Draper stations boardings were combined together to evaluate ridership increases associated with the addition of a Bluffdale station. These combined boardings were then compared to the Draper station ridership from the high investment scenario. Figure 14-4 summarizes the results.

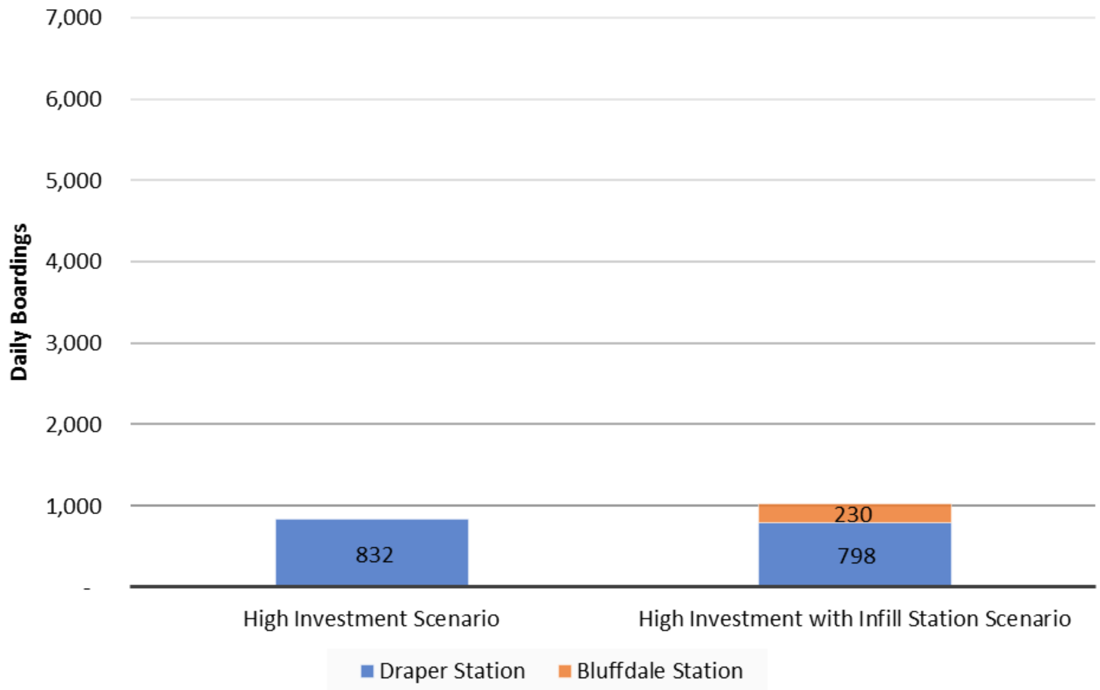


Figure 14-4: Bluffdale Infill Station Boardings

In the high investment scenario, the total boardings at the Draper station were roughly 800. With the addition of the Bluffdale station approximately 200 additional boardings occurred between the two stations. However, boardings at the Draper Station dropped to about 800, suggesting that some of the ridership at the Bluffdale station is cannibalized from the Draper station. This suggests little ridership benefit in providing this infill station. However, it is recommended that future evaluation of the Bluffdale infill station include a model run where the addition of the station is isolated to better gauge the ridership effects.

14.3.2 Infill Station Ridership Analysis - Centerville Station

The Woods Cross, Centerville and Farmington station boardings were combined together to evaluate ridership increases associated with the addition of a Centerville station. These combined boardings were then compared to the sum of the Woods Cross and Farmington station ridership from the High Investment Scenario. Figure 14-5 summarizes the results.

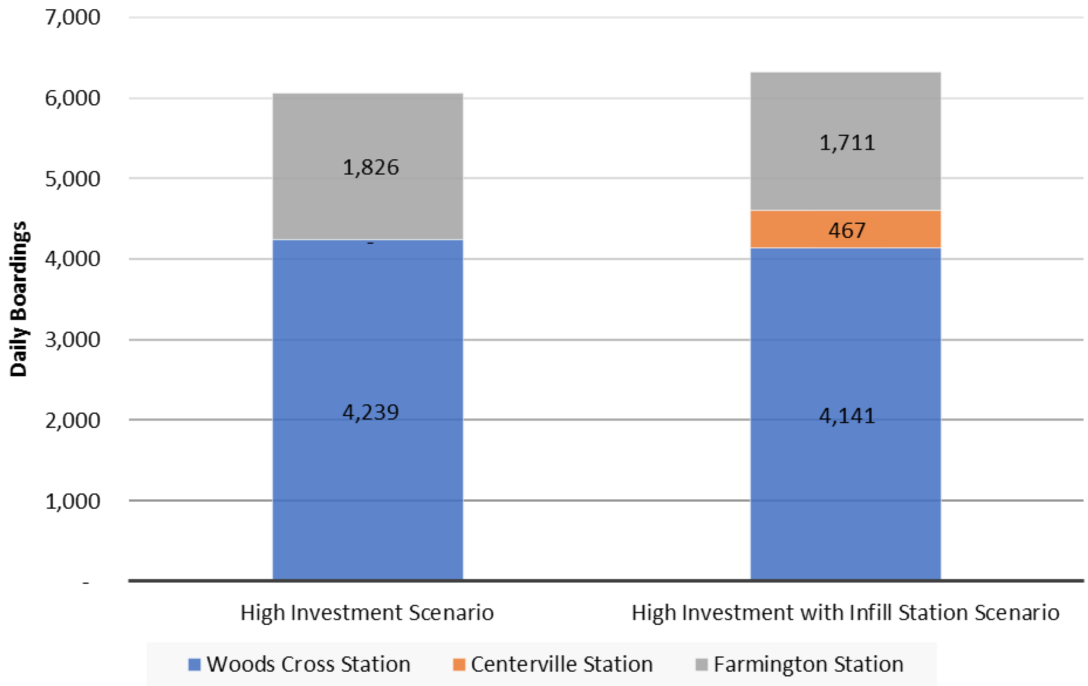


Figure 14-5: Centerville Infill Station Boardings

In the High Investment Scenario, the total boardings were approximately 6,000 between the Woods Cross and Farmington Stations. The addition of the Centerville station added about 250 additional boardings between the three stations, suggesting that many of the 470 boardings reported at the Centerville station are cannibalized from the two adjacent stations. As with the Bluffdale Station, this analysis suggests little ridership benefit from this infill station. However, it is recommended that future evaluation of the Centerville infill station include a model run where the addition of the station is isolated to better gauge the ridership effects.

14.3.3 Infill Station Ridership Analysis – Sunset Station

The Clearfield, Sunset and Roy station boardings were combined together to evaluate ridership increases associated with the addition of a Sunset station. These combined boardings were then compared to the sum of the Clearfield and Roy station boardings from the High Investment Scenario. Figure 14-6 summarizes the results.

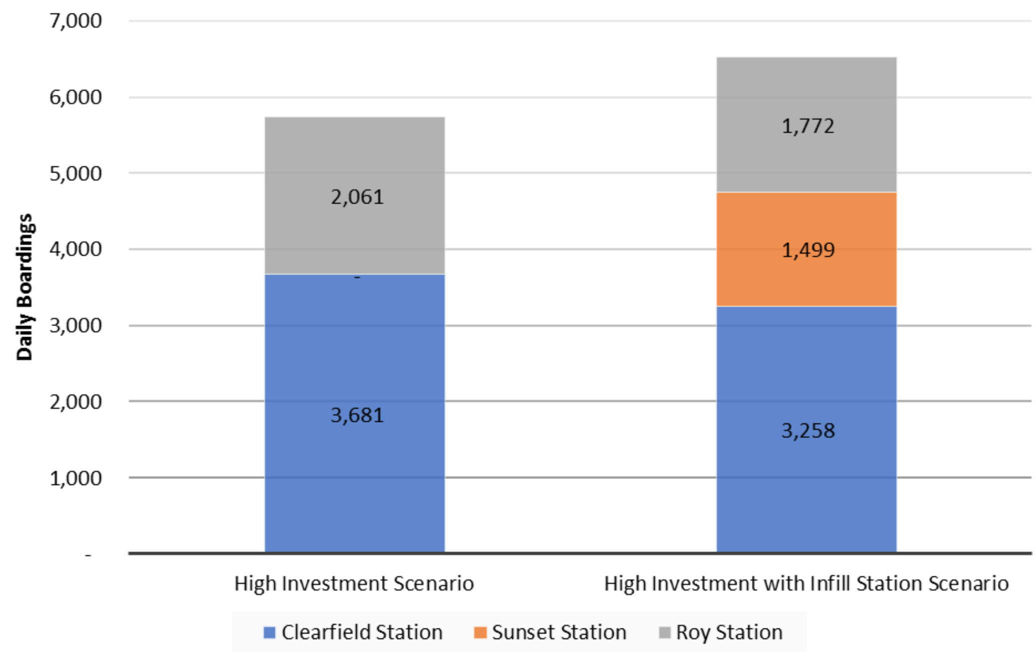


Figure 14-6: Sunset Infill Station Boardings

In the High Investment Scenario, the total boardings were approximately 5,700 between the Clearfield and Roy stations. While the station itself has about 1,500 boardings, the addition of the Sunset station only adds about 800 boardings between the three stations. This suggests that this station also cannibalizes ridership from the two adjacent stations, though not to the extent of the Centerville and Bluffdale infill stations. As with the other infill stations, it is recommended that future evaluation of the Sunset infill station include a model run where the addition of the station is isolated to better gauge the ridership effects.

15 Full Double Track 90 MPH Analysis

Although not a full-fledged scenario, LTK was asked to evaluate Ogden-Provo travel time savings associated with raising the corridor top speed from 79 MPH to 90 MPH and fully double tracking between Ogden and Provo. This includes the six Double Track Feasibility Workshop red zones detailed in Table 33.

An increase to 90 MPH would not require any special treatment of grade crossings under FRA regulations. The FrontRunner E-ATC train control system would require control line adjustments to support such a speed but would not require replacement. The most significant regulatory impact of 90 MPH operation is the necessary track maintenance standards upgrade from FRA Class 4 to FRA Class 5.

LTK was directed to assume that all straight track segments on FrontRunner currently operated with a 79 MPH maximum speed could be upgraded to 90 MPH. On existing 79 MPH curves, UTA provided PTC-related FrontRunner South and FrontRunner North spreadsheets showing degree of curvature and super-elevation. Curve speeds were computed based on the standard FRA curve speed formula and an assumed 3” of unbalance/cant deficiency. The speeds were rounded down to the next lowest 5 MPH increment while being capped at 90 MPH, meaning that the curves were modeled with a maximum speed of 80, 85 or 90 MPH depending on their geometry. UTA directed that no consideration of increased superelevation or FRA waivers for higher unbalance/cant deficiency criteria be considered.

Only ideal day (no additional perturbation) simulations were modeled for the Full Double Track 90 MPH analysis. The time-distance string chart for the morning peak period is shown in Figure 15-1. Note that the strings are entirely blue or red for the full trip between Provo and Ogden, indicating no single track bottlenecks in the FrontRunner corridor. Despite the lack of meets, variable dwells, consistent with all previous simulation scenarios under ideal conditions, do cause some trains to fall behind schedule. Overall ideal day OTP is 98.82%.

LTK estimated that a 5-day perturbed simulation would yield an OTP of approximately 96% with full double track and a 90 MPH maximum speed. This is based on reviewing the offset between ideal day and perturbed simulation results for the other four future scenarios, then reducing this offset by half due to greater dispatch efficiency associated with full double track.

LTK found that Ogden-Provo travel times improve by 27 minutes under full double track 90 MPH operation versus the High Investment Scenario. Of these 27 minutes, only 3 minutes of savings are attributable to the higher speed under EMU operation. The remaining 24 minutes are related to complete elimination of meets, including associated train control-enforced slowing and waiting time at passing sidings and end-of-second-main-track locations.

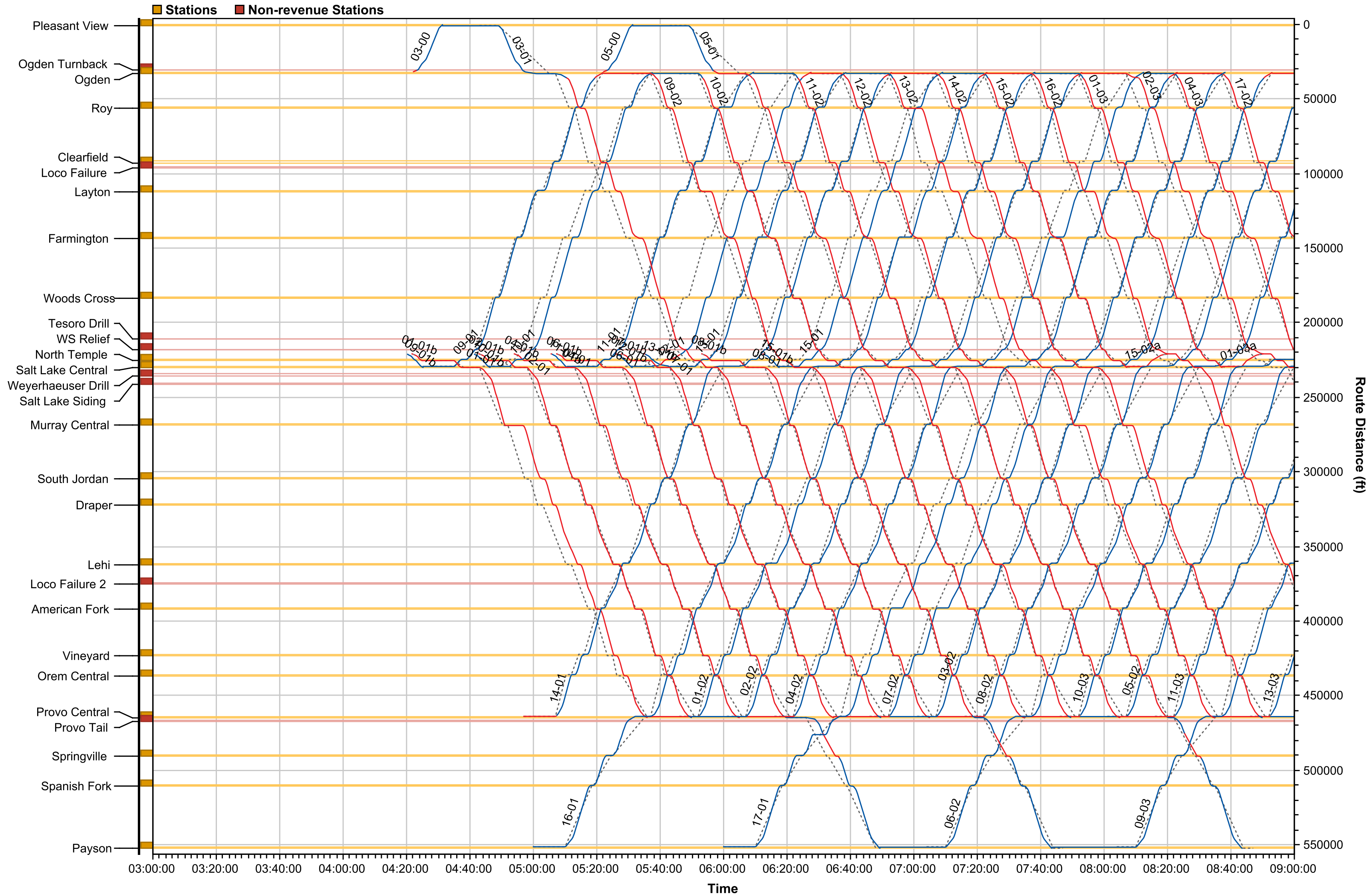


Figure 15-1: Full Double Track Analysis Time-Distance ("String") Chart – 3 AM – 9 AM –No Added Perturbations

16 Appendix A Operating Plans

16.1 Existing (pre-PTC) Operating Plan

Table 58 - Baseline Scenario Operating Plan - Northbound

Train	Provo	Orem	American Fork	Lehi	Draper	South Jordan	Murray	Salt Lake Central	Salt Lake Central	North Temple	WS Relief	Woods Cross	Farmington	Layton	Clearfield	Roy	Ogden	Pleasant View
3									3:25	3:31	3:33	3:42	3:52	4:00	4:07	4:15	4:22	4:37
4									4:25	4:31	4:33	4:42	4:52	5:00	5:07	5:15	5:22	
5																	5:22	5:37
6									5:25	5:31	5:33	5:42	5:52	6:00	6:07	6:15	6:22	
7	4:50	4:58	5:07	5:16	5:25	5:30	5:38	5:50	5:55	6:01	6:03	6:12	6:22	6:30	6:37	6:45	6:52	
8	5:20	5:28	5:37	5:46	5:55	6:00	6:08	6:20	6:25	6:31	6:33	6:42	6:52	7:00	7:07	7:15	7:22	
9	5:50	5:58	6:07	6:16	6:25	6:30	6:38	6:50	6:55	7:01	7:03	7:12	7:22	7:30	7:37	7:45	7:52	
1	6:20	6:28	6:37	6:46	6:55	7:00	7:08	7:20	7:25	7:31	7:33	7:42	7:52	8:00	8:07	8:15	8:22	
2	6:50	6:58	7:07	7:16	7:25	7:30	7:38	7:50	7:55	8:01	8:03	8:12	8:22	8:30	8:37	8:45	8:52	
3	7:20	7:28	7:37	7:46	7:55	8:00	8:08	8:20	8:25	8:31	8:33	8:42	8:52	9:00	9:07	9:15	9:22	
4	7:50	7:58	8:07	8:16	8:25	8:30	8:38	8:50	8:55	9:01	9:03	9:12	9:22	9:30	9:37	9:45	9:52	
5	8:20	8:28	8:37	8:46	8:55	9:00	9:08	9:20	9:25	*(Train ends at North Temple)*								
6	8:50	8:58	9:07	9:16	9:25	9:30	9:38	9:50	9:55	10:01	10:03	10:12	10:22	10:30	10:37	10:45	10:52	
7	9:20	9:28	9:37	9:46	9:55	10:00	10:08	10:20	10:25	*(Train ends at North Temple)*								
8	9:50	9:58	10:07	10:16	10:25	10:30	10:38	10:50	10:55	11:01	11:03	11:12	11:22	11:30	11:37	11:45	11:52	
1	10:50	10:58	11:07	11:16	11:25	11:30	11:38	11:50	11:55	12:01	12:03	12:12	12:22	12:30	12:37	12:45	12:52	
3	11:50	11:58	12:07	12:16	12:25	12:30	12:38	12:50	12:55	13:01	13:03	13:12	13:22	13:30	13:37	13:45	13:52	
4	12:50	12:58	13:07	13:16	13:25	13:30	13:38	13:50	13:55	14:01	14:03	14:12	14:22	14:30	14:37	14:45	14:52	
6	13:50	13:58	14:07	14:16	14:25	14:30	14:38	14:50	14:55	15:01	15:03	15:12	15:22	15:30	15:37	15:45	15:52	
2									15:25	15:31	15:33	15:42	15:52	16:00	16:07	16:15	16:22	
8	14:50	14:58	15:07	15:16	15:25	15:30	15:38	15:50	15:55	16:01	16:03	16:12	16:22	16:30	16:37	16:45	16:52	
9									16:25	16:31	16:33	16:42	16:52	17:00	17:07	17:15	17:22	
1	15:50	15:58	16:07	16:16	16:25	16:30	16:38	16:50	16:55	17:01	17:03	17:12	17:22	17:30	17:37	17:45	17:52	
3	16:20	16:28	16:37	16:46	16:55	17:00	17:08	17:20	17:25	17:31	17:33	17:42	17:52	18:00	18:07	18:15	18:22	18:37
5	16:50	16:58	17:07	17:16	17:25	17:30	17:38	17:50	17:55	18:01	18:03	18:12	18:22	18:30	18:37	18:45	18:52	
4	17:20	17:28	17:37	17:46	17:55	18:00	18:08	18:20	18:25	18:31	18:33	18:42	18:52	19:00	19:07	19:15	19:22	19:37
7	17:50	17:58	18:07	18:16	18:25	18:30	18:38	18:50	18:55	19:01	19:03	19:12	19:22	19:30	19:37	19:45	19:52	
6	18:20	18:28	18:37	18:46	18:55	19:00	19:08	19:20	19:25	*(Train ends at North Temple)*								
2	18:50	18:58	19:07	19:16	19:25	19:30	19:38	19:50	19:55	20:01	20:03	20:12	20:22	20:30	20:37	20:45	20:52	
8	19:20	19:28	19:37	19:46	19:55	20:00	20:08	20:20	20:25	*(Train ends at North Temple)*								
9	19:50	19:58	20:07	20:16	20:25	20:30	20:38	20:50	20:55	21:01	21:03	21:12	21:22	21:30	21:37	21:45	21:52	
1	20:50	20:58	21:07	21:16	21:25	21:30	21:38	21:50	21:55	22:01	22:03	22:12	22:22	22:30	22:37	22:45	22:52	
3									22:55	23:01	23:03	23:12	23:22	23:30	23:37	23:45	23:52	
5	22:20	22:28	22:37	22:46	22:55	23:00	23:08	23:20	23:25	23:45	23:47	23:55	0:05	0:13	0:20	0:28	0:35	

Table 59 - Baseline Scenario Operating Plan - Southbound

Train	Pleasant View	Ogden	Roy	Clearfield	Layton	Farmington	Woods Cross	WS Relief	North Temple	Salt Lake Central	Salt Lake Central	Murray	South Jordan	Draper	Lehi	American Fork	Orem	Provo
1									5:03	5:06	5:11	5:22	5:30	5:36	5:46	5:53	6:05	6:12
2									5:33	5:36	5:41	5:52	6:00	6:06	6:16	6:23	6:35	6:42
3	4:52	5:07	5:15	5:24	5:30	5:40	5:50	5:58	6:03	6:06	6:11	6:22	6:30	6:36	6:46	6:53	7:05	7:12
4		5:37	5:45	5:54	6:00	6:10	6:20	6:28	6:33	6:36	6:41	6:52	7:00	7:06	7:16	7:23	7:35	7:42
5	5:52	6:07	6:15	6:24	6:30	6:40	6:50	6:58	7:03	7:06	7:11	7:22	7:30	7:36	7:46	7:53	8:05	8:12
6		6:37	6:45	6:54	7:00	7:10	7:20	7:28	7:33	7:36	7:41	7:52	8:00	8:06	8:16	8:23	8:35	8:42
7		7:07	7:15	7:24	7:30	7:40	7:50	7:58	8:03	8:06	8:11	8:22	8:30	8:36	8:46	8:53	9:05	9:12
8		7:37	7:45	7:54	8:00	8:10	8:20	8:28	8:33	8:36	8:41	8:52	9:00	9:06	9:16	9:23	9:35	9:42
9		8:07	8:15	8:24	8:30	8:40	8:50	8:58	9:03	9:06	*(Train ends at Salt Lake Central)*							
1		8:37	8:45	8:54	9:00	9:10	9:20	9:28	9:33	9:36	9:41	9:52	10:00	10:06	10:16	10:23	10:35	10:42
3		9:37	9:45	9:54	10:00	10:10	10:20	10:28	10:33	10:36	10:41	10:52	11:00	11:06	11:16	11:23	11:35	11:42
4		10:07	10:15	10:24	10:30	10:40	10:50	10:58	11:03	11:06	11:11	11:22	11:30	11:36	11:46	11:53	12:05	12:12
6		11:07	11:15	11:24	11:30	11:40	11:50	11:58	12:03	12:06	12:11	12:22	12:30	12:36	12:46	12:53	13:05	13:12
8		12:07	12:15	12:24	12:30	12:40	12:50	12:58	13:03	13:06	13:11	13:22	13:30	13:36	13:46	13:53	14:05	14:12
1		13:07	13:15	13:24	13:30	13:40	13:50	13:58	14:03	14:06	14:11	14:22	14:30	14:36	14:46	14:53	15:05	15:12
3		14:07	14:15	14:24	14:30	14:40	14:50	14:58	15:03	15:06	15:11	15:22	15:30	15:36	15:46	15:53	16:05	16:12
5									15:33	15:36	15:41	15:52	16:00	16:06	16:16	16:23	16:35	16:42
4		15:07	15:15	15:24	15:30	15:40	15:50	15:58	16:03	16:06	16:11	16:22	16:30	16:36	16:46	16:53	17:05	17:12
7		15:37	15:45	15:54	16:00	16:10	16:20	16:28	16:33	16:36	16:41	16:52	17:00	17:06	17:16	17:23	17:35	17:42
6		16:07	16:15	16:24	16:30	16:40	16:50	16:58	17:03	17:06	17:11	17:22	17:30	17:36	17:46	17:53	18:05	18:12
2		16:37	16:45	16:54	17:00	17:10	17:20	17:28	17:33	17:36	17:41	17:52	18:00	18:06	18:16	18:23	18:35	18:42
8		17:07	17:15	17:24	17:30	17:40	17:50	17:58	18:03	18:06	18:11	18:22	18:30	18:36	18:46	18:53	19:05	19:12
9		17:37	17:45	17:54	18:00	18:10	18:20	18:28	18:33	18:36	18:41	18:52	19:00	19:06	19:16	19:23	19:35	19:42
1		18:07	18:15	18:24	18:30	18:40	18:50	18:58	19:03	19:06	19:11	19:22	19:30	19:36	19:46	19:53	20:05	20:12
5		19:07	19:15	19:24	19:30	19:40	19:50	19:58	20:03	20:06	20:11	20:22	20:30	20:36	20:46	20:53	21:05	21:12
3	18:52	19:37	19:45	19:54	20:00	20:10	20:20	20:28	20:33	20:36	*(Train ends at Salt Lake Central)*							
7		20:07	20:15	20:24	20:30	20:40	20:50	20:58	21:03	21:06	21:11	21:22	21:30	21:36	21:46	21:53	22:05	22:12
4	19:52	20:37	20:45	20:54	21:00	21:10	21:20	21:28	21:33	21:36	*(Train ends at Salt Lake Central)*							
2		21:07	21:15	21:24	21:30	21:40	21:50	21:58	22:03	22:06	22:11	22:22	22:30	22:36	22:46	22:53	23:05	23:12
9		22:37	22:45	22:54	23:00	23:10	23:20	23:28	23:45	23:48	23:50	23:59	0:07	0:13	0:23	0:30	0:39	0:46
1		23:07	23:15	23:24	23:30	23:40	23:55	0:03	0:05	0:08	*(Train ends at Salt Lake Central)*							

16.2 Future Baseline with PTC Scenario Operating Plan

Table 60 - Future Baseline with PTC Scenario Operating Plan - Northbound

Train	Provo	Orem	American Fork	Lehi	Draper	South Jordan	Murray	Salt Lake Central	Salt Lake Central	North Temple	North Temple	WS Relief	Woods Cross	Farmington	Layton	Clearfield	Roy	Ogden	Pleasant View
3																		4:22	4:37
5																		5:22	5:37
4									4:25	4:28	4:31	4:33	4:42	4:53	5:02	5:07	5:16	5:24	
6									5:25	5:28	5:31	5:33	5:42	5:53	6:02	6:07	6:16	6:24	
7	4:47	4:56	5:06	5:15	5:24	5:30	5:39	5:49	5:55	5:58	6:01	6:03	6:12	6:23	6:32	6:37	6:46	6:54	
8	5:17	5:26	5:36	5:45	5:54	6:00	6:09	6:19	6:25	6:28	6:31	6:33	6:42	6:53	7:02	7:07	7:16	7:24	
9	5:47	5:56	6:06	6:15	6:24	6:30	6:39	6:49	6:55	6:58	7:01	7:03	7:12	7:23	7:32	7:37	7:46	7:54	
10	6:17	6:26	6:36	6:45	6:54	7:00	7:09	7:19	7:25	7:28	7:31	7:33	7:42	7:53	8:02	8:07	8:16	8:24	
1	6:47	6:56	7:06	7:15	7:24	7:30	7:39	7:49	7:55	7:58	8:01	8:03	8:12	8:23	8:32	8:37	8:46	8:54	
2	7:17	7:26	7:36	7:45	7:54	8:00	8:09	8:19	8:25	8:28	8:31	8:33	8:42	8:53	9:02	9:07	9:16	9:24	
3	7:47	7:56	8:06	8:15	8:24	8:30	8:39	8:49	8:55	8:58									
4	8:17	8:26	8:36	8:45	8:54	9:00	9:09	9:19	9:25	9:28	9:31	9:33	9:42	9:53	10:02	10:07	10:16	10:24	
5	8:47	8:56	9:06	9:15	9:24	9:30	9:39	9:49	9:55	9:58									
6	9:17	9:26	9:36	9:45	9:54	10:00	10:09	10:19	10:25	10:28	10:31	10:33	10:42	10:53	11:02	11:07	11:16	11:24	
7	9:47	9:56	10:06	10:15	10:24	10:30	10:39	10:49	10:55	10:58									
8	10:17	10:26	10:36	10:45	10:54	11:00	11:09	11:19	11:25	11:28	11:31	11:33	11:42	11:53	12:02	12:07	12:16	12:24	
10	11:17	11:26	11:36	11:45	11:54	12:00	12:09	12:19	12:25	12:28	12:31	12:33	12:42	12:53	13:02	13:07	13:16	13:24	
2	12:17	12:26	12:36	12:45	12:54	13:00	13:09	13:19	13:25	13:28	13:31	13:33	13:42	13:53	14:02	14:07	14:16	14:24	
4	13:17	13:26	13:36	13:45	13:54	14:00	14:09	14:19	14:25	14:28	14:31	14:33	14:42	14:53	15:02	15:07	15:16	15:24	
5									14:55	14:58	15:01	15:03	15:12	15:23	15:32	15:37	15:46	15:54	
6	14:17	14:26	14:36	14:45	14:54	15:00	15:09	15:19	15:25	15:28	15:31	15:33	15:42	15:53	16:02	16:07	16:16	16:24	
7									15:55	15:58	16:01	16:03	16:12	16:23	16:32	16:37	16:46	16:54	
8	15:17	15:26	15:36	15:45	15:54	16:00	16:09	16:19	16:25	16:28	16:31	16:33	16:42	16:53	17:02	17:07	17:16	17:24	
9									16:55	16:58	17:01	17:03	17:12	17:23	17:32	17:37	17:46	17:54	
10	16:17	16:26	16:36	16:45	16:54	17:00	17:09	17:19	17:25	17:28	17:31	17:33	17:42	17:53	18:02	18:07	18:16	18:24	18:37
1	16:47	16:56	17:06	17:15	17:24	17:30	17:39	17:49	17:55	17:58	18:01	18:03	18:12	18:23	18:32	18:37	18:46	18:54	
2	17:17	17:26	17:36	17:45	17:54	18:00	18:09	18:19	18:25	18:28	18:31	18:33	18:42	18:53	19:02	19:07	19:16	19:24	19:37
3	17:47	17:56	18:06	18:15	18:24	18:30	18:39	18:49	18:55	18:58	19:01	19:03	19:12	19:23	19:32	19:37	19:46	19:54	
4	18:17	18:26	18:36	18:45	18:54	19:00	19:09	19:19	19:25	19:28									
5	18:47	18:56	19:06	19:15	19:24	19:30	19:39	19:49	19:55	19:58	20:01	20:03	20:12	20:23	20:32	20:37	20:46	20:54	
6	19:17	19:26	19:36	19:45	19:54	20:00	20:09	20:19	20:25	20:28									
7	19:47	19:56	20:06	20:15	20:24	20:30	20:39	20:49	20:55	20:58	21:01	21:03	21:12	21:23	21:32	21:37	21:46	21:54	
8	20:17	20:26	20:36	20:45	20:54	21:00	21:09	21:19	21:25	21:28									
9	20:47	20:56	21:06	21:14	21:24	21:30	21:39	21:49	21:55	21:58	22:01	22:03	22:12	22:23	22:32	22:37	22:46	22:54	
1	21:47	21:56	22:06	22:15	22:24	22:30	22:39	22:49	22:55	22:58	23:01	23:03	23:12	23:23	23:32	23:37	23:46	23:54	

Table 61 - Future Baseline with PTC Scenario Operating Plan - Southbound

Train	Pleasant View	Ogden	Roy	Clearfield	Layton	Farmington	Woods Cross	WS Relief	North Temple	North Temple	Salt Lake Central	Salt Lake Central	Murray	South Jordan	Draper	Lehi	American Fork	Orem	Provo
1										5:03	5:06	5:09	5:21	5:30	5:35	5:45	5:53	6:05	6:13
2										5:33	5:36	5:39	5:51	6:00	6:05	6:15	6:23	6:35	6:43
3	4:52	5:07	5:16	5:25	5:32	5:39	5:50	5:58	6:02	6:03	6:06	6:09	6:21	6:30	6:35	6:45	6:53	7:05	7:13
4		5:37	5:46	5:55	6:02	6:09	6:20	6:28	6:32	6:33	6:36	6:39	6:51	7:00	7:05	7:15	7:23	7:35	7:43
5	5:52	6:07	6:16	6:25	6:32	6:39	6:50	6:58	7:02	7:03	7:06	7:09	7:21	7:30	7:35	7:45	7:53	8:05	8:13
6		6:37	6:46	6:55	7:02	7:09	7:20	7:28	7:32	7:33	7:36	7:39	7:51	8:00	8:05	8:15	8:23	8:35	8:43
7		7:07	7:16	7:25	7:32	7:39	7:50	7:58	8:02	8:03	8:06	8:09	8:21	8:30	8:35	8:45	8:53	9:05	9:13
8		7:37	7:46	7:55	8:02	8:09	8:20	8:28	8:32	8:33	8:36	8:39	8:51	9:00	9:05	9:15	9:23	9:35	9:43
9		8:07	8:16	8:25	8:32	8:39	8:50	8:58	9:02	9:03	9:06								
10		8:37	8:46	8:55	9:02	9:09	9:20	9:28	9:32	9:33	9:36	9:39	9:51	10:00	10:05	10:15	10:23	10:35	10:43
1		9:07	9:16	9:25	9:32	9:39	9:50	9:58	10:02	10:03	10:06								
2		9:37	9:46	9:55	10:02	10:09	10:20	10:28	10:32	10:33	10:36	10:39	10:51	11:00	11:05	11:15	11:23	11:35	11:43
4		10:37	10:46	10:55	11:02	11:09	11:20	11:28	11:32	11:33	11:36	11:39	11:51	12:00	12:05	12:15	12:23	12:35	12:43
6		11:37	11:46	11:55	12:02	12:09	12:20	12:28	12:32	12:33	12:36	12:39	12:51	13:00	13:05	13:15	13:23	13:35	13:43
8		12:37	12:46	12:55	13:02	13:09	13:20	13:28	13:32	13:33	13:36	13:39	13:51	14:00	14:05	14:15	14:23	14:35	14:43
10		13:37	13:46	13:55	14:02	14:09	14:20	14:28	14:32	14:33	14:36	14:39	14:51	15:00	15:05	15:15	15:23	15:35	15:43
1										15:03	15:06	15:09	15:21	15:30	15:35	15:45	15:53	16:05	16:13
2		14:37	14:46	14:55	15:02	15:09	15:20	15:28	15:32	15:33	15:36	15:39	15:51	16:00	16:05	16:15	16:23	16:35	16:43
3										16:03	16:06	16:09	16:21	16:30	16:35	16:45	16:53	17:05	17:13
4		15:37	15:46	15:55	16:02	16:09	16:20	16:28	16:32	16:33	16:36	16:39	16:51	17:00	17:05	17:15	17:23	17:35	17:43
5		16:07	16:16	16:25	16:32	16:39	16:50	16:58	17:02	17:03	17:06	17:09	17:21	17:30	17:35	17:45	17:53	18:05	18:13
6		16:37	16:46	16:55	17:02	17:09	17:20	17:28	17:32	17:33	17:36	17:39	17:51	18:00	18:05	18:15	18:23	18:35	18:43
7		17:07	17:16	17:25	17:32	17:39	17:50	17:58	18:02	18:03	18:06	18:09	18:21	18:30	18:35	18:45	18:53	19:05	19:13
8		17:37	17:46	17:55	18:02	18:09	18:20	18:28	18:32	18:33	18:36	18:39	18:51	19:00	19:05	19:15	19:23	19:35	19:43
9		18:07	18:16	18:25	18:32	18:39	18:50	18:58	19:02	19:03	19:06	19:09	19:21	19:30	19:35	19:45	19:53	20:05	20:13
1		19:07	19:16	19:25	19:32	19:39	19:50	19:58	20:02	20:03	20:06	20:09	20:21	20:30	20:35	20:45	20:53	21:05	21:13
10	18:52	19:37	19:46	19:55	20:02	20:09	20:20	20:28	20:32	20:33	20:36								
3		20:07	20:16	20:25	20:32	20:39	20:50	20:58	21:02	21:03	21:06	21:09	21:21	21:30	21:35	21:45	21:53	22:05	22:13
2	19:52	20:37	20:46	20:55	21:02	21:09	21:20	21:28	21:32	21:33	21:36								
5		21:07	21:16	21:25	21:32	21:39	21:50	21:58	22:02	22:03	22:06	22:09	22:21	22:30	22:35	22:45	22:53	23:05	23:13
4											22:36	22:39	22:51	23:00	23:05	23:15	23:23	23:35	23:43
7		22:07	22:16	22:25	22:32	22:39	22:50	22:58	23:02	23:03	23:06	23:09	23:21	23:30	23:35	23:45	23:53	0:05	0:13

16.3 Low Investment Scenario Operating Plan

Table 62 - Low Investment Scenario Operating Plan - Northbound

Train	Payson	Spanish Fork	Springville	Provo	Orem	Vineyard	American Fork	Lehi	Draper	South Jordan	Murray	Salt Lake Central	Salt Lake Central	N Temple Arrival	N Tmpl Departure	WS Relief	Woods Cross	Farmington	Layton	Clearfield	Roy	Ogden	Pleasant View
3																						4:22	4:37
5																						5:22	5:37
4													4:25	4:28	4:31	4:33	4:42	4:53	5:02	5:07	5:16	5:24	
6													5:25	5:28	5:31	5:33	5:42	5:53	6:02	6:07	6:16	6:24	
7				4:47	4:56	5:01	5:07	5:16	5:25	5:31	5:39	5:49	5:55	5:58	6:01	6:03	6:12	6:23	6:32	6:37	6:46	6:54	
8				5:17	5:26	5:31	5:37	5:46	5:55	6:01	6:09	6:19	6:25	6:28	6:31	6:33	6:42	6:53	7:02	7:07	7:16	7:24	
9	5:22	5:31	5:37	5:47	5:56	6:01	6:07	6:16	6:25	6:31	6:39	6:49	6:55	6:58	7:01	7:03	7:12	7:23	7:32	7:37	7:46	7:54	
10				6:17	6:26	6:31	6:37	6:46	6:55	7:01	7:09	7:19	7:25	7:28	7:31	7:33	7:42	7:53	8:02	8:07	8:16	8:24	
11	6:22	6:31	6:37	6:47	6:56	7:01	7:07	7:16	7:25	7:31	7:39	7:49	7:55	7:58	8:01	8:03	8:12	8:23	8:32	8:37	8:46	8:54	
2				7:17	7:26	7:31	7:37	7:46	7:55	8:01	8:09	8:19	8:25	8:28	8:31	8:33	8:42	8:53	9:02	9:07	9:16	9:24	
1	7:22	7:31	7:37	7:47	7:56	8:01	8:07	8:16	8:25	8:31	8:39	8:49	8:55	8:58									
4				8:17	8:26	8:31	8:37	8:46	8:55	9:01	9:09	9:19	9:25	9:28	9:31	9:33	9:42	9:53	10:02	10:07	10:16	10:24	
3	8:22	8:31	8:37	8:47	8:56	9:01	9:07	9:16	9:25	9:31	9:39	9:49	9:55	9:58									
6				9:17	9:26	9:31	9:37	9:46	9:55	10:01	10:09	10:19	10:25	10:28	10:31	10:33	10:42	10:53	11:02	11:07	11:16	11:24	
7				9:47	9:56	10:01	10:07	10:16	10:25	10:31	10:39	10:49	10:55	10:58									
8				10:17	10:26	10:31	10:37	10:46	10:55	11:01	11:09	11:19	11:25	11:28	11:31	11:33	11:42	11:53	12:02	12:07	12:16	12:24	
10				11:17	11:26	11:31	11:37	11:46	11:55	12:01	12:09	12:19	12:25	12:28	12:31	12:33	12:42	12:53	13:02	13:07	13:16	13:24	
2				12:17	12:26	12:31	12:37	12:46	12:55	13:01	13:09	13:19	13:25	13:28	13:31	13:33	13:42	13:53	14:02	14:07	14:16	14:24	
4				13:17	13:26	13:31	13:37	13:46	13:55	14:01	14:09	14:19	14:25	14:28	14:31	14:33	14:42	14:53	15:02	15:07	15:16	15:24	
1													14:55	14:58	15:01	15:03	15:12	15:23	15:32	15:37	15:46	15:54	
6				14:17	14:26	14:31	14:37	14:46	14:55	15:01	15:09	15:19	15:25	15:28	15:31	15:33	15:42	15:53	16:02	16:07	16:16	16:24	
3													15:55	15:58	16:01	16:03	16:12	16:23	16:32	16:37	16:46	16:54	
8				15:17	15:26	15:31	15:37	15:46	15:55	16:01	16:09	16:19	16:25	16:28	16:31	16:33	16:42	16:53	17:02	17:07	17:16	17:24	
7													16:55	16:58	17:01	17:03	17:12	17:23	17:32	17:37	17:46	17:54	
10				16:17	16:26	16:31	16:37	16:46	16:55	17:01	17:09	17:19	17:25	17:28	17:31	17:33	17:42	17:53	18:02	18:07	18:16	18:24	18:37
9				16:47	16:56	17:01	17:07	17:16	17:25	17:31	17:39	17:49	17:55	17:58	18:01	18:03	18:12	18:23	18:32	18:37	18:46	18:54	
5	16:52	17:01	17:07	17:17	17:26	17:31	17:37	17:46	17:55	18:01	18:09	18:19	18:25	18:28	18:31	18:33	18:42	18:53	19:02	19:07	19:16	19:24	19:37
11				17:47	17:56	18:01	18:07	18:16	18:25	18:31	18:39	18:49	18:55	18:58	19:01	19:03	19:12	19:23	19:32	19:37	19:46	19:54	
2	17:52	18:01	18:07	18:17	18:26	18:31	18:37	18:46	18:55	19:01	19:09	19:19	19:25	19:28									
1				18:47	18:56	19:01	19:07	19:16	19:25	19:31	19:39	19:49	19:55	19:58	20:01	20:03	20:12	20:23	20:32	20:37	20:46	20:54	
4	18:52	19:01	19:07	19:17	19:26	19:31	19:37	19:46	19:55	20:01	20:09	20:19	20:25	20:28									
3				19:47	19:56	20:01	20:07	20:16	20:25	20:31	20:39	20:49	20:55	20:58	21:01	21:03	21:12	21:23	21:32	21:37	21:46	21:54	
6	19:52	20:01	20:07	20:17	20:26	20:31	20:37	20:46	20:55	21:01	21:09	21:19	21:25	21:28									
7				20:47	20:56	21:01	21:07	21:16	21:25	21:31	21:39	21:49	21:55	21:58	22:01	22:03	22:12	22:23	22:32	22:37	22:46	22:54	
9				21:47	21:56	22:01	22:07	22:16	22:25	22:31	22:39	22:49	22:55	22:58	23:01	23:03	23:12	23:23	23:32	23:37	23:46	23:54	

Table 63 - Low Investment Scenario Operating Plan - Southbound

Train	PV	Ogden	Roy	Clearfield	Layton	Farmington	Woods Cross	WS Relief	North Temple	North Temple	Salt Lake Central	Salt Lake Central	Murray	South Jordan	Draper	Lehi	American Fork	Vineyard	Orem	Provo	Springville	Spanish Fork	Payson
1										5:03	5:06	5:09	5:21	5:30	5:36	5:45	5:54	6:03	6:07	6:16	6:26	6:32	6:42
2										5:33	5:36	5:39	5:51	6:00	6:06	6:15	6:24	6:33	6:37	6:46			
3	4:52	5:07	5:16	5:25	5:32	5:39	5:49	5:58	6:02	6:03	6:06	6:09	6:21	6:30	6:36	6:45	6:54	7:03	7:07	7:16	7:26	7:32	7:42
4		5:37	5:46	5:55	6:02	6:09	6:19	6:28	6:32	6:33	6:36	6:39	6:51	7:00	7:06	7:15	7:24	7:33	7:37	7:46			
5	5:52	6:07	6:16	6:25	6:32	6:39	6:49	6:58	7:02	7:03	7:06	7:09	7:21	7:30	7:36	7:45	7:54	8:03	8:07	8:16	8:26	8:32	8:42
6		6:37	6:46	6:55	7:02	7:09	7:19	7:28	7:32	7:33	7:36	7:39	7:51	8:00	8:06	8:15	8:24	8:33	8:37	8:46			
7		7:07	7:16	7:25	7:32	7:39	7:49	7:58	8:02	8:03	8:06	8:09	8:21	8:30	8:36	8:45	8:54	9:03	9:07	9:16			
8		7:37	7:46	7:55	8:02	8:09	8:19	8:28	8:32	8:33	8:36	8:39	8:51	9:00	9:06	9:15	9:24	9:33	9:37	9:46			
9		8:07	8:16	8:25	8:32	8:39	8:49	8:58	9:02	9:03	9:06												
10		8:37	8:46	8:55	9:02	9:09	9:19	9:28	9:32	9:33	9:36	9:39	9:51	10:00	10:06	10:15	10:24	10:33	10:37	10:46			
11		9:07	9:16	9:25	9:32	9:39	9:49	9:58	10:02	10:03	10:06												
2		9:37	9:46	9:55	10:02	10:09	10:19	10:28	10:32	10:33	10:36	10:39	10:51	11:00	11:06	11:15	11:24	11:33	11:37	11:46			
4		10:37	10:46	10:55	11:02	11:09	11:19	11:28	11:32	11:33	11:36	11:39	11:51	12:00	12:06	12:15	12:24	12:33	12:37	12:46			
6		11:37	11:46	11:55	12:02	12:09	12:19	12:28	12:32	12:33	12:36	12:39	12:51	13:00	13:06	13:15	13:24	13:33	13:37	13:46			
8		12:37	12:46	12:55	13:02	13:09	13:19	13:28	13:32	13:33	13:36	13:39	13:51	14:00	14:06	14:15	14:24	14:33	14:37	14:46			
10		13:37	13:46	13:55	14:02	14:09	14:19	14:28	14:32	14:33	14:36	14:39	14:51	15:00	15:06	15:15	15:24	15:33	15:37	15:46			
9										15:03	15:06	15:09	15:21	15:30	15:36	15:45	15:54	16:03	16:07	16:16			
2		14:37	14:46	14:55	15:02	15:09	15:19	15:28	15:32	15:33	15:36	15:39	15:51	16:00	16:06	16:15	16:24	16:33	16:37	16:46	16:56	17:02	17:12
11										16:03	16:06	16:09	16:21	16:30	16:36	16:45	16:54	17:03	17:07	17:16			
4		15:37	15:46	15:55	16:02	16:09	16:19	16:28	16:32	16:33	16:36	16:39	16:51	17:00	17:06	17:15	17:24	17:33	17:37	17:46	17:56	18:02	18:12
1		16:07	16:16	16:25	16:32	16:39	16:49	16:58	17:02	17:03	17:06	17:09	17:21	17:30	17:36	17:45	17:54	18:03	18:07	18:16			
6		16:37	16:46	16:55	17:02	17:09	17:19	17:28	17:32	17:33	17:36	17:39	17:51	18:00	18:06	18:15	18:24	18:33	18:37	18:46	18:56	19:02	19:12
3		17:07	17:16	17:25	17:32	17:39	17:49	17:58	18:02	18:03	18:06	18:09	18:21	18:30	18:36	18:45	18:54	19:03	19:07	19:16			
8		17:37	17:46	17:55	18:02	18:09	18:19	18:28	18:32	18:33	18:36	18:39	18:51	19:00	19:06	19:15	19:24	19:33	19:37	19:46	19:56	20:02	20:12
7		18:07	18:16	18:25	18:32	18:39	18:49	18:58	19:02	19:03	19:06	19:09	19:21	19:30	19:36	19:45	19:54	20:03	20:07	20:16			
9		19:07	19:16	19:25	19:32	19:39	19:49	19:58	20:02	20:03	20:06	20:09	20:21	20:30	20:36	20:45	20:54	21:03	21:07	21:16			
10	18:52	19:37	19:46	19:55	20:02	20:09	20:19	20:28	20:32	20:33	20:36												
11		20:07	20:16	20:25	20:32	20:39	20:49	20:58	21:02	21:03	21:06	21:09	21:21	21:30	21:36	21:45	21:54	22:03	22:07	22:16			
5	19:52	20:37	20:46	20:55	21:02	21:09	21:19	21:28	21:32	21:33	21:36												
1		21:07	21:16	21:25	21:32	21:39	21:49	21:58	22:02	22:03	22:06	22:09	22:21	22:30	22:36	22:45	22:54	23:03	23:07	23:16	23:26	23:32	23:42
2											22:36	22:39	22:51	23:00	23:06	23:15	23:24	23:33	23:37	23:46			
3		22:07	22:16	22:25	22:32	22:39	22:49	22:58	23:02	23:03	23:06	23:09	23:21	23:30	23:36	23:45	23:54	0:03	0:07	0:16			

16.4 Medium Investment Scenario Operating Plan

Table 64 - Medium Investment Scenario Operating Plan - Northbound

Train	Payson	Spanish Fork	Springville	Provo	Orem	Vineyard	American Fork	Lehi	Draper	South Jordan	Murray	Salt Lake Central	Salt Lake Central	North Temple	North Temple	WS Relief	Woods Cross	Farmington	Layton	Clearfield	Roy	Ogden	Pleasant View
3																						4:22	4:37
5																						5:22	5:37
13													4:12	4:15	4:16	4:19	4:28	4:36	4:45	4:52	5:02	5:11	
6													4:57	5:00	5:01	5:04	5:13	5:21	5:30	5:37	5:47	5:56	
16													5:27	5:30	5:31	5:34	5:43	5:51	6:00	6:07	6:17	6:26	
21													5:42	5:45	5:46	5:49	5:58	6:06	6:15	6:22	6:32	6:41	
7				4:37	4:45	4:50	4:58	5:08	5:23	5:31	5:41	5:48	5:57	6:00	6:01	6:04	6:13	6:21	6:30	6:37	6:47	6:56	
17													6:12	6:15	6:16	6:19	6:28	6:36	6:45	6:52	7:02	7:11	
8				5:07	5:15	5:20	5:28	5:38	5:53	6:01	6:11	6:18	6:27	6:30	6:31	6:34	6:43	6:51	7:00	7:07	7:17	7:26	
18	4:50	4:59	5:05	5:22	5:30	5:35	5:43	5:53	6:08	6:16	6:26	6:33	6:42	6:45	6:46	6:49	6:58	7:06	7:15	7:22	7:32	7:41	
9				5:37	5:45	5:50	5:58	6:08	6:23	6:31	6:41	6:48	6:57	7:00	7:01	7:04	7:13	7:21	7:30	7:37	7:47	7:56	
22				5:52	6:00	6:05	6:13	6:23	6:38	6:46	6:56	7:03	7:12	7:15	7:16	7:19	7:28	7:36	7:45	7:52	8:02	8:11	
12				6:07	6:15	6:20	6:28	6:38	6:53	7:01	7:11	7:18	7:27	7:30	7:31	7:34	7:43	7:51	8:00	8:07	8:17	8:26	
19	5:50	5:59	6:05	6:22	6:30	6:35	6:43	6:53	7:08	7:16	7:26	7:33	7:42	7:45	7:46	7:49	7:58	8:06	8:15	8:22	8:32	8:41	
1				6:37	6:45	6:50	6:58	7:08	7:23	7:31	7:41	7:48	7:57	8:00	8:01	8:04	8:13	8:21	8:30	8:37	8:47	8:56	
11				6:52	7:00	7:05	7:13	7:23	7:38	7:46	7:56	8:03	8:12	8:15	8:16	8:19	8:28	8:36	8:45	8:52	9:02	9:11	
2				7:07	7:15	7:20	7:28	7:38	7:53	8:01	8:11	8:18	8:27	8:30	8:31	8:34	8:43	8:51	9:00	9:07	9:17	9:26	
10	6:50	6:59	7:05	7:22	7:30	7:35	7:43	7:53	8:08	8:16	8:26	8:33	8:42	8:45	8:46	8:49							
3				7:37	7:45	7:50	7:58	8:08	8:23	8:31	8:41	8:48	8:57	9:00	9:01	9:04	9:13	9:21	9:30	9:37	9:47	9:56	
14				7:52	8:00	8:05	8:13	8:23	8:38	8:46	8:56	9:03	9:12	9:15	9:16	9:19							
13				8:07	8:15	8:20	8:28	8:38	8:53	9:01	9:11	9:18	9:27	9:30	9:31	9:34	9:43	9:51	10:00	10:07	10:17	10:26	
20	7:50	7:59	8:05	8:22	8:30	8:35	8:43	8:53	9:08	9:16	9:26	9:33	9:42	9:45	9:46	9:49							
5				8:37	8:45	8:50	8:58	9:08	9:23	9:31	9:41	9:48	9:57	10:00	10:01	10:04	10:13	10:21	10:30	10:37	10:47	10:56	
6				8:52	9:00	9:05	9:13	9:23	9:38	9:46	9:56	10:03	10:12	10:15	10:16	10:19							
15				9:07	9:15	9:20	9:28	9:38	9:53	10:01	10:11	10:18	10:27	10:30	10:31	10:34	10:43	10:51	11:00	11:07	11:17	11:26	
16				9:37	9:45	9:50	9:58	10:08	10:23	10:31	10:41	10:48	10:57	11:00	11:01	11:04	11:13	11:21	11:30	11:37	11:47	11:56	
7				10:07	10:15	10:20	10:28	10:38	10:53	11:01	11:11	11:18	11:27	11:30	11:31	11:34	11:43	11:51	12:00	12:07	12:17	12:26	
8				10:37	10:45	10:50	10:58	11:08	11:23	11:31	11:41	11:48	11:57	12:00	12:01	12:04	12:13	12:21	12:30	12:37	12:47	12:56	
9				11:07	11:15	11:20	11:28	11:38	11:53	12:01	12:11	12:18	12:27	12:30	12:31	12:34	12:43	12:51	13:00	13:07	13:17	13:26	
12				11:37	11:45	11:50	11:58	12:08	12:23	12:31	12:41	12:48	12:57	13:00	13:01	13:04	13:13	13:21	13:30	13:37	13:47	13:56	
1				12:07	12:15	12:20	12:28	12:38	12:53	13:01	13:11	13:18	13:27	13:30	13:31	13:34	13:43	13:51	14:00	14:07	14:17	14:26	

Table 64 - Medium Investment Scenario Operating Plan - Northbound

Train	Payson	Spanish Fork	Springville	Provo	Orem	Vineyard	American Fork	Lehi	Draper	South Jordan	Murray	Salt Lake Central	Salt Lake Central	North Temple	North Temple	WS Relief	Woods Cross	Farmington	Layton	Clearfield	Roy	Ogden	Pleasant View
2				12:37	12:45	12:50	12:58	13:08	13:23	13:31	13:41	13:48	13:57	14:00	14:01	14:04	14:13	14:21	14:30	14:37	14:47	14:56	
3				13:07	13:15	13:20	13:28	13:38	13:53	14:01	14:11	14:18	14:27	14:30	14:31	14:34	14:43	14:51	15:00	15:07	15:17	15:26	
13				13:37	13:45	13:50	13:58	14:08	14:23	14:31	14:41	14:48	14:57	15:00	15:01	15:04	15:13	15:21	15:30	15:37	15:47	15:56	
5				14:07	14:15	14:20	14:28	14:38	14:53	15:01	15:11	15:18	15:27	15:30	15:31	15:34	15:43	15:51	16:00	16:07	16:17	16:26	
21													15:42	15:45	15:46	15:49	15:58	16:06	16:15	16:22	16:32	16:41	
15				14:37	14:45	14:50	14:58	15:08	15:23	15:31	15:41	15:48	15:57	16:00	16:01	16:04	16:13	16:21	16:30	16:37	16:47	16:56	
6													16:12	16:15	16:16	16:19	16:28	16:36	16:45	16:52	17:02	17:11	
16				15:07	15:15	15:20	15:28	15:38	15:53	16:01	16:11	16:18	16:27	16:30	16:31	16:34	16:43	16:51	17:00	17:07	17:17	17:26	
18													16:42	16:45	16:46	16:49	16:58	17:06	17:15	17:22	17:32	17:41	
7				15:37	15:45	15:50	15:58	16:08	16:23	16:31	16:41	16:48	16:57	17:00	17:01	17:04	17:13	17:21	17:30	17:37	17:47	17:56	
10													17:12	17:15	17:16	17:19	17:28	17:36	17:45	17:52	18:02	18:11	
8				16:07	16:15	16:20	16:28	16:38	16:53	17:01	17:11	17:18	17:27	17:30	17:31	17:34	17:43	17:51	18:00	18:07	18:17	18:26	18:40
9				16:22	16:30	16:35	16:43	16:53	17:08	17:16	17:26	17:33	17:42	17:45	17:46	17:49	17:58	18:06	18:15	18:22	18:32	18:41	
14				16:37	16:45	16:50	16:58	17:08	17:23	17:31	17:41	17:48	17:57	18:00	18:01	18:04	18:13	18:21	18:30	18:37	18:47	18:56	
4	16:20	16:29	16:35	16:52	17:00	17:05	17:13	17:23	17:38	17:46	17:56	18:03	18:12	18:15	18:16	18:19	18:28	18:36	18:45	18:52	19:02	19:11	
20				17:07	17:15	17:20	17:28	17:38	17:53	18:01	18:11	18:18	18:27	18:30	18:31	18:34	18:43	18:51	19:00	19:07	19:17	19:26	19:40
1				17:22	17:30	17:35	17:43	17:53	18:08	18:16	18:26	18:33	18:42	18:45	18:46	18:49	18:58	19:06	19:15	19:22	19:32	19:41	
22				17:37	17:45	17:50	17:58	18:08	18:23	18:31	18:41	18:48	18:57	19:00	19:01	19:04							
12	17:20	17:29	17:35	17:52	18:00	18:05	18:13	18:23	18:38	18:46	18:56	19:03	19:12	19:15	19:16	19:19	19:28	19:36	19:45	19:52	20:02	20:11	
17				18:07	18:15	18:20	18:28	18:38	18:53	19:01	19:11	19:18	19:27	19:30	19:31	19:34							
3				18:22	18:30	18:35	18:43	18:53	19:08	19:16	19:26	19:33	19:42	19:45	19:46	19:49	19:58	20:06	20:15	20:22	20:32	20:41	
11				18:37	18:45	18:50	18:58	19:08	19:23	19:31	19:41	19:48	19:57	20:00	20:01	20:04							
2	18:20	18:29	18:35	18:52	19:00	19:05	19:13	19:23	19:38	19:46	19:56	20:03	20:12	20:15	20:16	20:19	20:28	20:36	20:45	20:52	21:02	21:11	
19				19:07	19:15	19:20	19:28	19:38	19:53	20:01	20:11	20:18	20:27	20:30	20:31	20:34							
5				19:22	19:30	19:35	19:43	19:53	20:08	20:16	20:26	20:33	20:42	20:45	20:46	20:49	20:58	21:06	21:15	21:22	21:32	21:41	
21				19:37	19:45	19:50	19:58	20:08	20:23	20:31	20:41	20:48	20:57	21:00	21:01	21:04							
13	19:20	19:29	19:35	19:52	20:00	20:05	20:13	20:23	20:38	20:46	20:56	21:03	21:12	21:15	21:16	21:19	21:28	21:36	21:45	21:52	22:02	22:11	
6				20:22	20:30	20:35	20:43	20:53	21:08	21:16	21:26	21:33	21:42	21:45	21:46	21:49	21:58	22:06	22:15	22:22	22:32	22:41	
18				20:52	21:00	21:05	21:13	21:23	21:38	21:46	21:56	22:03	22:12	22:15	22:16	22:19	22:28	22:36	22:45	22:52	23:02	23:11	
10				21:22	21:30	21:35	21:43	21:53	22:08	22:16	22:26	22:33	22:42	22:45	22:46	22:49	22:58	23:06	23:15	23:22	23:32	23:41	
9				21:52	22:00	22:05	22:13	22:23	22:38	22:46	22:56	23:03	23:12	23:15	23:16	23:19	23:28	23:36	23:45	23:52	0:02	0:11	
8				22:22	22:30	22:35	22:43	22:53	23:08	23:16	23:26	23:33	23:42	23:45	23:46	23:49							

Table 65 - Medium Investment Scenario Operating Plan - Southbound

Train	Pleasant View	Ogden	Roy	Clearfield	Layton	Farmington	Woods Cross	WS Relief	North Temple	North Temple	Salt Lake Central	Salt Lake Central	Murray	South Jordan	Draper	Lehi	American Fork	Vineyard	Orem	Provo	Springville	Spanish Fork	Payson
12										4:32	4:35	4:42	4:52	5:00	5:11	5:22	5:31	5:41	5:48	5:55			
10										4:47	4:50	4:57	5:07	5:15	5:26	5:37	5:46	5:56	6:03	6:10	6:23	6:29	6:38
1										5:02	5:05	5:12	5:22	5:30	5:41	5:52	6:01	6:11	6:18	6:25			
11										5:17	5:20	5:27	5:37	5:45	5:56	6:07	6:16	6:26	6:33	6:40			
2										5:32	5:35	5:42	5:52	6:00	6:11	6:22	6:31	6:41	6:48	6:55			
20										5:47	5:50	5:57	6:07	6:15	6:26	6:37	6:46	6:56	7:03	7:10	7:23	7:29	7:38
3	4:49	5:04	5:11	5:23	5:29	5:38	5:48	5:57	6:00	6:02	6:05	6:12	6:22	6:30	6:41	6:52	7:01	7:11	7:18	7:25			
14										6:17	6:20	6:27	6:37	6:45	6:56	7:07	7:16	7:26	7:33	7:40			
13		5:34	5:41	5:53	5:59	6:08	6:18	6:27	6:30	6:32	6:35	6:42	6:52	7:00	7:11	7:22	7:31	7:41	7:48	7:55			
4		5:49	5:56	6:08	6:14	6:23	6:33	6:42	6:45	6:47	6:50	6:57	7:07	7:15	7:26	7:37	7:46	7:56	8:03	8:10	8:23	8:29	8:38
5	5:49	6:04	6:11	6:23	6:29	6:38	6:48	6:57	7:00	7:02	7:05	7:12	7:22	7:30	7:41	7:52	8:01	8:11	8:18	8:25			
6		6:19	6:26	6:38	6:44	6:53	7:03	7:12	7:15	7:17	7:20	7:27	7:37	7:45	7:56	8:07	8:16	8:26	8:33	8:40			
15		6:34	6:41	6:53	6:59	7:08	7:18	7:27	7:30	7:32	7:35	7:42	7:52	8:00	8:11	8:22	8:31	8:41	8:48	8:55			
16		6:49	6:56	7:08	7:14	7:23	7:33	7:42	7:45	7:47	7:50	7:57	8:07	8:15	8:26	8:37	8:46	8:56	9:03	9:10			
21		7:04	7:11	7:23	7:29	7:38	7:48	7:57	8:00	8:02	8:05												
7		7:19	7:26	7:38	7:44	7:53	8:03	8:12	8:15	8:17	8:20	8:27	8:37	8:45	8:56	9:07	9:16	9:26	9:33	9:40			
17		7:34	7:41	7:53	7:59	8:08	8:18	8:27	8:30	8:32	8:35												
8		7:49	7:56	8:08	8:14	8:23	8:33	8:42	8:45	8:47	8:50	8:57	9:07	9:15	9:26	9:37	9:46	9:56	10:03	10:10			
18		8:04	8:11	8:23	8:29	8:38	8:48	8:57	9:00	9:02	9:05												
9		8:19	8:26	8:38	8:44	8:53	9:03	9:12	9:15	9:17	9:20	9:27	9:37	9:45	9:56	10:07	10:16	10:26	10:33	10:40			
22		8:34	8:41	8:53	8:59	9:08	9:18	9:27	9:30	9:32	9:35												
12		8:49	8:56	9:08	9:14	9:23	9:33	9:42	9:45	9:47	9:50	9:57	10:07	10:15	10:26	10:37	10:46	10:56	11:03	11:10			
1		9:19	9:26	9:38	9:44	9:53	10:03	10:12	10:15	10:17	10:20	10:27	10:37	10:45	10:56	11:07	11:16	11:26	11:33	11:40			
2		9:49	9:56	10:08	10:14	10:23	10:33	10:42	10:45	10:47	10:50	10:57	11:07	11:15	11:26	11:37	11:46	11:56	12:03	12:10			
3		10:19	10:26	10:38	10:44	10:53	11:03	11:12	11:15	11:17	11:20	11:27	11:37	11:45	11:56	12:07	12:16	12:26	12:33	12:40			
13		10:49	10:56	11:08	11:14	11:23	11:33	11:42	11:45	11:47	11:50	11:57	12:07	12:15	12:26	12:37	12:46	12:56	13:03	13:10			
5		11:19	11:26	11:38	11:44	11:53	12:03	12:12	12:15	12:17	12:20	12:27	12:37	12:45	12:56	13:07	13:16	13:26	13:33	13:40			
15		11:49	11:56	12:08	12:14	12:23	12:33	12:42	12:45	12:47	12:50	12:57	13:07	13:15	13:26	13:37	13:46	13:56	14:03	14:10			
16		12:19	12:26	12:38	12:44	12:53	13:03	13:12	13:15	13:17	13:20	13:27	13:37	13:45	13:56	14:07	14:16	14:26	14:33	14:40			
7		12:49	12:56	13:08	13:14	13:23	13:33	13:42	13:45	13:47	13:50	13:57	14:07	14:15	14:26	14:37	14:46	14:56	15:03	15:10			
8		13:19	13:26	13:38	13:44	13:53	14:03	14:12	14:15	14:17	14:20	14:27	14:37	14:45	14:56	15:07	15:16	15:26	15:33	15:40			
9		13:49	13:56	14:08	14:14	14:23	14:33	14:42	14:45	14:47	14:50	14:57	15:07	15:15	15:26	15:37	15:46	15:56	16:03	16:10			
14										15:02	15:05	15:12	15:22	15:30	15:41	15:52	16:01	16:11	16:18	16:25			
12		14:19	14:26	14:38	14:44	14:53	15:03	15:12	15:15	15:17	15:20	15:27	15:37	15:45	15:56	16:07	16:16	16:26	16:33	16:40	16:53	16:59	17:08
20										15:32	15:35	15:42	15:52	16:00	16:11	16:22	16:31	16:41	16:48	16:55			
1		14:49	14:56	15:08	15:14	15:23	15:33	15:42	15:45	15:47	15:50	15:57	16:07	16:15	16:26	16:37	16:46	16:56	17:03	17:10			
22										16:02	16:05	16:12	16:22	16:30	16:41	16:52	17:01	17:11	17:18	17:25			
2		15:19	15:26	15:38	15:44	15:53	16:03	16:12	16:15	16:17	16:20	16:27	16:37	16:45	16:56	17:07	17:16	17:26	17:33	17:40	17:53	17:59	18:08

Table 65 - Medium Investment Scenario Operating Plan - Southbound

Train	Pleasant View	Ogden	Roy	Clearfield	Layton	Farmington	Woods Cross	WS Relief	North Temple	North Temple	Salt Lake Central	Salt Lake Central	Murray	South Jordan	Draper	Lehi	American Fork	Vineyard	Orem	Provo	Springville	Spanish Fork	Payson
17										16:32	16:35	16:42	16:52	17:00	17:11	17:22	17:31	17:41	17:48	17:55			
3		15:49	15:56	16:08	16:14	16:23	16:33	16:42	16:45	16:47	16:50	16:57	17:07	17:15	17:26	17:37	17:46	17:56	18:03	18:10			
11		16:04	16:11	16:23	16:29	16:38	16:48	16:57	17:00	17:02	17:05	17:12	17:22	17:30	17:41	17:52	18:01	18:11	18:18	18:25			
13		16:19	16:26	16:38	16:44	16:53	17:03	17:12	17:15	17:17	17:20	17:27	17:37	17:45	17:56	18:07	18:16	18:26	18:33	18:40	18:53	18:59	19:08
19		16:34	16:41	16:53	16:59	17:08	17:18	17:27	17:30	17:32	17:35	17:42	17:52	18:00	18:11	18:22	18:31	18:41	18:48	18:55			
5		16:49	16:56	17:08	17:14	17:23	17:33	17:42	17:45	17:47	17:50	17:57	18:07	18:15	18:26	18:37	18:46	18:56	19:03	19:10			
21		17:04	17:11	17:23	17:29	17:38	17:48	17:57	18:00	18:02	18:05	18:12	18:22	18:30	18:41	18:52	19:01	19:11	19:18	19:25			
15		17:19	17:26	17:38	17:44	17:53	18:03	18:12	18:15	18:17	18:20	18:27	18:37	18:45	18:56	19:07	19:16	19:26	19:33	19:40	19:53	19:59	20:08
6		17:34	17:41	17:53	17:59	18:08	18:18	18:27	18:30	18:32	18:35	18:42	18:52	19:00	19:11	19:22	19:31	19:41	19:48	19:55			
16		17:49	17:56	18:08	18:14	18:23	18:33	18:42	18:45	18:47	18:50												
18		18:04	18:11	18:23	18:29	18:38	18:48	18:57	19:00	19:02	19:05	19:12	19:22	19:30	19:41	19:52	20:01	20:11	20:18	20:25			
7		18:19	18:26	18:38	18:44	18:53	19:03	19:12	19:15	19:17	19:20												
10		18:34	18:41	18:53	18:59	19:08	19:18	19:27	19:30	19:32	19:35	19:42	19:52	20:00	20:11	20:22	20:31	20:41	20:48	20:55			
9		19:04	19:11	19:23	19:29	19:38	19:48	19:57	20:00	20:02	20:05	20:12	20:22	20:30	20:41	20:52	21:01	21:11	21:18	21:25			
14		19:19	19:26	19:38	19:44	19:53	20:03	20:12	20:15	20:17	20:20												
8	18:49	19:34	19:41	19:53	19:59	20:08	20:18	20:27	20:30	20:32	20:35	20:42	20:52	21:00	21:11	21:22	21:31	21:41	21:48	21:55			
1		20:04	20:11	20:23	20:29	20:38	20:48	20:57	21:00	21:02	21:05	21:12	21:22	21:30	21:41	21:52	22:01	22:11	22:18	22:25			
20	19:49	20:34	20:41	20:53	20:59	21:08	21:18	21:27	21:30	21:32	21:35	21:42	21:52	22:00	22:11	22:22	22:31	22:41	22:48	22:55			
12		20:49	20:56	21:08	21:14	21:23	21:33	21:42	21:45	21:47	21:50												
3		21:04	21:11	21:23	21:29	21:38	21:48	21:57	22:00	22:02	22:05	22:12	22:22	22:30	22:41	22:52	23:01	23:11	23:18	23:25	23:38	23:44	23:53
2		21:34	21:41	21:53	21:59	22:08	22:18	22:27	22:30	22:32	22:35	22:42	22:52	23:00	23:11	23:22	23:31	23:41	23:48	23:55			
5		22:04	22:11	22:23	22:29	22:38	22:48	22:57	23:00	23:02	23:05	23:12	23:22	23:30	23:41	23:52	0:01	0:11	0:18	0:25			
13		22:34	22:41	22:53	22:59	23:08	23:18	23:27	23:30	23:32	23:35												
6		23:04	23:11	23:23	23:29	23:38	23:48	23:57	0:00	0:02	0:05												

16.5 High Investment Scenario Operating Plan

Table 66 - High Investment Scenario Operating Plan - Northbound

Train	Payson	Spanish Fork	Springville	Provo	Orem	Vineyard	American Fork	Lehi	Draper	South Jordan	Murray	Salt Lake Central	Salt Lake Central	North Temple	North Temple	WS Relief	Woods Cross	Farmington	Layton	Clearfield	Roy	Ogden	Pleasant View
3																						4:22	4:37
5																						5:22	5:37
13													4:12	4:15	4:16	4:19	4:28	4:36	4:46	4:52	5:01	5:11	
6													4:57	5:00	5:01	5:04	5:13	5:21	5:31	5:37	5:46	5:56	
16													5:27	5:30	5:31	5:34	5:43	5:51	6:01	6:07	6:16	6:26	
21													5:42	5:45	5:46	5:49	5:58	6:06	6:16	6:22	6:31	6:41	
7				4:45	4:51	4:57	5:04	5:13	5:25	5:31	5:41	5:51	5:57	6:00	6:01	6:04	6:13	6:21	6:31	6:37	6:46	6:56	
17													6:12	6:15	6:16	6:19	6:28	6:36	6:46	6:52	7:01	7:11	
8				5:15	5:21	5:27	5:34	5:43	5:55	6:01	6:11	6:21	6:27	6:30	6:31	6:34	6:43	6:51	7:01	7:07	7:16	7:26	
18	5:05	5:14	5:20	5:30	5:36	5:42	5:49	5:58	6:10	6:16	6:26	6:36	6:42	6:45	6:46	6:49	6:58	7:06	7:16	7:22	7:31	7:41	
9				5:45	5:51	5:57	6:04	6:13	6:25	6:31	6:41	6:51	6:57	7:00	7:01	7:04	7:13	7:21	7:31	7:37	7:46	7:56	
12				6:00	6:06	6:12	6:19	6:28	6:40	6:46	6:56	7:06	7:12	7:15	7:16	7:19	7:28	7:36	7:46	7:52	8:01	8:11	
10				6:15	6:21	6:27	6:34	6:43	6:55	7:01	7:11	7:21	7:27	7:30	7:31	7:34	7:43	7:51	8:01	8:07	8:16	8:26	
19	6:05	6:14	6:20	6:30	6:36	6:42	6:49	6:58	7:10	7:16	7:26	7:36	7:42	7:45	7:46	7:49	7:58	8:06	8:16	8:22	8:31	8:41	
11				6:45	6:51	6:57	7:04	7:13	7:25	7:31	7:41	7:51	7:57	8:00	8:01	8:04	8:13	8:21	8:31	8:37	8:46	8:56	
2				7:00	7:06	7:12	7:19	7:28	7:40	7:46	7:56	8:06	8:12	8:15	8:16	8:19	8:28	8:36	8:46	8:52	9:01	9:11	
20				7:15	7:21	7:27	7:34	7:43	7:55	8:01	8:11	8:21	8:27	8:30	8:31	8:34	8:43	8:51	9:01	9:07	9:16	9:26	
1	7:05	7:14	7:20	7:30	7:36	7:42	7:49	7:58	8:10	8:16	8:26	8:36	8:42	8:45	8:46	8:49							
14				7:45	7:51	7:57	8:04	8:13	8:25	8:31	8:41	8:51	8:57	9:00	9:01	9:04	9:13	9:21	9:31	9:37	9:46	9:56	
13				8:00	8:06	8:12	8:19	8:28	8:40	8:46	8:56	9:06	9:12	9:15	9:16	9:19							
4				8:15	8:21	8:27	8:34	8:43	8:55	9:01	9:11	9:21	9:27	9:30	9:31	9:34	9:43	9:51	10:01	10:07	10:16	10:26	
3	8:05	8:14	8:20	8:30	8:36	8:42	8:49	8:58	9:10	9:16	9:26	9:36	9:42	9:45	9:46	9:49							
6				8:45	8:51	8:57	9:04	9:13	9:25	9:31	9:41	9:51	9:57	10:00	10:01	10:04	10:13	10:21	10:31	10:37	10:46	10:56	
15				9:00	9:06	9:12	9:19	9:28	9:40	9:46	9:56	10:06	10:12	10:15	10:16	10:19							
16				9:15	9:21	9:27	9:34	9:43	9:55	10:01	10:11	10:21	10:27	10:30	10:31	10:34	10:43	10:51	11:01	11:07	11:16	11:26	
7				9:45	9:51	9:57	10:04	10:13	10:25	10:31	10:41	10:51	10:57	11:00	11:01	11:04	11:13	11:21	11:31	11:37	11:46	11:56	
8				10:15	10:21	10:27	10:34	10:43	10:55	11:01	11:11	11:21	11:27	11:30	11:31	11:34	11:43	11:51	12:01	12:07	12:16	12:26	
9				10:45	10:51	10:57	11:04	11:13	11:25	11:31	11:41	11:51	11:57	12:00	12:01	12:04	12:13	12:21	12:31	12:37	12:46	12:56	
10				11:15	11:21	11:27	11:34	11:43	11:55	12:01	12:11	12:21	12:27	12:30	12:31	12:34	12:43	12:51	13:01	13:07	13:16	13:26	
11				11:45	11:51	11:57	12:04	12:13	12:25	12:31	12:41	12:51	12:57	13:00	13:01	13:04	13:13	13:21	13:31	13:37	13:46	13:56	
20				12:15	12:21	12:27	12:34	12:43	12:55	13:01	13:11	13:21	13:27	13:30	13:31	13:34	13:43	13:51	14:01	14:07	14:16	14:26	
14				12:45	12:51	12:57	13:04	13:13	13:25	13:31	13:41	13:51	13:57	14:00	14:01	14:04	14:13	14:21	14:31	14:37	14:46	14:56	
4				13:15	13:21	13:27	13:34	13:43	13:55	14:01	14:11	14:21	14:27	14:30	14:31	14:34	14:43	14:51	15:01	15:07	15:16	15:26	
6				13:45	13:51	13:57	14:04	14:13	14:25	14:31	14:41	14:51	14:57	15:00	15:01	15:04	15:13	15:21	15:31	15:37	15:46	15:56	
16				14:15	14:21	14:27	14:34	14:43	14:55	15:01	15:11	15:21	15:27	15:30	15:31	15:34	15:43	15:51	16:01	16:07	16:16	16:26	
21													15:42	15:45	15:46	15:49	15:58	16:06	16:16	16:22	16:31	16:41	

Table 66 - High Investment Scenario Operating Plan - Northbound

Train	Payson	Spanish Fork	Springville	Provo	Orem	Vineyard	American Fork	Lehi	Draper	South Jordan	Murray	Salt Lake Central	Salt Lake Central	North Temple	North Temple	WS Relief	Woods Cross	Farmington	Layton	Clearfield	Roy	Ogden	Pleasant View
7				14:45	14:51	14:57	15:04	15:13	15:25	15:31	15:41	15:51	15:57	16:00	16:01	16:04	16:13	16:21	16:31	16:37	16:46	16:56	
1													16:12	16:15	16:16	16:19	16:28	16:36	16:46	16:52	17:01	17:11	
8				15:15	15:21	15:27	15:34	15:43	15:55	16:01	16:11	16:21	16:27	16:30	16:31	16:34	16:43	16:51	17:01	17:07	17:16	17:26	
18													16:42	16:45	16:46	16:49	16:58	17:06	17:16	17:22	17:31	17:41	
9				15:45	15:51	15:57	16:04	16:13	16:25	16:31	16:41	16:51	16:57	17:00	17:01	17:04	17:13	17:21	17:31	17:37	17:46	17:56	
3													17:12	17:15	17:16	17:19	17:28	17:36	17:46	17:52	18:01	18:11	
10				16:15	16:21	16:27	16:34	16:43	16:55	17:01	17:11	17:21	17:27	17:30	17:31	17:34	17:43	17:51	18:01	18:07	18:16	18:26	18:40
12				16:30	16:36	16:42	16:49	16:58	17:10	17:16	17:26	17:36	17:42	17:45	17:46	17:49	17:58	18:06	18:16	18:22	18:31	18:41	
11				16:45	16:51	16:57	17:04	17:13	17:25	17:31	17:41	17:51	17:57	18:00	18:01	18:04	18:13	18:21	18:31	18:37	18:46	18:56	
5	16:35	16:44	16:50	17:00	17:06	17:12	17:19	17:28	17:40	17:46	17:56	18:06	18:12	18:15	18:16	18:19	18:28	18:36	18:46	18:52	19:01	19:11	
20				17:15	17:21	17:27	17:34	17:43	17:55	18:01	18:11	18:21	18:27	18:30	18:31	18:34	18:43	18:51	19:01	19:07	19:16	19:26	19:40
15				17:30	17:36	17:42	17:49	17:58	18:10	18:16	18:26	18:36	18:42	18:45	18:46	18:49	18:58	19:06	19:16	19:22	19:31	19:41	
14				17:45	17:51	17:57	18:04	18:13	18:25	18:31	18:41	18:51	18:57	19:00	19:01	19:04							
13	17:35	17:44	17:50	18:00	18:06	18:12	18:19	18:28	18:40	18:46	18:56	19:06	19:12	19:15	19:16	19:19	19:28	19:36	19:46	19:52	20:01	20:11	
4				18:15	18:21	18:27	18:34	18:43	18:55	19:01	19:11	19:21	19:27	19:30	19:31	19:34							
2				18:30	18:36	18:42	18:49	18:58	19:10	19:16	19:26	19:36	19:42	19:45	19:46	19:49	19:58	20:06	20:16	20:22	20:31	20:41	
6				18:45	18:51	18:57	19:04	19:13	19:25	19:31	19:41	19:51	19:57	20:00	20:01	20:04							
17	18:35	18:44	18:50	19:00	19:06	19:12	19:19	19:28	19:40	19:46	19:56	20:06	20:12	20:15	20:16	20:19	20:28	20:36	20:46	20:52	21:01	21:11	
16				19:15	19:21	19:27	19:34	19:43	19:55	20:01	20:11	20:21	20:27	20:30	20:31	20:34							
21				19:30	19:36	19:42	19:49	19:58	20:10	20:16	20:26	20:36	20:42	20:45	20:46	20:49	20:58	21:06	21:16	21:22	21:31	21:41	
7				19:45	19:51	19:57	20:04	20:13	20:25	20:31	20:41	20:51	20:57	21:00	21:01	21:04							
19	19:35	19:44	19:50	20:00	20:06	20:12	20:19	20:28	20:40	20:46	20:56	21:06	21:12	21:15	21:16	21:19	21:28	21:36	21:46	21:52	22:01	22:11	
18				20:30	20:36	20:42	20:49	20:58	21:10	21:16	21:26	21:36	21:42	21:45	21:46	21:49	21:58	22:06	22:16	22:22	22:31	22:41	
3				21:00	21:06	21:12	21:19	21:28	21:40	21:46	21:56	22:06	22:12	22:15	22:16	22:19	22:28	22:36	22:46	22:52	23:01	23:11	
12				21:30	21:36	21:42	21:49	21:58	22:10	22:16	22:26	22:36	22:42	22:45	22:46	22:49	22:58	23:06	23:16	23:22	23:31	23:41	
10				22:00	22:06	22:12	22:19	22:28	22:40	22:46	22:56	23:06	23:12	23:15	23:16	23:19	23:28	23:36	23:46	23:52	0:01	0:11	
15				22:30	22:36	22:42	22:49	22:58	23:10	23:16	23:26	23:36	23:42	23:45	23:46	23:49							

Table 67 - High Investment Scenario Operating Plan - Southbound

Train	Pleasant View	Ogden	Roy	Clearfield	Layton	Farmington	Woods Cross	WS Relief	North Temple	North Temple	Salt Lake Central	Salt Lake Central	Murray	South Jordan	Draper	Lehi	American Fork	Vineyard	Orem	Provo	Springville	Spanish Fork	Payson
12										4:31	4:34	4:37	4:49	4:56	5:03	5:12	5:21	5:30	5:35	5:45			
10										4:46	4:49	4:52	5:04	5:11	5:18	5:27	5:36	5:45	5:50	6:00			
1										5:01	5:04	5:07	5:19	5:26	5:33	5:42	5:51	6:00	6:05	6:15	6:27	6:33	6:42
11										5:16	5:19	5:22	5:34	5:41	5:48	5:57	6:06	6:15	6:20	6:30			
2										5:31	5:34	5:37	5:49	5:56	6:03	6:12	6:21	6:30	6:35	6:45			
20										5:46	5:49	5:52	6:04	6:11	6:18	6:27	6:36	6:45	6:50	7:00			
3	4:50	5:04	5:14	5:23	5:30	5:37	5:47	5:56	6:00	6:01	6:04	6:07	6:19	6:26	6:33	6:42	6:51	7:00	7:05	7:15	7:27	7:33	7:42
14										6:16	6:19	6:22	6:34	6:41	6:48	6:57	7:06	7:15	7:20	7:30			
13		5:34	5:44	5:53	6:00	6:07	6:17	6:26	6:30	6:31	6:34	6:37	6:49	6:56	7:03	7:12	7:21	7:30	7:35	7:45			
4		5:49	5:59	6:08	6:15	6:22	6:32	6:41	6:45	6:46	6:49	6:52	7:04	7:11	7:18	7:27	7:36	7:45	7:50	8:00			
5	5:50	6:04	6:14	6:23	6:30	6:37	6:47	6:56	7:00	7:01	7:04	7:07	7:19	7:26	7:33	7:42	7:51	8:00	8:05	8:15	8:27	8:33	8:42
6		6:19	6:29	6:38	6:45	6:52	7:02	7:11	7:15	7:16	7:19	7:22	7:34	7:41	7:48	7:57	8:06	8:15	8:20	8:30			
15		6:34	6:44	6:53	7:00	7:07	7:17	7:26	7:30	7:31	7:34	7:37	7:49	7:56	8:03	8:12	8:21	8:30	8:35	8:45			
16		6:49	6:59	7:08	7:15	7:22	7:32	7:41	7:45	7:46	7:49	7:52	8:04	8:11	8:18	8:27	8:36	8:45	8:50	9:00			
21		7:04	7:14	7:23	7:30	7:37	7:47	7:56	8:00	8:01	8:04												
7		7:19	7:29	7:38	7:45	7:52	8:02	8:11	8:15	8:16	8:19	8:22	8:34	8:41	8:48	8:57	9:06	9:15	9:20	9:30			
17		7:34	7:44	7:53	8:00	8:07	8:17	8:26	8:30	8:31	8:34												
8		7:49	7:59	8:08	8:15	8:22	8:32	8:41	8:45	8:46	8:49	8:52	9:04	9:11	9:18	9:27	9:36	9:45	9:50	10:00			
18		8:04	8:14	8:23	8:30	8:37	8:47	8:56	9:00	9:01	9:04												
9		8:19	8:29	8:38	8:45	8:52	9:02	9:11	9:15	9:16	9:19	9:22	9:34	9:41	9:48	9:57	10:06	10:15	10:20	10:30			
12		8:34	8:44	8:53	9:00	9:07	9:17	9:26	9:30	9:31	9:34												
10		8:49	8:59	9:08	9:15	9:22	9:32	9:41	9:45	9:46	9:49	9:52	10:04	10:11	10:18	10:27	10:36	10:45	10:50	11:00			
11		9:19	9:29	9:38	9:45	9:52	10:02	10:11	10:15	10:16	10:19	10:22	10:34	10:41	10:48	10:57	11:06	11:15	11:20	11:30			
20		9:49	9:59	10:08	10:15	10:22	10:32	10:41	10:45	10:46	10:49	10:52	11:04	11:11	11:18	11:27	11:36	11:45	11:50	12:00			
14		10:19	10:29	10:38	10:45	10:52	11:02	11:11	11:15	11:16	11:19	11:22	11:34	11:41	11:48	11:57	12:06	12:15	12:20	12:30			
4		10:49	10:59	11:08	11:15	11:22	11:32	11:41	11:45	11:46	11:49	11:52	12:04	12:11	12:18	12:27	12:36	12:45	12:50	13:00			
6		11:19	11:29	11:38	11:45	11:52	12:02	12:11	12:15	12:16	12:19	12:22	12:34	12:41	12:48	12:57	13:06	13:15	13:20	13:30			
16		11:49	11:59	12:08	12:15	12:22	12:32	12:41	12:45	12:46	12:49	12:52	13:04	13:11	13:18	13:27	13:36	13:45	13:50	14:00			
7		12:19	12:29	12:38	12:45	12:52	13:02	13:11	13:15	13:16	13:19	13:22	13:34	13:41	13:48	13:57	14:06	14:15	14:20	14:30			
8		12:49	12:59	13:08	13:15	13:22	13:32	13:41	13:45	13:46	13:49	13:52	14:04	14:11	14:18	14:27	14:36	14:45	14:50	15:00			
9		13:19	13:29	13:38	13:45	13:52	14:02	14:11	14:15	14:16	14:19	14:22	14:34	14:41	14:48	14:57	15:06	15:15	15:20	15:30			
10		13:49	13:59	14:08	14:15	14:22	14:32	14:41	14:45	14:46	14:49	14:52	15:04	15:11	15:18	15:27	15:36	15:45	15:50	16:00			
12										15:01	15:04	15:07	15:19	15:26	15:33	15:42	15:51	16:00	16:05	16:15			
11		14:19	14:29	14:38	14:45	14:52	15:02	15:11	15:15	15:16	15:19	15:22	15:34	15:41	15:48	15:57	16:06	16:15	16:20	16:30			
13										15:31	15:34	15:37	15:49	15:56	16:03	16:12	16:21	16:30	16:35	16:45	16:57	17:03	17:12
20		14:49	14:59	15:08	15:15	15:22	15:32	15:41	15:45	15:46	15:49	15:52	16:04	16:11	16:18	16:27	16:36	16:45	16:50	17:00			
15										16:01	16:04	16:07	16:19	16:26	16:33	16:42	16:51	17:00	17:05	17:15			
14		15:19	15:29	15:38	15:45	15:52	16:02	16:11	16:15	16:16	16:19	16:22	16:34	16:41	16:48	16:57	17:06	17:15	17:20	17:30			

Table 67 - High Investment Scenario Operating Plan - Southbound

Train	Pleasant View	Ogden	Roy	Clearfield	Layton	Farmington	Woods Cross	WS Relief	North Temple	North Temple	Salt Lake Central	Salt Lake Central	Murray	South Jordan	Draper	Lehi	American Fork	Vineyard	Orem	Provo	Springville	Spanish Fork	Payson
17										16:31	16:34	16:37	16:49	16:56	17:03	17:12	17:21	17:30	17:35	17:45	17:57	18:03	18:12
4		15:49	15:59	16:08	16:15	16:22	16:32	16:41	16:45	16:46	16:49	16:52	17:04	17:11	17:18	17:27	17:36	17:45	17:50	18:00			
2		16:04	16:14	16:23	16:30	16:37	16:47	16:56	17:00	17:01	17:04	17:07	17:19	17:26	17:33	17:42	17:51	18:00	18:05	18:15			
6		16:19	16:29	16:38	16:45	16:52	17:02	17:11	17:15	17:16	17:19	17:22	17:34	17:41	17:48	17:57	18:06	18:15	18:20	18:30			
19		16:34	16:44	16:53	17:00	17:07	17:17	17:26	17:30	17:31	17:34	17:37	17:49	17:56	18:03	18:12	18:21	18:30	18:35	18:45	18:57	19:03	19:12
16		16:49	16:59	17:08	17:15	17:22	17:32	17:41	17:45	17:46	17:49	17:52	18:04	18:11	18:18	18:27	18:36	18:45	18:50	19:00			
21		17:04	17:14	17:23	17:30	17:37	17:47	17:56	18:00	18:01	18:04	18:07	18:19	18:26	18:33	18:42	18:51	19:00	19:05	19:15			
7		17:19	17:29	17:38	17:45	17:52	18:02	18:11	18:15	18:16	18:19	18:22	18:34	18:41	18:48	18:57	19:06	19:15	19:20	19:30			
1		17:34	17:44	17:53	18:00	18:07	18:17	18:26	18:30	18:31	18:34	18:37	18:49	18:56	19:03	19:12	19:21	19:30	19:35	19:45	19:57	20:03	20:12
8		17:49	17:59	18:08	18:15	18:22	18:32	18:41	18:45	18:46	18:49												
18		18:04	18:14	18:23	18:30	18:37	18:47	18:56	19:00	19:01	19:04	19:07	19:19	19:26	19:33	19:42	19:51	20:00	20:05	20:15			
9		18:19	18:29	18:38	18:45	18:52	19:02	19:11	19:15	19:16	19:19												
3		18:34	18:44	18:53	19:00	19:07	19:17	19:26	19:30	19:31	19:34	19:37	19:49	19:56	20:03	20:12	20:21	20:30	20:35	20:45			
12		19:04	19:14	19:23	19:30	19:37	19:47	19:56	20:00	20:01	20:04	20:07	20:19	20:26	20:33	20:42	20:51	21:00	21:05	21:15			
11		19:19	19:29	19:38	19:45	19:52	20:02	20:11	20:15	20:16	20:19												
10	18:52	19:34	19:44	19:53	20:00	20:07	20:17	20:26	20:30	20:31	20:34	20:37	20:49	20:56	21:03	21:12	21:21	21:30	21:35	21:45			
5		19:49	19:59	20:08	20:15	20:22	20:32	20:41	20:45	20:46	20:49												
15		20:04	20:14	20:23	20:30	20:37	20:47	20:56	21:00	21:01	21:04	21:07	21:19	21:26	21:33	21:42	21:51	22:00	22:05	22:15			
20	19:52	20:34	20:44	20:53	21:00	21:07	21:17	21:26	21:30	21:31	21:34	21:37	21:49	21:56	22:03	22:12	22:21	22:30	22:35	22:45			
13		20:49	20:59	21:08	21:15	21:22	21:32	21:41	21:45	21:46	21:49												
2		21:04	21:14	21:23	21:30	21:37	21:47	21:56	22:00	22:01	22:04	22:07	22:19	22:26	22:33	22:42	22:51	23:00	23:05	23:15	23:27	23:33	23:42
17		21:34	21:44	21:53	22:00	22:07	22:17	22:26	22:30	22:31	22:34	22:37	22:49	22:56	23:03	23:12	23:21	23:30	23:35	23:45			
21		22:04	22:14	22:23	22:30	22:37	22:47	22:56	23:00	23:01	23:04	23:07	23:19	23:26	23:33	23:42	23:51	0:00	0:05	0:15			
19		22:34	22:44	22:53	23:00	23:07	23:17	23:26	23:30	23:31	23:34												
18		23:04	23:14	23:23	23:30	23:37	23:47	23:56	0:00	0:01	0:04												

16.6 High Investment Scenario with Infill Stations Operating Plan

Table 68 - High Investment Scenario with Infill Stations Operating Plan - Northbound

Train	Santaquin	Payson	Spanish Fork	Springville	Provo Arrival	Provo Departure	Orem	Vineyard	American Fork	Lehi	Bluffdale	Draper	South Jordan	Murray	Salt Lake Central	Salt Lake Central	North Temple	North Temple	WS Relief	Woods Cross	Centerville	Farmington	Layton	Clearfield	Sunset	Roy	Ogden Arrival	Ogden Departure	Business District Ogden	Pleasant View	Willard	Brigham City
6																4:57	5:00	5:01	5:04	5:13	5:18	5:22	5:31	5:36	5:41	5:49	5:58					
22																5:12	5:15	5:16	5:19	5:28	5:33	5:37	5:46	5:51	5:56	6:04	6:13	6:14	6:18	6:23	6:34	6:43
16																5:27	5:30	5:31	5:34	5:43	5:48	5:52	6:01	6:06	6:11	6:19	6:28					
19																5:42	5:45	5:46	5:49	5:58	6:03	6:07	6:16	6:21	6:26	6:34	6:43					
7						4:45	4:53	4:59	5:06	5:15	5:23	5:28	5:34	5:43	5:48	5:57	6:00	6:01	6:04	6:13	6:18	6:22	6:31	6:36	6:41	6:49	6:58					
17																6:12	6:15	6:16	6:19	6:28	6:33	6:37	6:46	6:51	6:56	7:04	7:13	7:14	7:18	7:23	7:34	7:43
8						5:15	5:23	5:29	5:36	5:45	5:53	5:58	6:04	6:09	6:19	6:27	6:30	6:31	6:34	6:43	6:48	6:52	7:01	7:06	7:11	7:19	7:28					
18	5:00	5:05	5:14	5:21	5:29	5:30	5:38	5:44	5:51	6:00	6:08	6:13	6:19	6:24	6:34	6:42	6:45	6:46	6:49	6:58	7:03	7:07	7:16	7:21	7:26	7:34	7:43					
9						5:45	5:53	5:59	6:06	6:15	6:23	6:28	6:34	6:39	6:49	6:57	7:00	7:01	7:04	7:13	7:18	7:22	7:31	7:36	7:41	7:49	7:58					
12						6:00	6:08	6:14	6:21	6:30	6:38	6:43	6:49	6:54	7:04	7:12	7:15	7:16	7:19	7:28	7:33	7:37	7:46	7:51	7:56	8:04	8:13	8:14	8:18	8:23	8:34	8:43
10						6:15	6:23	6:29	6:36	6:45	6:53	6:58	7:04	7:09	7:19	7:27	7:30	7:31	7:34	7:43	7:48	7:52	8:01	8:06	8:11	8:19	8:28					
21	6:00	6:05	6:14	6:21	6:29	6:30	6:38	6:44	6:51	7:00	7:08	7:13	7:19	7:24	7:34	7:42	7:45	7:46	7:49	7:58	8:03	8:07	8:16	8:21	8:26	8:34	8:43					
11						6:45	6:53	6:59	7:06	7:15	7:23	7:28	7:34	7:39	7:49	7:57	8:00	8:01	8:04	8:13	8:18	8:22	8:31	8:36	8:41	8:49	8:58					
2						7:00	7:08	7:14	7:21	7:30	7:38	7:43	7:49	7:54	8:04	8:12	8:15	8:16	8:19	8:28	8:33	8:37	8:46	8:51	8:56	9:04	9:13					
20						7:15	7:23	7:29	7:36	7:45	7:53	7:58	8:04	8:09	8:19	8:27	8:30	8:31	8:34	8:43	8:48	8:52	9:01	9:06	9:11	9:19	9:28					
1	7:00	7:05	7:14	7:21	7:29	7:30	7:38	7:44	7:51	8:00	8:08	8:13	8:19	8:24	8:34	8:42	8:45	8:46	8:49													
14						7:45	7:53	7:59	8:06	8:15	8:23	8:28	8:34	8:39	8:49	8:57	9:00	9:01	9:04	9:13	9:18	9:22	9:31	9:36	9:41	9:49	9:58					
13						8:00	8:08	8:14	8:21	8:30	8:38	8:43	8:49	8:54	9:04	9:12	9:15	9:16	9:19													
4						8:15	8:23	8:29	8:36	8:45	8:53	8:58	9:04	9:09	9:19	9:27	9:30	9:31	9:34	9:43	9:48	9:52	10:01	10:06	10:11	10:19	10:28					
3	8:00	8:05	8:14	8:21	8:29	8:30	8:38	8:44	8:51	9:00	9:08	9:13	9:19	9:24	9:34	9:42	9:45	9:46	9:49													
6						8:45	8:53	8:59	9:06	9:15	9:23	9:28	9:34	9:39	9:49	9:57	10:00	10:01	10:04	10:13	10:18	10:22	10:31	10:36	10:41	10:49	10:58					
15						9:00	9:08	9:14	9:21	9:30	9:38	9:43	9:49	9:54	10:04	10:12	10:15	10:16	10:19													
16						9:15	9:23	9:29	9:36	9:45	9:53	9:58	10:04	10:09	10:19	10:27	10:30	10:31	10:34	10:43	10:48	10:52	11:01	11:06	11:11	11:19	11:28					
7						9:45	9:53	9:59	10:06	10:15	10:23	10:28	10:34	10:39	10:49	10:57	11:00	11:01	11:04	11:13	11:18	11:22	11:31	11:36	11:41	11:49	11:58					
8						10:15	10:23	10:29	10:36	10:45	10:53	10:58	11:04	11:09	11:19	11:27	11:30	11:31	11:34	11:43	11:48	11:52	12:01	12:06	12:11	12:19	12:28					
9						10:45	10:53	10:59	11:06	11:15	11:23	11:28	11:34	11:39	11:49	11:57	12:00	12:01	12:04	12:13	12:18	12:22	12:31	12:36	12:41	12:49	12:58					
10						11:15	11:23	11:29	11:36	11:45	11:53	11:58	12:04	12:09	12:19	12:27	12:30	12:31	12:34	12:43	12:48	12:52	13:01	13:06	13:11	13:19	13:28					
11						11:45	11:53	11:59	12:06	12:15	12:23	12:28	12:34	12:39	12:49	12:57	13:00	13:01	13:04	13:13	13:18	13:22	13:31	13:36	13:41	13:49	13:58					
20						12:15	12:23	12:29	12:36	12:45	12:53	12:58	13:04	13:09	13:19	13:27	13:30	13:31	13:34	13:43	13:48	13:52	14:01	14:06	14:11	14:19	14:28					
14						12:45	12:53	12:59	13:06	13:15	13:23	13:28	13:34	13:39	13:49	13:57	14:00	14:01	14:04	14:13	14:18	14:22	14:31	14:36	14:41	14:49	14:58					

Table 68 - High Investment Scenario with Infill Stations Operating Plan - Northbound

Train	Santaquin	Payson	Spanish Fork	Springville	Provo Arrival	Provo Departure	Orem	Vineyard	American Fork	Lehi	Bluffdale	Draper	South Jordan	Murray	Salt Lake Central	Salt Lake Central	North Temple	North Temple	WS Relief	Woods Cross	Centerville	Farmington	Layton	Clearfield	Sunset	Roy	Ogden Arrival	Ogden Departure	Business District Ogden	Pleasant View	Willard	Brigham City
4						13:15	13:23	13:29	13:36	13:45	13:53	13:58	14:04	14:09	14:19	14:27	14:30	14:31	14:34	14:43	14:48	14:52	15:01	15:06	15:11	15:19	15:28					
6						13:45	13:53	13:59	14:06	14:15	14:23	14:28	14:34	14:39	14:49	14:57	15:00	15:01	15:04	15:13	15:18	15:22	15:31	15:36	15:41	15:49	15:58					
16						14:15	14:23	14:29	14:36	14:45	14:53	14:58	15:04	15:09	15:19	15:27	15:30	15:31	15:34	15:43	15:48	15:52	16:01	16:06	16:11	16:19	16:28					
13																15:42	15:45	15:46	15:49	15:58	16:03	16:07	16:16	16:21	16:26	16:34	16:43	16:44	16:48	17:53	17:04	17:13
7						14:45	14:53	14:59	15:06	15:15	15:23	15:28	15:34	15:39	15:49	15:57	16:00	16:01	16:04	16:13	16:18	16:22	16:31	16:36	16:41	16:49	16:58					
1																16:12	16:15	16:16	16:19	16:28	16:33	16:37	16:46	16:51	16:56	17:04	17:13					
8						15:15	15:23	15:29	15:36	15:45	15:53	15:58	16:04	16:09	16:19	16:27	16:30	16:31	16:34	16:43	16:48	16:52	17:01	17:06	17:11	17:19	17:28					
3																16:42	16:45	16:46	16:49	16:58	17:03	17:07	17:16	17:21	17:26	17:34	17:43	17:44	17:48	18:53	18:04	18:13
9						15:45	15:53	15:59	16:06	16:15	16:23	16:28	16:34	16:39	16:49	16:57	17:00	17:01	17:04	17:13	17:18	17:22	17:31	17:36	17:41	17:49	17:58					
15																17:12	17:15	17:16	17:19	17:28	17:33	17:37	17:46	17:51	17:56	18:04	18:13					
10						16:15	16:23	16:29	16:36	16:45	16:53	16:58	17:04	17:09	17:19	17:27	17:30	17:31	17:34	17:43	17:48	17:52	18:01	18:06	18:11	18:19	18:28					
19						16:30	16:38	16:44	16:51	17:00	17:08	17:13	17:19	17:24	17:34	17:42	17:45	17:46	17:49	17:58	18:03	18:07	18:16	18:21	18:26	18:34	18:43	18:44	18:48	19:53	19:04	19:13
11						16:45	16:53	16:59	17:06	17:15	17:23	17:28	17:34	17:39	17:49	17:57	18:00	18:01	18:04	18:13	18:18	18:22	18:31	18:36	18:41	18:49	18:58					
5	16:30	16:35	16:44	16:51	16:59	17:00	17:08	17:14	17:21	17:30	17:38	17:43	17:49	17:54	18:04	18:12	18:15	18:16	18:19	18:28	18:33	18:37	18:46	18:51	18:56	19:04	19:13					
20						17:15	17:23	17:29	17:36	17:45	17:53	17:58	18:04	18:09	18:19	18:27	18:30	18:31	18:34	18:43	18:48	18:52	19:01	19:06	19:11	19:19	19:28					
17						17:30	17:38	17:44	17:51	18:00	18:08	18:13	18:19	18:24	18:34	18:42	18:45	18:46	18:49	18:58	19:03	19:07	19:16	19:21	19:26	19:34	19:43	19:44	19:48	20:53	20:04	20:13
14						17:45	17:53	17:59	18:06	18:15	18:23	18:28	18:34	18:39	18:49	18:57	19:00	19:01	19:04													
22	17:30	17:35	17:44	17:51	17:59	18:00	18:08	18:14	18:21	18:30	18:38	18:43	18:49	18:54	19:04	19:12	19:15	19:16	19:19	19:28	19:33	19:37	19:46	19:51	19:56	20:04	20:13					
4						18:15	18:23	18:29	18:36	18:45	18:53	18:58	19:04	19:09	19:19	19:27	19:30	19:31	19:34													
21						18:30	18:38	18:44	18:51	19:00	19:08	19:13	19:19	19:24	19:34	19:42	19:45	19:46	19:49	19:58	20:03	20:07	20:16	20:21	20:26	20:34	20:43					
6						18:45	18:53	18:59	19:06	19:15	19:23	19:28	19:34	19:39	19:49	19:57	20:00	20:01	20:04													
18	18:30	18:35	18:44	18:51	18:59	19:00	19:08	19:14	19:21	19:30	19:38	19:43	19:49	19:54	20:04	20:12	20:15	20:16	20:19	20:28	20:33	20:37	20:46	20:51	20:56	21:04	21:13					
16						19:15	19:23	19:29	19:36	19:45	19:53	19:58	20:04	20:09	20:19	20:27	20:30	20:31	20:34													
12						19:30	19:38	19:44	19:51	20:00	20:08	20:13	20:19	20:24	20:34	20:42	20:45	20:46	20:49	20:58	21:03	21:07	21:16	21:21	21:26	21:34	21:43					
7						19:45	19:53	19:59	20:06	20:15	20:23	20:28	20:34	20:39	20:49	20:57	21:00	21:01	21:04													
2	19:30	19:35	19:44	19:51	19:59	20:00	20:08	20:14	20:21	20:30	20:38	20:43	20:49	20:54	21:04	21:12	21:15	21:16	21:19	21:28	21:33	21:37	21:46	21:51	21:56	22:04	22:13					
13						20:30	20:38	20:44	20:51	21:00	21:08	21:13	21:19	21:24	21:34	21:42	21:45	21:46	21:49	21:58	22:03	22:07	22:16	22:21	22:26	22:34	22:43					
15						21:00	21:08	21:14	21:21	21:30	21:38	21:43	21:49	21:54	22:04	22:12	22:15	22:16	22:19	22:28	22:33	22:37	22:46	22:51	22:56	23:04	23:13	23:14	23:18	0:23	23:34	23:43
3						21:30	21:38	21:44	21:51	22:00	22:08	22:13	22:19	22:24	22:34	22:42	22:45	22:46	22:49	22:58	23:03	23:07	23:16	23:21	23:26	23:34	23:43					
5						22:00	22:08	22:14	22:21	22:30	22:38	22:43	22:49	22:54	23:04	23:12	23:15	23:16	23:19	23:28	23:33	23:37	23:46	23:51	23:56	0:04	0:13					
19						22:30	22:38	22:44	22:51	23:00	23:08	23:13	23:19	23:24	23:34	23:42	23:45	23:46	23:49													

Table 69 - High Investment Scenario with Infill Stations Operating Plan - Southbound

Train	Brigham City	Willard	Pleasant View	Business District Ogden	Ogden Arrival	Ogden Departure	Roy	Sunset	Clearfield	Layton	Farmington	Centerville	Woods Cross	WS Relief	North Temple	North Temple	Salt Lake Central	Salt Lake Central	Murray	South Jordan	Draper	Bluffdale	Lehi	American Fork	Vineyard	Orem	Provo Arrival	Provo Departure	Springville	Spanish Fork	Payson	Santaquin
12																4:32	4:35	4:42	4:52	5:00	5:06	5:10	5:16	5:25	5:35	5:42	5:48					
10																4:47	4:50	4:57	5:07	5:15	5:21	5:25	5:31	5:40	5:50	5:57	6:03					
1																5:02	5:05	5:12	5:22	5:30	5:36	5:40	5:46	5:55	6:05	6:12	6:18	6:19	6:27	6:33	6:42	6:49
11																5:17	5:20	5:27	5:37	5:45	5:51	5:55	6:01	6:10	6:20	6:27	6:33					
2																5:32	5:35	5:42	5:52	6:00	6:06	6:10	6:16	6:25	6:35	6:42	6:48					
20																5:47	5:50	5:57	6:07	6:15	6:21	6:25	6:31	6:40	6:50	6:57	7:03					
3						5:02	5:09	5:16	5:22	5:28	5:37	5:42	5:48	5:57	6:00	6:02	6:05	6:12	6:22	6:30	6:36	6:40	6:46	6:55	7:05	7:12	7:18	7:19	7:27	7:33	7:42	7:49
14																6:17	6:20	6:27	6:37	6:45	6:51	6:55	7:01	7:10	7:20	7:27	7:33					
13	5:03	5:11	5:21	5:26	5:30	5:32	5:39	5:46	5:52	5:58	6:07	6:12	6:18	6:27	6:30	6:32	6:35	6:42	6:52	7:00	7:06	7:10	7:16	7:25	7:35	7:42	7:48					
4						5:47	5:54	6:01	6:07	6:13	6:22	6:27	6:33	6:42	6:45	6:47	6:50	6:57	7:07	7:15	7:21	7:25	7:31	7:40	7:50	7:57	8:03					
5						6:02	6:09	6:16	6:22	6:28	6:37	6:42	6:48	6:57	7:00	7:02	7:05	7:12	7:22	7:30	7:36	7:40	7:46	7:55	8:05	8:12	8:18	8:19	8:27	8:33	8:42	8:49
6						6:17	6:24	6:31	6:37	6:43	6:52	6:57	7:03	7:12	7:15	7:17	7:20	7:27	7:37	7:45	7:51	7:55	8:01	8:10	8:20	8:27	8:33					
15	6:03	6:11	6:21	6:26	6:30	6:32	6:39	6:46	6:52	6:58	7:07	7:12	7:18	7:27	7:30	7:32	7:35	7:42	7:52	8:00	8:06	8:10	8:16	8:25	8:35	8:42	8:48					
16						6:47	6:54	7:01	7:07	7:13	7:22	7:27	7:33	7:42	7:45	7:47	7:50	7:57	8:07	8:15	8:21	8:25	8:31	8:40	8:50	8:57	9:03					
19						7:02	7:09	7:16	7:22	7:28	7:37	7:42	7:48	7:57	8:00	8:02	8:05															
7						7:17	7:24	7:31	7:37	7:43	7:52	7:57	8:03	8:12	8:15	8:17	8:20	8:27	8:37	8:45	8:51	8:55	9:01	9:10	9:20	9:27	9:33					
22	7:03	7:11	7:21	7:26	7:30	7:32	7:39	7:46	7:52	7:58	8:07	8:12	8:18	8:27	8:30	8:32	8:35															
8						7:47	7:54	8:01	8:07	8:13	8:22	8:27	8:33	8:42	8:45	8:47	8:50	8:57	9:07	9:15	9:21	9:25	9:31	9:40	9:50	9:57	10:03					
18						8:02	8:09	8:16	8:22	8:28	8:37	8:42	8:48	8:57	9:00	9:02	9:05															
9						8:17	8:24	8:31	8:37	8:43	8:52	8:57	9:03	9:12	9:15	9:17	9:20	9:27	9:37	9:45	9:51	9:55	10:01	10:10	10:20	10:27	10:33					
17	8:03	8:11	8:21	8:26	8:30	8:32	8:39	8:46	8:52	8:58	9:07	9:12	9:18	9:27	9:30	9:32	9:35															
10						8:47	8:54	9:01	9:07	9:13	9:22	9:27	9:33	9:42	9:45	9:47	9:50	9:57	10:07	10:15	10:21	10:25	10:31	10:40	10:50	10:57	11:03					
11						9:17	9:24	9:31	9:37	9:43	9:52	9:57	10:03	10:12	10:15	10:17	10:20	10:27	10:37	10:45	10:51	10:55	11:01	11:10	11:20	11:27	11:33					
20						9:47	9:54	10:01	10:07	10:13	10:22	10:27	10:33	10:42	10:45	10:47	10:50	10:57	11:07	11:15	11:21	11:25	11:31	11:40	11:50	11:57	12:03					
14						10:17	10:24	10:31	10:37	10:43	10:52	10:57	11:03	11:12	11:15	11:17	11:20	11:27	11:37	11:45	11:51	11:55	12:01	12:10	12:20	12:27	12:33					
4						10:47	10:54	11:01	11:07	11:13	11:22	11:27	11:33	11:42	11:45	11:47	11:50	11:57	12:07	12:15	12:21	12:25	12:31	12:40	12:50	12:57	13:03					
6						11:17	11:24	11:31	11:37	11:43	11:52	11:57	12:03	12:12	12:15	12:17	12:20	12:27	12:37	12:45	12:51	12:55	13:01	13:10	13:20	13:27	13:33					
16						11:47	11:54	12:01	12:07	12:13	12:22	12:27	12:33	12:42	12:45	12:47	12:50	12:57	13:07	13:15	13:21	13:25	13:31	13:40	13:50	13:57	14:03					
7						12:17	12:24	12:31	12:37	12:43	12:52	12:57	13:03	13:12	13:15	13:17	13:20	13:27	13:37	13:45	13:51	13:55	14:01	14:10	14:20	14:27	14:33					
8						12:47	12:54	13:01	13:07	13:13	13:22	13:27	13:33	13:42	13:45	13:47	13:50	13:57	14:07	14:15	14:21	14:25	14:31	14:40	14:50	14:57	15:03					
9						13:17	13:24	13:31	13:37	13:43	13:52	13:57	14:03	14:12	14:15	14:17	14:20	14:27	14:37	14:45	14:51	14:55	15:01	15:10	15:20	15:27	15:33					
10						13:47	13:54	14:01	14:07	14:13	14:22	14:27	14:33	14:42	14:45	14:47	14:50	14:57	15:07	15:15	15:21	15:25	15:31	15:40	15:50	15:57	16:03					
19																15:02	15:05	15:12	15:22	15:30	15:36	15:40	15:46	15:55	16:05	16:12	16:18					
11						14:17	14:24	14:31	14:37	14:43	14:52	14:57	15:03	15:12	15:15	15:17	15:20	15:27	15:37	15:45	15:51	15:55	16:01	16:10	16:20	16:27	16:33					
22																15:32	15:35	15:42	15:52	16:00	16:06	16:10	16:16	16:25	16:35	16:42	16:48	16:49	16:57	17:03	17:12	17:19
20						14:47	14:54	15:01	15:07	15:13	15:22	15:27	15:33	15:42	15:45	15:47	15:50	15:57	16:07	16:15	16:21	16:25	16:31	16:40	16:50	16:57	17:03					
17																16:02	16:05	16:12	16:22	16:30	16:36	16:40	16:46	16:55	17:05	17:12	17:18					
14						15:17	15:24	15:31	15:37	15:43	15:52	15:57	16:03	16:12	16:15	16:17	16:20	16:27	16:37	16:45	16:51	16:55	17:01	17:10	17:20	17:27	17:33					

Table 69 - High Investment Scenario with Infill Stations Operating Plan - Southbound

Train	Brigham City	Willard	Pleasant View	Business District Ogden	Ogden Arrival	Ogden Departure	Roy	Sunset	Clearfield	Layton	Farmington	Centerville	Woods Cross	WS Relief	North Temple	North Temple	Salt Lake Central	Salt Lake Central	Murray	South Jordan	Draper	Bluffdale	Lehi	American Fork	Vineyard	Orem	Provo Arrival	Provo Departure	Springville	Spanish Fork	Payson	Santaquin
18																16:32	16:35	16:42	16:52	17:00	17:06	17:10	17:16	17:25	17:35	17:42	17:48	17:49	17:57	18:03	18:12	18:19
4						15:47	15:54	16:01	16:07	16:13	16:22	16:27	16:33	16:42	16:45	16:47	16:50	16:57	17:07	17:15	17:21	17:25	17:31	17:40	17:50	17:57	18:03					
21						16:02	16:09	16:16	16:22	16:28	16:37	16:42	16:48	16:57	17:00	17:02	17:05	17:12	17:22	17:30	17:36	17:40	17:46	17:55	18:05	18:12	18:18					
6						16:17	16:24	16:31	16:37	16:43	16:52	16:57	17:03	17:12	17:15	17:17	17:20	17:27	17:37	17:45	17:51	17:55	18:01	18:10	18:20	18:27	18:33					
2						16:32	16:39	16:46	16:52	16:58	17:07	17:12	17:18	17:27	17:30	17:32	17:35	17:42	17:52	18:00	18:06	18:10	18:16	18:25	18:35	18:42	18:48	18:49	18:57	19:03	19:12	19:19
16						16:47	16:54	17:01	17:07	17:13	17:22	17:27	17:33	17:42	17:45	17:47	17:50	17:57	18:07	18:15	18:21	18:25	18:31	18:40	18:50	18:57	19:03					
12	16:33	16:41	16:51	16:56	17:00	17:02	17:09	17:16	17:22	17:28	17:37	17:42	17:48	17:57	18:00	18:02	18:05	18:12	18:22	18:30	18:36	18:40	18:46	18:55	19:05	19:12	19:18					
7						17:17	17:24	17:31	17:37	17:43	17:52	17:57	18:03	18:12	18:15	18:17	18:20	18:27	18:37	18:45	18:51	18:55	19:01	19:10	19:20	19:27	19:33					
1						17:32	17:39	17:46	17:52	17:58	18:07	18:12	18:18	18:27	18:30	18:32	18:35	18:42	18:52	19:00	19:06	19:10	19:16	19:25	19:35	19:42	19:48	19:49	19:57	20:03	20:12	20:19
8						17:47	17:54	18:01	18:07	18:13	18:22	18:27	18:33	18:42	18:45	18:47	18:50															
13	17:33	17:41	17:51	17:56	18:00	18:02	18:09	18:16	18:22	18:28	18:37	18:42	18:48	18:57	19:00	19:02	19:05	19:12	19:22	19:30	19:36	19:40	19:46	19:55	20:05	20:12	20:18					
9						18:17	18:24	18:31	18:37	18:43	18:52	18:57	19:03	19:12	19:15	19:17	19:20															
15						18:32	18:39	18:46	18:52	18:58	19:07	19:12	19:18	19:27	19:30	19:32	19:35	19:42	19:52	20:00	20:06	20:10	20:16	20:25	20:35	20:42	20:48					
10						18:47	18:54	19:01	19:07	19:13	19:22	19:27	19:33	19:42	19:45	19:47	19:50															
3	18:33	18:41	18:51	18:56	19:00	19:02	19:09	19:16	19:22	19:28	19:37	19:42	19:48	19:57	20:00	20:02	20:05	20:12	20:22	20:30	20:36	20:40	20:46	20:55	21:05	21:12	21:18					
11						19:17	19:24	19:31	19:37	19:43	19:52	19:57	20:03	20:12	20:15	20:17	20:20															
5						19:32	19:39	19:46	19:52	19:58	20:07	20:12	20:18	20:27	20:30	20:32	20:35	20:42	20:52	21:00	21:06	21:10	21:16	21:25	21:35	21:42	21:48					
20						19:47	19:54	20:01	20:07	20:13	20:22	20:27	20:33	20:42	20:45	20:47	20:50															
19	19:33	19:41	19:51	19:56	20:00	20:02	20:09	20:16	20:22	20:28	20:37	20:42	20:48	20:57	21:00	21:02	21:05	21:12	21:22	21:30	21:36	21:40	21:46	21:55	22:05	22:12	22:18					
22						20:32	20:39	20:46	20:52	20:58	21:07	21:12	21:18	21:27	21:30	21:32	21:35	21:42	21:52	22:00	22:06	22:10	22:16	22:25	22:35	22:42	22:48					
21						21:02	21:09	21:16	21:22	21:28	21:37	21:42	21:48	21:57	22:00	22:02	22:05	22:12	22:22	22:30	22:36	22:40	22:46	22:55	23:05	23:12	23:18	23:19	23:27	23:33	23:42	23:49
18						21:32	21:39	21:46	21:52	21:58	22:07	22:12	22:18	22:27	22:30	22:32	22:35	22:42	22:52	23:00	23:06	23:10	23:16	23:25	23:35	23:42	23:48					
12						22:02	22:09	22:16	22:22	22:28	22:37	22:42	22:48	22:57	23:00	23:02	23:05	23:12	23:22	23:30	23:36	23:40	23:46	23:55	0:05	0:12	0:18					
2						22:32	22:39	22:46	22:52	22:58	23:07	23:12	23:18	23:27	23:30	23:32	23:35															

17 Appendix B Travel Time Results

17.1 Baseline Simulation Travel Time Results

Table 70 - Baseline Simulation Travel Time Results - Northbound

Northbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Scheduled Travel Time
Provo Central	Orem Central	40.03	0:07:57	41.24	0:07:43	39.35	0:08:06	40.96	0:07:46	40.43	0:07:53	40.39	0:07:53	0:08:00
Orem Central	American Fork	51.98	0:09:46	47.75	0:10:38	50.67	0:10:01	49.31	0:10:18	52.68	0:09:38	50.41	0:10:04	0:09:00
American Fork	Lehi	38.94	0:08:40	38.58	0:08:45	38.46	0:08:47	39.11	0:08:38	37.09	0:09:06	38.43	0:08:47	0:09:00
Lehi	Draper	45.06	0:09:56	49.00	0:09:09	47.75	0:09:23	45.61	0:09:49	48.77	0:09:11	47.18	0:09:30	0:09:00
Draper	South Jordan	34.98	0:05:40	36.14	0:05:29	35.91	0:05:31	35.31	0:05:36	36.41	0:05:26	35.74	0:05:32	0:05:00
South Jordan	Murray Central	45.78	0:08:54	44.88	0:09:05	46.90	0:08:42	42.77	0:09:32	44.81	0:09:06	44.99	0:09:04	0:08:00
Murray Central	Salt Lake Central	31.56	0:13:43	31.24	0:13:51	31.20	0:13:52	33.06	0:13:05	30.81	0:14:03	31.55	0:13:43	0:17:00
Salt Lake Central	North Temple	8.78	0:05:55	8.51	0:06:06	8.83	0:05:53	8.95	0:05:48	8.46	0:06:08	8.70	0:05:58	0:06:00
North Temple	Woods Cross	42.63	0:11:04	42.88	0:11:00	42.17	0:11:11	42.92	0:10:59	43.15	0:10:56	42.75	0:11:02	0:11:00
Woods Cross	Farmington	41.92	0:10:55	42.56	0:10:45	43.64	0:10:30	44.30	0:10:20	43.72	0:10:28	43.21	0:10:36	0:10:00
Farmington	Layton	42.14	0:08:28	42.46	0:08:24	41.47	0:08:36	41.82	0:08:31	41.69	0:08:33	41.91	0:08:30	0:08:00
Layton	Clearfield	37.46	0:05:54	36.08	0:06:07	34.02	0:06:30	35.46	0:06:14	35.27	0:06:16	35.62	0:06:12	0:07:00
Clearfield	Roy	45.32	0:09:08	45.34	0:09:07	46.33	0:08:56	46.35	0:08:56	47.69	0:08:41	46.19	0:08:58	0:08:00
Roy	Ogden	39.82	0:06:37	39.90	0:06:37	40.01	0:06:36	39.89	0:06:37	39.99	0:06:36	39.92	0:06:36	0:07:00
Ogden	Pleasant View	31.78	0:11:25	31.78	0:11:25	31.78	0:11:25	31.78	0:11:25	31.78	0:11:25	31.78	0:11:25	0:15:00

Notes:

All travel times are station leave to station leave except the following:

Orem to Provo – Orem leave time to Provo arrive time

Ogden to Pleasant View – Ogden arrive time to Pleasant View arrive time

Pleasant View to Ogden – Trips 3-08 and 4-08 run in the evening and have unusually long dwells at Ogden Station and do not have a corresponding revenue return trip in the morning. For this reason, these trains have been omitted from the results.

Table 71- Baseline Simulation Travel Time Results - Southbound

Southbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		
Starting Station	**Ending Station**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Scheduled Travel Time**
Pleasant View	Ogden	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	0:15:00
Ogden	Roy	29.03	0:09:07	29.40	0:09:00	29.24	0:09:02	28.63	0:09:14	29.36	0:09:00	29.13	0:09:05	0:08:00
Roy	Clearfield	46.20	0:08:57	48.11	0:08:35	46.62	0:08:52	48.57	0:08:30	45.36	0:09:07	46.94	0:08:48	0:09:00
Clearfield	Layton	35.78	0:06:11	35.87	0:06:10	33.79	0:06:32	35.25	0:06:16	36.49	0:06:03	35.41	0:06:14	0:06:00
Layton	Farmington	39.23	0:09:05	37.70	0:09:27	39.13	0:09:07	39.09	0:09:07	38.11	0:09:21	38.64	0:09:14	0:10:00
Farmington	Woods Cross	43.92	0:10:26	43.57	0:10:31	44.16	0:10:22	44.89	0:10:12	44.06	0:10:24	44.12	0:10:23	0:10:00
Woods Cross	North Temple	35.83	0:13:10	36.42	0:12:57	36.31	0:12:59	35.72	0:13:12	36.17	0:13:02	36.09	0:13:04	0:13:00
North Temple	Salt Lake Central	7.45	0:07:00	7.40	0:07:03	7.62	0:06:50	7.30	0:07:08	7.48	0:06:58	7.45	0:07:00	0:08:00
Salt Lake Central	Murray Central	34.05	0:12:42	31.61	0:13:41	34.12	0:12:41	31.01	0:13:57	33.93	0:12:45	32.89	0:13:09	0:11:00
Murray Central	South Jordan	45.38	0:08:59	47.82	0:08:32	44.05	0:09:15	46.01	0:08:52	47.20	0:08:38	46.05	0:08:51	0:08:00
South Jordan	Draper	38.96	0:05:05	38.35	0:05:10	39.57	0:05:00	40.19	0:04:56	39.02	0:05:04	39.21	0:05:03	0:06:00
Draper	Lehi	42.71	0:10:29	44.32	0:10:07	43.77	0:10:14	45.40	0:09:52	43.27	0:10:21	43.87	0:10:13	0:10:00
Lehi	American Fork	44.77	0:07:32	45.40	0:07:26	42.07	0:08:01	46.61	0:07:15	42.49	0:07:57	44.20	0:07:38	0:07:00
American Fork	Orem Central	46.53	0:10:55	46.51	0:10:55	46.20	0:10:59	45.99	0:11:02	46.30	0:10:58	46.30	0:10:58	0:12:00
Orem Central	Provo Central	46.27	0:06:53	46.50	0:06:51	46.48	0:06:51	46.33	0:06:52	46.50	0:06:51	46.41	0:06:52	0:07:00

Notes:

All travel times are station leave to station leave except the following:

Orem to Provo – Orem leave time to Provo arrive time

Ogden to Pleasant View – Ogden arrive time to Pleasant View arrive time

Pleasant View to Ogden – Trips 3-08 and 4-08 run in the evening and have unusually long dwells at Ogden Station and do not have a corresponding revenue return trip in the morning. For this reason, these trains have been omitted from the results.

17.2 Future Baseline Simulation Travel Time Results

Table 72 - Future Baseline Simulation Travel Time Results - Northbound

Northbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Scheduled Travel Time
Provo Central	Orem Central	35.06	0:09:05	35.01	0:09:06	35.38	0:09:00	33.88	0:09:24	35.25	0:09:02	34.91	0:09:07	0:09:00
Orem Central	American Fork	41.68	0:12:11	38.69	0:13:07	40.03	0:12:41	40.45	0:12:33	39.02	0:13:01	39.95	0:12:43	0:10:00
American Fork	Lehi	37.36	0:09:02	36.84	0:09:10	35.45	0:09:32	37.16	0:09:05	35.01	0:09:39	36.34	0:09:18	0:08:00
Lehi	Draper	45.50	0:09:51	45.77	0:09:47	47.98	0:09:20	44.85	0:09:59	46.83	0:09:34	46.16	0:09:42	0:10:00
Draper	South Jordan	34.38	0:05:46	34.96	0:05:40	34.82	0:05:41	34.17	0:05:48	34.92	0:05:40	34.65	0:05:43	0:06:00
South Jordan	Murray Central	45.50	0:08:58	46.15	0:08:50	47.20	0:08:38	41.43	0:09:50	48.60	0:08:23	45.64	0:08:56	0:09:00
Murray Central	Salt Lake Central	32.19	0:13:27	30.12	0:14:22	32.20	0:13:26	32.76	0:13:13	31.63	0:13:41	31.75	0:13:38	0:16:00
Salt Lake Central	North Temple	9.52	0:05:27	10.05	0:05:10	9.82	0:05:17	10.28	0:05:03	9.74	0:05:20	9.88	0:05:16	0:06:00
North Temple	Woods Cross	41.25	0:11:26	37.63	0:12:32	40.51	0:11:39	40.43	0:11:40	40.91	0:11:32	40.10	0:11:46	0:11:00
Woods Cross	Farmington	39.58	0:11:34	42.68	0:10:44	42.44	0:10:47	42.31	0:10:49	42.65	0:10:44	41.90	0:10:56	0:11:00
Farmington	Layton	39.80	0:08:57	41.08	0:08:41	39.44	0:09:02	39.75	0:08:58	38.71	0:09:12	39.74	0:08:58	0:09:00
Layton	Clearfield	35.67	0:06:12	37.32	0:05:55	39.11	0:05:39	38.53	0:05:44	39.28	0:05:37	37.94	0:05:49	0:05:00
Clearfield	Roy	47.95	0:08:38	49.33	0:08:23	46.58	0:08:53	47.81	0:08:39	48.25	0:08:35	47.97	0:08:38	0:09:00
Roy	Ogden	33.96	0:07:46	32.88	0:08:01	33.97	0:07:46	33.89	0:07:47	33.98	0:07:46	33.73	0:07:49	0:08:00
Ogden	Pleasant View	31.92	0:11:22	31.92	0:11:22	31.92	0:11:22	31.92	0:11:22	31.92	0:11:22	31.92	0:11:22	0:13:00

Notes:

All travel times are station leave to station leave except the following:

Orem to Provo – Orem leave time to Provo arrive time

Ogden to Pleasant View – Ogden arrive time to Pleasant View arrive time

Pleasant View to Ogden – Trips 10-06 and 2-07 run in the evening and have unusually long dwells at Ogden Station and do not have a corresponding revenue return trip in the morning. For this reason, these trains have been omitted from the results.

Table 73 - Future Baseline Simulation Travel Time Results - Southbound

Southbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Scheduled Travel Time
Pleasant View	Ogden	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	0:15:00
Ogden	Roy	27.37	0:09:40	27.70	0:09:33	28.66	0:09:13	28.12	0:09:24	27.54	0:09:36	27.87	0:09:29	0:09:00
Roy	Clearfield	44.23	0:09:21	43.59	0:09:29	44.74	0:09:14	45.14	0:09:09	45.31	0:09:07	44.59	0:09:16	0:09:00
Clearfield	Layton	32.60	0:06:47	31.26	0:07:04	30.21	0:07:19	31.17	0:07:05	32.38	0:06:49	31.50	0:07:01	0:07:00
Layton	Farmington	44.71	0:07:58	44.55	0:08:00	47.82	0:07:27	44.13	0:08:05	44.94	0:07:56	45.19	0:07:53	0:07:00
Farmington	Woods Cross	42.70	0:10:43	44.31	0:10:20	41.85	0:10:57	45.01	0:10:10	43.11	0:10:37	43.37	0:10:34	0:11:00
Woods Cross	North Temple	33.14	0:14:14	32.62	0:14:27	33.26	0:14:11	32.70	0:14:25	33.23	0:14:12	32.99	0:14:18	0:13:00
North Temple	Salt Lake Central	11.94	0:04:22	11.83	0:04:24	11.87	0:04:23	11.85	0:04:24	11.82	0:04:25	11.86	0:04:24	0:06:00
Salt Lake Central	Murray Central	32.76	0:13:12	33.00	0:13:07	32.60	0:13:16	32.76	0:13:12	34.18	0:12:40	33.05	0:13:05	0:12:00
Murray Central	South Jordan	43.95	0:09:17	44.56	0:09:09	46.01	0:08:52	38.43	0:10:37	44.18	0:09:14	43.26	0:09:26	0:09:00
South Jordan	Draper	38.17	0:05:11	34.14	0:05:48	33.91	0:05:50	34.69	0:05:42	34.35	0:05:46	34.98	0:05:40	0:05:00
Draper	Lehi	42.03	0:10:40	41.95	0:10:41	42.66	0:10:30	41.88	0:10:42	41.35	0:10:50	41.97	0:10:41	0:10:00
Lehi	American Fork	40.13	0:08:25	39.63	0:08:31	40.95	0:08:15	40.18	0:08:24	37.94	0:08:54	39.74	0:08:30	0:08:00
American Fork	Orem Central	46.28	0:10:58	47.65	0:10:39	47.18	0:10:46	47.19	0:10:46	46.83	0:10:51	47.02	0:10:48	0:12:00
Orem Central	Provo Central	39.67	0:08:02	39.82	0:08:00	39.54	0:08:03	39.89	0:07:59	39.89	0:07:59	39.76	0:08:01	0:08:00

Notes:

All travel times are station leave to station leave except the following:

Orem to Provo – Orem leave time to Provo arrive time

Ogden to Pleasant View – Ogden arrive time to Pleasant View arrive time

Pleasant View to Ogden – Trips 10-06 and 2-07 run in the evening and have unusually long dwells at Ogden Station and do not have a corresponding revenue return trip in the morning. For this reason, these trains have been omitted from the results.

17.3 Low Investment Scenario Simulation Travel Time Results

Table 74 - Low Investment Scenario Travel Time Results - Northbound

Northbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Scheduled Travel Time
Payson	Spanish Fork	47.60	0:09:50	47.60	0:09:50	47.60	0:09:50	47.60	0:09:50	47.60	0:09:50	47.60	0:09:50	0:09:00
Spanish Fork	Springville	36.61	0:06:14	33.32	0:06:51	41.58	0:05:29	35.08	0:06:30	32.83	0:06:57	35.62	0:06:24	0:06:00
Springville	Provo Central	28.72	0:10:23	29.76	0:10:01	28.58	0:10:26	28.59	0:10:25	28.88	0:10:19	28.90	0:10:19	0:10:00
Provo Central	Orem Central	39.34	0:08:06	39.78	0:08:00	40.55	0:07:51	38.00	0:08:23	39.85	0:07:59	39.48	0:08:04	0:08:00
Orem Central	Vineyard	26.59	0:05:49	26.67	0:05:48	26.04	0:05:56	26.09	0:05:56	27.21	0:05:41	26.52	0:05:50	0:06:00
Vineyard	American Fork	45.96	0:07:41	49.81	0:07:05	50.28	0:07:01	45.37	0:07:47	46.23	0:07:38	47.44	0:07:27	0:06:00
American Fork	Lehi	40.76	0:08:17	39.03	0:08:39	41.91	0:08:04	40.52	0:08:20	38.32	0:08:49	40.07	0:08:26	0:08:00
Lehi	Draper	46.89	0:09:33	46.73	0:09:35	46.08	0:09:43	46.57	0:09:37	47.66	0:09:24	46.78	0:09:35	0:10:00
Draper	South Jordan	34.06	0:05:49	34.64	0:05:43	33.81	0:05:51	33.67	0:05:53	33.71	0:05:52	33.97	0:05:50	0:06:00
South Jordan	Murray Central	47.58	0:08:34	47.01	0:08:40	48.17	0:08:28	44.10	0:09:15	47.46	0:08:35	46.82	0:08:42	0:08:00
Murray Central	Salt Lake Central	33.82	0:12:48	30.26	0:14:18	31.98	0:13:32	34.05	0:12:43	33.14	0:13:04	32.59	0:13:17	0:15:00
Salt Lake Central	North Temple	9.41	0:05:31	9.89	0:05:15	9.66	0:05:23	10.39	0:05:00	9.76	0:05:19	9.81	0:05:18	0:06:00
North Temple	Woods Cross	39.39	0:11:59	39.04	0:12:05	38.65	0:12:12	39.70	0:11:53	39.41	0:11:58	39.23	0:12:01	0:12:00
Woods Cross	Farmington	41.09	0:11:09	42.33	0:10:49	40.60	0:11:17	43.57	0:10:31	42.41	0:10:48	41.97	0:10:55	0:11:00
Farmington	Layton	39.87	0:08:56	39.99	0:08:55	39.20	0:09:06	40.20	0:08:52	39.16	0:09:06	39.68	0:08:59	0:09:00
Layton	Clearfield	38.03	0:05:49	36.68	0:06:01	35.70	0:06:11	39.10	0:05:39	36.03	0:06:08	37.07	0:05:58	0:05:00
Clearfield	Roy	47.41	0:08:44	48.63	0:08:30	48.15	0:08:36	48.97	0:08:27	47.09	0:08:47	48.04	0:08:37	0:09:00
Roy	Ogden	33.13	0:07:58	33.12	0:07:58	33.14	0:07:58	33.08	0:07:58	33.08	0:07:58	33.11	0:07:58	0:10:00
Ogden	Pleasant View	38.60	0:09:24	38.60	0:09:24	38.60	0:09:24	38.60	0:09:24	38.60	0:09:24	38.60	0:09:24	0:13:00

Notes:
All travel times are station leave to station leave except the following:
Orem to Provo – Orem leave time to Provo arrive time (except trains to Payson)
Ogden to Pleasant View – Ogden arrive time to Pleasant View arrive time
Pleasant View to Ogden – Trips 10-06 and 5-03 run in the evening and have unusually long dwells at Ogden Station and do not have a corresponding revenue return trip in the morning. For this reason, these trains have been omitted from the results.

Table 75 - Low Investment Scenario Travel Time Results - Southbound

Southbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		Scheduled Travel Time
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	
Pleasant View	Ogden	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	0:15:00
Ogden	Roy	27.68	0:09:33	28.10	0:09:25	27.89	0:09:29	27.35	0:09:40	27.38	0:09:39	27.67	0:09:33	0:09:00
Roy	Clearfield	45.45	0:09:05	44.43	0:09:18	45.77	0:09:02	45.14	0:09:09	45.23	0:09:08	45.20	0:09:08	0:09:00
Clearfield	Layton	31.80	0:06:57	32.27	0:06:51	30.52	0:07:14	32.38	0:06:49	32.95	0:06:42	31.96	0:06:55	0:07:00
Layton	Farmington	46.53	0:07:40	44.58	0:08:00	43.54	0:08:11	46.46	0:07:40	45.10	0:07:54	45.21	0:07:53	0:07:00
Farmington	Woods Cross	45.17	0:10:08	47.56	0:09:38	47.26	0:09:41	46.39	0:09:52	44.03	0:10:24	46.05	0:09:57	0:10:00
Woods Cross	North Temple	32.83	0:14:22	32.76	0:14:24	32.84	0:14:22	32.76	0:14:24	32.81	0:14:23	32.80	0:14:23	0:14:00
North Temple	Salt Lake Central	10.79	0:04:50	10.71	0:04:52	10.93	0:04:46	10.87	0:04:48	11.03	0:04:44	10.87	0:04:48	0:06:00
Salt Lake Central	Murray Central	35.79	0:12:05	34.10	0:12:41	36.64	0:11:48	36.24	0:11:56	35.96	0:12:02	35.72	0:12:07	0:12:00
Murray Central	South Jordan	43.67	0:09:20	45.58	0:08:57	45.99	0:08:52	40.82	0:09:59	45.96	0:08:52	44.31	0:09:12	0:09:00
South Jordan	Draper	34.91	0:05:40	34.35	0:05:46	34.69	0:05:42	35.02	0:05:39	33.64	0:05:53	34.52	0:05:44	0:06:00
Draper	Lehi	41.78	0:10:43	42.76	0:10:29	43.01	0:10:25	44.14	0:10:09	44.22	0:10:08	43.16	0:10:23	0:09:00
Lehi	American Fork	39.07	0:08:38	39.65	0:08:31	40.00	0:08:26	38.41	0:08:47	38.53	0:08:46	39.13	0:08:38	0:09:00
American Fork	Vineyard	39.98	0:08:52	39.59	0:08:57	39.49	0:08:58	39.39	0:09:00	39.84	0:08:53	39.66	0:08:56	0:09:00
Vineyard	Orem Central	33.87	0:04:32	32.55	0:04:43	35.01	0:04:23	32.53	0:04:43	34.55	0:04:27	33.67	0:04:34	0:04:00
Orem Central	Provo Central	38.78	0:08:13	38.82	0:08:12	38.81	0:08:12	38.24	0:08:20	38.16	0:08:21	38.56	0:08:16	0:10:00
Provo Central	Springville	34.39	0:08:34	37.53	0:07:51	33.09	0:08:54	34.17	0:08:37	35.43	0:08:19	34.86	0:08:27	0:10:00
Springville	Spanish Fork	38.75	0:05:53	39.54	0:05:46	38.37	0:05:56	38.75	0:05:53	38.75	0:05:53	38.83	0:05:52	0:06:00
Spanish Fork	Payson	50.20	0:09:25	50.20	0:09:25	50.20	0:09:25	50.20	0:09:25	50.20	0:09:25	50.20	0:09:25	0:10:00

Notes:
All travel times are station leave to station leave except the following:
Orem to Provo – Orem leave time to Provo arrive time (except trains to Payson)
Ogden to Pleasant View – Ogden arrive time to Pleasant View arrive time
Pleasant View to Ogden – Trips 10-06 and 5-03 run in the evening and have unusually long dwells at Ogden Station and do not have a corresponding revenue return trip in the morning. For this reason, these trains have been omitted from the results.

17.4 Medium Investment Scenario Simulation Travel Time Results

Table 76 - Medium Investment Scenario Travel Time Results - Northbound

Northbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Scheduled Travel Time
Payson	Spanish Fork	46.93	0:09:58	46.93	0:09:58	46.93	0:09:58	46.93	0:09:58	46.93	0:09:58	46.93	0:09:58	0:09:00
Spanish Fork	Springville	40.38	0:05:39	40.38	0:05:39	40.38	0:05:39	40.38	0:05:39	40.38	0:05:39	40.38	0:05:39	0:06:00
Springville	Provo Central	19.93	0:14:57	19.99	0:14:54	19.04	0:15:39	19.04	0:15:39	19.60	0:15:13	19.51	0:15:17	0:10:00
Provo Central	Orem Central	39.50	0:08:04	39.68	0:08:02	39.25	0:08:07	38.12	0:08:21	39.25	0:08:07	39.15	0:08:08	0:08:00
Orem Central	Vineyard	29.52	0:05:14	29.81	0:05:11	29.84	0:05:11	29.61	0:05:13	29.70	0:05:12	29.69	0:05:13	0:05:00
Vineyard	American Fork	46.41	0:07:37	46.14	0:07:39	45.58	0:07:45	45.86	0:07:42	46.25	0:07:38	46.04	0:07:40	0:08:00
American Fork	Lehi	29.39	0:11:29	26.82	0:12:35	29.36	0:11:30	27.46	0:12:18	24.96	0:13:32	27.49	0:12:17	0:10:00
Lehi	Draper	32.80	0:13:39	32.00	0:14:00	31.81	0:14:05	33.04	0:13:33	32.70	0:13:42	32.46	0:13:48	0:15:00
Draper	South Jordan	25.43	0:07:47	27.96	0:07:05	25.79	0:07:41	16.17	0:12:15	27.14	0:07:18	23.53	0:08:25	0:08:00
South Jordan	Murray Central	38.09	0:10:42	40.77	0:10:00	38.29	0:10:39	32.01	0:12:44	40.41	0:10:05	37.63	0:10:50	0:10:00
Murray Central	Salt Lake Central	30.69	0:14:06	30.21	0:14:20	30.52	0:14:11	31.92	0:13:34	30.82	0:14:03	30.82	0:14:02	0:14:00
Salt Lake Central	North Temple	10.67	0:04:52	10.98	0:04:44	10.97	0:04:44	11.11	0:04:41	10.84	0:04:47	10.91	0:04:46	0:04:00
North Temple	Woods Cross	38.48	0:12:16	38.98	0:12:06	38.51	0:12:15	38.52	0:12:15	38.30	0:12:19	38.56	0:12:14	0:12:00
Woods Cross	Farmington	47.70	0:09:36	44.53	0:10:17	47.78	0:09:35	44.80	0:10:13	47.01	0:09:44	46.32	0:09:53	0:08:00
Farmington	Layton	42.75	0:08:20	42.39	0:08:25	42.18	0:08:27	42.67	0:08:21	42.65	0:08:21	42.53	0:08:23	0:09:00
Layton	Clearfield	35.56	0:06:13	35.77	0:06:11	35.15	0:06:17	34.97	0:06:19	34.13	0:06:28	35.10	0:06:18	0:07:00
Clearfield	Roy	43.55	0:09:30	44.86	0:09:13	44.49	0:09:18	45.42	0:09:07	43.86	0:09:26	44.43	0:09:19	0:10:00
Roy	Ogden	28.48	0:09:16	29.76	0:08:52	28.44	0:09:16	29.35	0:08:59	28.84	0:09:09	28.97	0:09:06	0:09:00
Ogden	Pleasant View	37.47	0:09:41	37.27	0:09:44	37.47	0:09:41	37.47	0:09:41	37.47	0:09:41	37.43	0:09:42	0:15:00

Notes:

All travel times are station leave to station leave except the following:

Orem to Provo – Orem leave time to Provo arrive time (except trains to Payson)

Ogden to Pleasant View – Ogden arrive time to Pleasant View arrive time

Pleasant View to Ogden – Trips 8-05 and 20-05 run in the evening and have unusually long dwells at Ogden Station and do not have a corresponding revenue return trip in the morning. For this reason, these trains have been omitted from the results.

Table 77 - Medium Investment Scenario Travel Time Results - Southbound

Southbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Scheduled Travel Time
Pleasant View	Ogden	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	0:15:00
Ogden	Roy	33.79	0:07:49	33.43	0:07:54	34.12	0:07:45	33.90	0:07:48	33.61	0:07:52	33.77	0:07:50	0:07:00
Roy	Clearfield	36.55	0:11:18	36.70	0:11:15	36.64	0:11:17	38.03	0:10:52	36.76	0:11:14	36.93	0:11:11	0:12:00
Clearfield	Layton	35.78	0:06:11	35.36	0:06:15	34.28	0:06:27	35.60	0:06:12	36.06	0:06:08	35.40	0:06:14	0:06:00
Layton	Farmington	39.53	0:09:01	40.08	0:08:54	39.68	0:08:59	39.70	0:08:59	39.52	0:09:01	39.70	0:08:59	0:09:00
Farmington	Woods Cross	42.87	0:10:41	42.90	0:10:40	43.15	0:10:37	41.02	0:11:10	42.19	0:10:51	42.41	0:10:48	0:10:00
Woods Cross	North Temple	30.52	0:15:27	30.83	0:15:18	31.12	0:15:09	31.75	0:14:51	31.28	0:15:05	31.10	0:15:10	0:14:00
North Temple	Salt Lake Central	6.90	0:07:33	6.98	0:07:28	6.94	0:07:30	7.47	0:06:58	6.91	0:07:32	7.03	0:07:25	0:04:00
Salt Lake Central	Murray Central	34.32	0:12:36	30.37	0:14:15	35.42	0:12:13	35.34	0:12:14	35.94	0:12:02	34.15	0:12:40	0:10:00
Murray Central	South Jordan	37.78	0:10:48	37.81	0:10:47	41.52	0:09:49	25.68	0:15:53	40.37	0:10:06	35.53	0:11:28	0:08:00
South Jordan	Draper	27.31	0:07:15	27.89	0:07:06	25.43	0:07:47	28.56	0:06:56	24.95	0:07:56	26.75	0:07:24	0:11:00
Draper	Lehi	33.56	0:13:21	35.58	0:12:36	35.59	0:12:35	36.00	0:12:27	34.13	0:13:08	34.95	0:12:49	0:11:00
Lehi	American Fork	34.05	0:09:55	31.55	0:10:42	34.16	0:09:53	31.81	0:10:37	31.09	0:10:51	32.48	0:10:24	0:09:00
American Fork	Vineyard	40.72	0:08:42	42.17	0:08:24	40.13	0:08:50	42.65	0:08:18	41.46	0:08:33	41.40	0:08:33	0:10:00
Vineyard	Orem Central	25.79	0:05:57	26.69	0:05:45	24.80	0:06:11	27.75	0:05:32	25.58	0:06:00	26.08	0:05:53	0:07:00
Orem Central	Provo Central	38.43	0:08:17	38.95	0:08:10	38.29	0:08:19	39.16	0:08:08	38.78	0:08:13	38.72	0:08:13	0:07:00
Provo Central	Springville	31.28	0:09:25	32.85	0:08:58	31.42	0:09:23	31.48	0:09:21	31.48	0:09:21	31.69	0:09:18	0:09:00
Springville	Spanish Fork	39.04	0:05:50	39.77	0:05:44	38.35	0:05:57	38.35	0:05:57	39.04	0:05:50	38.90	0:05:52	0:06:00
Spanish Fork	Payson	49.42	0:09:34	49.42	0:09:34	49.42	0:09:34	49.42	0:09:34	49.42	0:09:34	49.42	0:09:34	0:09:00

Notes:

All travel times are station leave to station leave except the following:

Orem to Provo – Orem leave time to Provo arrive time (except trains to Payson)

Ogden to Pleasant View – Ogden arrive time to Pleasant View arrive time

Pleasant View to Ogden – Trips 8-05 and 20-05 run in the evening and have unusually long dwells at Ogden Station and do not have a corresponding revenue return trip in the morning. For this reason, these trains have been omitted from the results.

17.5 High Investment Scenario Simulation Travel Time Results

Table 78 - High Investment Scenario Travel Time Results - Northbound

Northbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Scheduled Travel Time
Payson	Spanish Fork	46.88	0:09:59	46.88	0:09:59	46.88	0:09:59	46.88	0:09:59	46.88	0:09:59	46.88	0:09:59	0:09:00
Spanish Fork	Springville	39.77	0:05:44	39.77	0:05:44	39.77	0:05:44	39.77	0:05:44	39.77	0:05:44	39.77	0:05:44	0:05:00
Springville	Provo Central	24.76	0:12:02	24.76	0:12:02	24.76	0:12:02	24.76	0:12:02	24.76	0:12:02	24.76	0:12:02	0:10:00
Provo Central	Orem Central	36.82	0:08:39	38.28	0:08:19	36.86	0:08:38	36.30	0:08:46	37.36	0:08:31	37.11	0:08:35	0:08:00
Orem Central	Vineyard	34.53	0:04:29	32.85	0:04:42	34.39	0:04:30	32.68	0:04:44	33.59	0:04:36	33.59	0:04:36	0:05:00
Vineyard	American Fork	47.85	0:07:23	43.57	0:08:06	49.42	0:07:09	44.81	0:07:53	47.38	0:07:27	46.51	0:07:36	0:07:00
American Fork	Lehi	33.86	0:09:58	32.08	0:10:32	33.33	0:10:08	32.96	0:10:15	31.09	0:10:52	32.64	0:10:21	0:10:00
Lehi	Draper	37.81	0:11:51	39.12	0:11:27	38.77	0:11:33	39.30	0:11:24	39.25	0:11:25	38.84	0:11:32	0:12:00
Draper	South Jordan	31.71	0:06:15	35.71	0:05:33	33.35	0:05:56	26.43	0:07:30	33.99	0:05:49	31.89	0:06:13	0:06:00
South Jordan	Murray Central	44.31	0:09:12	43.02	0:09:29	44.94	0:09:04	36.89	0:11:03	44.93	0:09:05	42.58	0:09:35	0:09:00
Murray Central	Salt Lake Central	32.28	0:13:24	32.68	0:13:14	31.08	0:13:56	33.62	0:12:52	32.19	0:13:27	32.35	0:13:23	0:14:00
Salt Lake Central	North Temple	12.32	0:04:13	12.67	0:04:06	12.34	0:04:13	12.14	0:04:17	12.18	0:04:16	12.33	0:04:13	0:04:00
North Temple	Woods Cross	41.29	0:11:25	41.38	0:11:24	40.07	0:11:46	40.89	0:11:32	40.85	0:11:33	40.89	0:11:32	0:12:00
Woods Cross	Farmington	56.05	0:08:10	55.80	0:08:12	57.10	0:08:01	57.53	0:07:58	57.26	0:08:00	56.74	0:08:04	0:08:00
Farmington	Layton	41.84	0:08:31	43.00	0:08:17	41.43	0:08:36	42.30	0:08:26	41.28	0:08:38	41.96	0:08:30	0:09:00
Layton	Clearfield	32.46	0:06:48	32.70	0:06:45	32.18	0:06:52	33.35	0:06:38	32.19	0:06:52	32.57	0:06:47	0:07:00
Clearfield	Roy	41.64	0:09:56	42.32	0:09:47	40.78	0:10:09	42.23	0:09:48	41.17	0:10:03	41.62	0:09:56	0:10:00
Roy	Ogden	29.36	0:08:59	30.11	0:08:46	29.52	0:08:56	29.89	0:08:50	29.37	0:08:59	29.65	0:08:54	0:09:00
Ogden	Pleasant View	39.91	0:09:05	39.58	0:09:10	39.91	0:09:05	39.91	0:09:05	39.91	0:09:05	39.84	0:09:06	0:14:00

Notes:
Payson Extension – Assume five minute transfer time for trips continuing on to or coming from the Payson Extension
All travel times are station leave to station leave except the following:
Orem to Provo – Orem leave time to Provo arrive time
Ogden to Pleasant View – Ogden arrive time to Pleasant View arrive time
Pleasant View to Ogden – Trips 10-07 and 20-07 run in the evening and have unusually long dwells at Ogden Station and do not have a corresponding revenue return trip in the morning. For this reason, these trains have been omitted from the results.

Table 79 - High Investment Scenario Travel Time Results - Southbound

Southbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Scheduled Travel Time
Pleasant View	Ogden	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	0:15:00
Ogden	Roy	36.52	0:07:14	36.66	0:07:13	36.68	0:07:12	36.66	0:07:13	35.80	0:07:23	36.46	0:07:15	0:07:00
Roy	Clearfield	34.96	0:11:49	34.51	0:11:58	34.78	0:11:53	35.37	0:11:41	35.27	0:11:43	34.97	0:11:49	0:12:00
Clearfield	Layton	36.42	0:06:04	36.09	0:06:07	35.19	0:06:17	36.25	0:06:06	36.56	0:06:03	36.10	0:06:07	0:06:00
Layton	Farmington	39.78	0:08:58	40.21	0:08:52	40.05	0:08:54	39.76	0:08:58	39.57	0:09:00	39.87	0:08:56	0:09:00
Farmington	Woods Cross	44.60	0:10:16	43.82	0:10:27	44.98	0:10:11	45.21	0:10:08	45.59	0:10:03	44.83	0:10:13	0:10:00
Woods Cross	North Temple	34.07	0:13:50	33.26	0:14:11	34.02	0:13:52	33.80	0:13:57	33.96	0:13:53	33.82	0:13:57	0:14:00
North Temple	Salt Lake Central	5.95	0:08:46	6.12	0:08:31	5.98	0:08:43	6.00	0:08:41	5.92	0:08:48	5.99	0:08:42	0:10:00
Salt Lake Central	Murray Central	41.03	0:10:33	32.00	0:13:31	42.34	0:10:13	36.49	0:11:51	40.57	0:10:40	38.08	0:11:22	0:10:00
Murray Central	South Jordan	44.14	0:09:14	46.75	0:08:43	47.26	0:08:38	35.11	0:11:37	46.18	0:08:50	43.35	0:09:24	0:08:00
South Jordan	Draper	40.24	0:04:55	40.82	0:04:51	38.42	0:05:09	41.67	0:04:45	38.75	0:05:07	39.94	0:04:57	0:06:00
Draper	Lehi	43.48	0:10:18	38.48	0:11:39	42.35	0:10:35	42.37	0:10:35	41.59	0:10:46	41.58	0:10:47	0:10:00
Lehi	American Fork	39.69	0:08:30	38.18	0:08:51	39.47	0:08:33	39.20	0:08:37	37.91	0:08:54	38.88	0:08:41	0:09:00
American Fork	Vineyard	36.67	0:09:40	38.43	0:09:13	36.23	0:09:47	37.68	0:09:24	36.91	0:09:36	37.17	0:09:32	0:10:00
Vineyard	Orem Central	22.27	0:06:54	25.15	0:06:06	22.08	0:06:57	24.80	0:06:11	22.90	0:06:42	23.37	0:06:34	0:07:00
Orem Central	Provo Central	45.54	0:07:00	45.62	0:06:59	45.54	0:07:00	45.45	0:07:00	45.39	0:07:01	45.51	0:07:00	0:05:00
Provo Central	Springville	25.85	0:11:24	25.85	0:11:24	25.85	0:11:24	25.85	0:11:24	25.85	0:11:24	25.85	0:11:24	0:09:00
Springville	Spanish Fork	39.16	0:05:49	39.16	0:05:49	39.16	0:05:49	39.16	0:05:49	39.16	0:05:49	39.16	0:05:49	0:06:00
Spanish Fork	Payson	49.42	0:09:34	49.42	0:09:34	49.42	0:09:34	49.42	0:09:34	49.42	0:09:34	49.42	0:09:34	0:09:00

Notes:
Payson Extension – Assume five minute transfer time for trips continuing on to or coming from the Payson Extension
All travel times are station leave to station leave except the following:
Orem to Provo – Orem leave time to Provo arrive time
Ogden to Pleasant View – Ogden arrive time to Pleasant View arrive time
Pleasant View to Ogden – Trips 10-07 and 20-07 run in the evening and have unusually long dwells at Ogden Station and do not have a corresponding revenue return trip in the morning. For this reason, these trains have been omitted from the results.

17.6 High Investment with Infill Stations Scenario Simulation Travel Time Results

Table 80 - High Investment with Infill Stations Scenario Travel Time Results - Northbound

Northbound		Day 1		Day 2		Day 3		Day 4		Day 5		5 Day Average		
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Scheduled Travel Time
Santaquin	Payson	45.15	0:06:17	45.23	0:06:17	45.15	0:06:17	45.15	0:06:17	45.15	0:06:17	45.17	0:06:17	0:05:00
Payson	Spanish Fork	58.87	0:08:02	59.72	0:07:55	58.87	0:08:02	58.87	0:08:02	58.87	0:08:02	59.04	0:08:00	0:09:00
Spanish Fork	Springville	34.11	0:06:41	35.89	0:06:21	34.11	0:06:41	34.11	0:06:41	35.63	0:06:24	34.75	0:06:34	0:07:00
Springville	Provo Central	30.67	0:09:36	31.68	0:09:18	31.28	0:09:25	31.31	0:09:24	31.47	0:09:21	31.28	0:09:25	0:09:00
Provo Central	Orem Central	37.27	0:08:33	38.90	0:08:11	37.33	0:08:32	38.04	0:08:22	37.25	0:08:33	37.75	0:08:26	0:08:00
Orem Central	Vineyard	27.32	0:05:37	29.20	0:05:15	27.48	0:05:35	27.65	0:05:33	27.15	0:05:39	27.74	0:05:32	0:06:00
Vineyard	American Fork	42.44	0:08:21	43.46	0:08:09	44.07	0:08:02	44.15	0:08:01	42.52	0:08:20	43.31	0:08:11	0:07:00
American Fork	Lehi	37.45	0:09:01	38.28	0:08:49	37.44	0:09:01	35.87	0:09:25	36.66	0:09:13	37.12	0:09:06	0:09:00
Lehi	Bluffdale	38.33	0:08:16	38.77	0:08:11	39.24	0:08:05	38.29	0:08:17	38.91	0:08:09	38.70	0:08:12	0:08:00
Bluffdale	Draper	33.29	0:03:56	31.78	0:04:07	32.12	0:04:05	34.66	0:03:47	30.74	0:04:16	32.46	0:04:02	0:05:00
Draper	South Jordan	34.63	0:05:43	32.90	0:06:01	34.60	0:05:43	33.16	0:05:58	34.70	0:05:42	33.98	0:05:50	0:06:00
South Jordan	Murray Central	45.67	0:08:56	40.34	0:10:06	45.10	0:09:02	36.41	0:11:12	45.41	0:08:59	42.25	0:09:39	0:09:00
Murray Central	Salt Lake Central	32.38	0:13:22	32.49	0:13:19	31.79	0:13:37	34.27	0:12:38	32.56	0:13:17	32.68	0:13:14	0:14:00
Salt Lake Central	North Temple	12.82	0:04:04	12.67	0:04:07	12.68	0:04:07	12.80	0:04:04	12.43	0:04:12	12.68	0:04:07	0:04:00
North Temple	Woods Cross	40.07	0:11:46	41.09	0:11:29	40.02	0:11:47	40.63	0:11:36	40.57	0:11:37	40.47	0:11:39	0:12:00
Woods Cross	Centerville	29.28	0:04:48	31.17	0:04:31	29.17	0:04:49	31.43	0:04:28	29.42	0:04:47	30.06	0:04:41	0:05:00
Centerville	Farmington	56.06	0:05:40	56.57	0:05:37	57.21	0:05:33	54.72	0:05:48	55.89	0:05:41	56.08	0:05:40	0:04:00
Farmington	Layton	47.00	0:07:35	47.43	0:07:31	46.17	0:07:43	48.18	0:07:24	46.63	0:07:39	47.07	0:07:34	0:09:00
Layton	Clearfield	42.37	0:05:13	44.08	0:05:01	44.46	0:04:58	44.60	0:04:57	42.91	0:05:09	43.67	0:05:04	0:05:00
Clearfield	Sunset	41.08	0:04:42	40.50	0:04:46	40.67	0:04:44	40.96	0:04:42	38.61	0:05:00	40.34	0:04:47	0:05:00
Sunset	Roy	28.04	0:07:52	27.99	0:07:52	27.72	0:07:57	29.30	0:07:31	28.56	0:07:43	28.31	0:07:47	0:08:00
Roy	Ogden	34.33	0:07:37	34.34	0:07:37	34.33	0:07:37	34.32	0:07:37	34.33	0:07:37	34.33	0:07:37	0:09:00
Ogden	Business District Ogden	34.27	0:04:40	34.27	0:04:39	34.27	0:04:40	34.27	0:04:40	34.27	0:04:40	34.27	0:04:39	0:05:00
Business District Ogden	Pleasant View	41.84	0:04:57	41.84	0:04:57	41.84	0:04:57	41.84	0:04:57	41.84	0:04:57	41.84	0:04:57	0:05:00
Pleasant View	Willard	49.16	0:10:24	50.10	0:10:12	49.16	0:10:24	49.16	0:10:24	49.16	0:10:24	49.35	0:10:22	0:11:00
Willard	Brigham City	64.82	0:05:46	64.82	0:05:46	64.82	0:05:46	64.82	0:05:46	64.82	0:05:46	64.82	0:05:46	0:09:00

Notes:
All travel times are station leave to station leave except the following:
Roy to Ogden – Roy leave time to Ogden arrive time
Orem to Provo – Orem leave time to Provo arrive time (except trains to Santaquin)
Ogden to Brigham City – Ogden arrive time to Brigham City arrive time

Table 81 - High Investment with Infill Stations Scenario Travel Time Results - Southbound

Southbound		**Day 1**		**Day 2**		**Day 3**		**Day 4**		**Day 5**		**5 Day Average**		
Starting Station	**Ending Station**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Scheduled Travel Time**
Brigham City	Willard	46.72	0:08:00	46.72	0:08:00	46.72	0:08:00	46.72	0:08:00	46.72	0:08:00	46.72	0:08:00	0:08:00
Willard	Pleasant View	51.12	0:10:00	51.12	0:10:00	51.12	0:10:00	51.12	0:10:00	51.12	0:10:00	51.12	0:10:00	0:10:00
Pleasant View	Business District Ogden	41.37	0:05:00	36.54	0:05:40	41.37	0:05:00	41.37	0:05:00	41.37	0:05:00	40.31	0:05:08	0:05:00
Business District Ogden	Ogden	27.40	0:05:50	27.59	0:05:47	27.40	0:05:50	27.40	0:05:50	27.40	0:05:50	27.44	0:05:49	0:06:00
Ogden	Roy	31.54	0:08:18	32.68	0:08:00	31.81	0:08:14	32.89	0:07:57	31.80	0:08:14	32.13	0:08:09	0:07:00
Roy	Sunset	32.59	0:06:46	31.93	0:06:54	31.63	0:06:58	31.34	0:07:02	31.81	0:06:56	31.85	0:06:55	0:07:00
Sunset	Clearfield	32.02	0:06:01	32.41	0:05:57	32.48	0:05:56	33.06	0:05:50	31.20	0:06:11	32.22	0:05:59	0:06:00
Clearfield	Layton	38.50	0:05:44	38.32	0:05:46	37.16	0:05:57	38.43	0:05:45	38.73	0:05:42	38.22	0:05:47	0:06:00
Layton	Farmington	40.82	0:08:44	41.31	0:08:38	41.98	0:08:30	41.58	0:08:34	40.98	0:08:42	41.33	0:08:37	0:09:00
Farmington	Centerville	45.21	0:07:01	42.39	0:07:29	45.30	0:07:00	43.12	0:07:22	44.68	0:07:06	44.11	0:07:12	0:05:00
Centerville	Woods Cross	35.31	0:03:59	34.60	0:04:04	36.41	0:03:52	36.38	0:03:52	35.75	0:03:56	35.68	0:03:56	0:06:00
Woods Cross	North Temple	31.84	0:14:49	32.24	0:14:38	32.19	0:14:39	31.46	0:14:59	32.69	0:14:26	32.08	0:14:42	0:14:00
North Temple	Salt Lake Central	6.89	0:07:34	6.76	0:07:43	6.79	0:07:41	7.02	0:07:25	6.74	0:07:44	6.84	0:07:37	0:10:00
Salt Lake Central	Murray Central	41.18	0:10:30	35.51	0:12:11	42.48	0:10:11	36.73	0:11:47	41.43	0:10:27	39.26	0:11:01	0:10:00
Murray Central	South Jordan	44.87	0:09:05	46.86	0:08:42	46.48	0:08:46	33.62	0:12:08	47.09	0:08:39	43.06	0:09:28	0:08:00
South Jordan	Draper	40.73	0:04:52	39.61	0:05:00	38.39	0:05:09	42.43	0:04:40	39.49	0:05:01	40.08	0:04:56	0:06:00
Draper	Bluffdale	34.52	0:03:48	32.64	0:04:01	34.56	0:03:47	35.86	0:03:39	34.39	0:03:49	34.36	0:03:49	0:04:00
Bluffdale	Lehi	40.57	0:07:49	37.99	0:08:21	41.14	0:07:42	37.29	0:08:30	41.07	0:07:43	39.54	0:08:01	0:06:00
Lehi	American Fork	43.86	0:07:42	42.26	0:07:59	43.99	0:07:40	44.02	0:07:40	40.83	0:08:16	42.95	0:07:52	0:09:00
American Fork	Vineyard	37.72	0:09:24	37.33	0:09:29	36.72	0:09:39	38.51	0:09:12	36.76	0:09:38	37.40	0:09:28	0:10:00
Vineyard	Orem Central	22.74	0:06:45	23.99	0:06:24	22.71	0:06:46	24.84	0:06:11	23.10	0:06:39	23.45	0:06:33	0:07:00
Orem Central	Provo Central	44.73	0:07:07	45.03	0:07:04	44.58	0:07:09	44.81	0:07:06	44.89	0:07:06	44.81	0:07:06	0:06:00
Provo Central	Springville	38.48	0:07:39	38.26	0:07:42	39.02	0:07:33	39.71	0:07:25	38.32	0:07:41	38.75	0:07:36	0:09:00
Springville	Spanish Fork	40.71	0:05:36	41.56	0:05:29	38.60	0:05:54	39.55	0:05:46	39.54	0:05:46	39.97	0:05:42	0:06:00
Spanish Fork	Payson	40.71	0:05:36	41.56	0:05:29	38.60	0:05:54	39.55	0:05:46	39.54	0:05:46	54.96	0:08:36	0:09:00
Payson	Santaquin	55.20	0:08:34	55.53	0:08:31	54.28	0:08:43	54.90	0:08:37	54.90	0:08:37	49.41	0:05:45	0:07:00

Notes:
All travel times are station leave to station leave except the following:
Roy to Ogden – Roy leave time to Ogden arrive time
Orem to Provo – Orem leave time to Provo arrive time (except trains to Santaquin)
Ogden to Brigham City – Ogden arrive time to Brigham City arrive time

17.7 Scenario Simulation Travel Time 5 Day Average Results Summary

Table 82 - Scenario Travel Time 5 Day Average Results Summary - Northbound

Northbound		Baseline		Future Baseline		Low Investment		Medium Investment		High Investment		High Investment with Infill Stations	
Starting Station	**Ending Station**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**
Santaquin	Payson	-	-	-	-	-	-	-	-	-	-	45.17	0:06:17
Payson	Spanish Fork	-	-	-	-	47.60	0:09:50	46.93	0:09:58	46.88	0:09:59	59.04	0:08:00
Spanish Fork	Springville	-	-	-	-	35.62	0:06:24	40.38	0:05:39	39.77	0:05:44	34.75	0:06:34
Springville	Provo Central	-	-	-	-	28.90	0:10:19	19.51	0:15:17	24.76	0:12:02	31.28	0:09:25
Provo Central	Orem Central	40.39	0:07:53	34.91	0:09:07	39.48	0:08:04	39.15	0:08:08	37.11	0:08:35	37.75	0:08:26
Orem Central	Vineyard	-	-	-	-	26.52	0:05:50	29.69	0:05:13	33.59	0:04:36	27.74	0:05:32
Vineyard	American Fork	-	-	-	-	47.44	0:07:27	46.04	0:07:40	46.51	0:07:36	43.31	0:08:11
Orem Central	American Fork	50.41	0:10:04	39.95	0:12:43	-	-	-	-	-	-		
American Fork	Lehi	38.43	0:08:47	36.34	0:09:18	40.07	0:08:26	27.49	0:12:17	32.64	0:10:21	37.12	0:09:06
Lehi	Bluffdale	-	-	-	-	-	-	-	-	-	-	38.70	0:08:12
Bluffdale	Draper	-	-	-	-	-	-	-	-	-	-	32.46	0:04:02
Lehi	Draper	47.18	0:09:30	46.16	0:09:42	46.78	0:09:35	32.46	0:13:48	38.84	0:11:32	-	-
Draper	South Jordan	35.74	0:05:32	34.65	0:05:43	33.97	0:05:50	23.53	0:08:25	31.89	0:06:13	33.98	0:05:50
South Jordan	Murray Central	44.99	0:09:04	45.64	0:08:56	46.82	0:08:42	37.63	0:10:50	42.58	0:09:35	42.25	0:09:39
Murray Central	Salt Lake Central	31.55	0:13:43	31.75	0:13:38	32.59	0:13:17	30.82	0:14:02	32.35	0:13:23	32.68	0:13:14
Salt Lake Central	North Temple	8.70	0:05:58	9.88	0:05:16	9.81	0:05:18	10.91	0:04:46	12.33	0:04:13	12.68	0:04:07
North Temple	Woods Cross	42.75	0:11:02	40.10	0:11:46	39.23	0:12:01	38.56	0:12:14	40.89	0:11:32	40.47	0:11:39
Woods Cross	Centerville	-	-	-	-	-	-	-	-	-	-	30.06	0:04:41
Centerville	Farmington	-	-	-	-	-	-	-	-	-	-	56.08	0:05:40
Woods Cross	Farmington	43.21	0:10:36	41.90	0:10:56	41.97	0:10:55	46.32	0:09:53	56.74	0:08:04	-	-
Farmington	Layton	41.91	0:08:30	39.74	0:08:58	39.68	0:08:59	42.53	0:08:23	41.96	0:08:30	47.07	0:07:34
Layton	Clearfield	35.62	0:06:12	37.94	0:05:49	37.07	0:05:58	35.10	0:06:18	32.57	0:06:47	43.67	0:05:04
Clearfield	Sunset	-	-	-	-	-	-	-	-	-	-	40.34	0:04:47
Sunset	Roy	-	-	-	-	-	-	-	-	-	-	28.31	0:07:47
Clearfield	Roy	46.19	0:08:58	47.97	0:08:38	48.04	0:08:37	44.43	0:09:19	41.62	0:09:56	-	-
Roy	Ogden	39.92	0:06:36	33.73	0:07:49	33.11	0:07:58	28.97	0:09:06	29.65	0:08:54	34.33	0:07:37

Table 82 - Scenario Travel Time 5 Day Average Results Summary - Northbound

Northbound		Baseline		Future Baseline		Low Investment		Medium Investment		High Investment		High Investment with Infill Stations	
Starting Station	**Ending Station**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**
Ogden	Business District Ogden	-	-	-	-	-	-	-	-	-	-	34.27	0:04:39
Business District Ogden	Pleasant View	-	-	-	-	-	-	-	-	-	-	41.84	0:04:57
Ogden	Pleasant View	31.78	0:11:25	31.92	0:11:22	38.60	0:09:24	37.43	0:09:42	39.84	0:09:06	-	-
Pleasant View	Willard	-	-	-	-	-	-	-	-	-	-	49.35	0:10:22
Willard	Brigham City	-	-	-	-	-	-	-	-	-	-	64.82	0:05:46

Table 83 – Scenario Travel Time 5 Day Average Results Summary - Southbound

Southbound		Baseline		Future Baseline		Low Investment		Medium Investment		High Investment		High Investment with Infill Stations	
Starting Station	Ending Station	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time	Average Speed (mph)	Travel Time
Brigham City	Willard	-	-	-	-	-	-	-	-	-	-	46.72	0:08:00
Willard	Pleasant View	-	-	-	-	-	-	-	-	-	-	51.12	0:10:00
Pleasant View	Business District Ogden	-	-	-	-	-	-	-	-	-	-	40.31	0:05:08
Business District Ogden	Ogden	-	-	-	-	-	-	-	-	-	-	27.44	0:05:49
Pleasant View	Ogden	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	24.43	0:15:00	-	-
Ogden	Roy	29.13	0:09:05	27.87	0:09:29	27.67	0:09:33	33.77	0:07:50	36.46	0:07:15	32.13	0:08:09
Roy	Sunset	-	-	-	-	-	-	-	-	-	-	31.85	0:06:55
Sunset	Clearfield	-	-	-	-	-	-	-	-	-	-	32.22	0:05:59
Roy	Clearfield	46.94	0:08:48	44.59	0:09:16	45.20	0:09:08	36.93	0:11:11	34.97	0:11:49	-	-
Clearfield	Layton	35.41	0:06:14	31.50	0:07:01	31.96	0:06:55	35.40	0:06:14	36.10	0:06:07	38.22	0:05:47
Layton	Farmington	38.64	0:09:14	45.19	0:07:53	45.21	0:07:53	39.70	0:08:59	39.87	0:08:56	41.33	0:08:37
Farmington	Centerville	-	-	-	-	-	-	-	-	-	-	44.11	0:07:12
Centerville	Woods Cross	-	-	-	-	-	-	-	-	-	-	35.68	0:03:56
Farmington	Woods Cross	44.12	0:10:23	43.37	0:10:34	46.05	0:09:57	42.41	0:10:48	44.83	0:10:13	-	-
Woods Cross	North Temple	36.09	0:13:04	32.99	0:14:18	32.80	0:14:23	31.10	0:15:10	33.82	0:13:57	32.08	0:14:42
North Temple	Salt Lake Central	7.45	0:07:00	11.86	0:04:24	10.87	0:04:48	7.03	0:07:25	5.99	0:08:42	6.84	0:07:37
Salt Lake Central	Murray Central	32.89	0:13:09	33.05	0:13:05	35.72	0:12:07	34.15	0:12:40	38.08	0:11:22	39.26	0:11:01
Murray Central	South Jordan	46.05	0:08:51	43.26	0:09:26	44.31	0:09:12	35.53	0:11:28	43.35	0:09:24	43.06	0:09:28
South Jordan	Draper	39.21	0:05:03	34.98	0:05:40	34.52	0:05:44	26.75	0:07:24	39.94	0:04:57	40.08	0:04:56
Draper	Bluffdale	-	-	-	-	-	-	-	-	-	-	34.36	0:03:49
Bluffdale	Lehi	-	-	-	-	-	-	-	-	-	-	39.54	0:08:01
Draper	Lehi	43.87	0:10:13	41.97	0:10:41	43.16	0:10:23	34.95	0:12:49	41.58	0:10:47	-	-
Lehi	American Fork	44.20	0:07:38	39.74	0:08:30	39.13	0:08:38	32.48	0:10:24	38.88	0:08:41	42.95	0:07:52
American Fork	Vineyard	-	-	-	-	39.66	0:08:56	41.40	0:08:33	37.17	0:09:32	37.40	0:09:28
Vineyard	Orem Central	-	-	-	-	33.67	0:04:34	26.08	0:05:53	23.37	0:06:34	23.45	0:06:33
American Fork	Orem Central	46.30	0:10:58	47.02	0:10:48	-	-	-	-	-	-	-	-

Table 83 – Scenario Travel Time 5 Day Average Results Summary - Southbound

Southbound		Baseline		Future Baseline		Low Investment		Medium Investment		High Investment		High Investment with Infill Stations	
Starting Station	**Ending Station**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**	**Average Speed (mph)**	**Travel Time**
Orem Central	Provo Central	46.41	0:06:52	39.76	0:08:01	38.56	0:08:16	38.72	0:08:13	45.51	0:07:00	44.81	0:07:06
Provo Central	Springville	-	-	-	-	34.86	0:08:27	31.69	0:09:18	25.85	0:11:24	38.75	0:07:36
Springville	Spanish Fork	-	-	-	-	38.83	0:05:52	38.90	0:05:52	39.16	0:05:49	39.97	0:05:42
Spanish Fork	Payson	-	-	-	-	50.20	0:09:25	49.42	0:09:34	49.42	0:09:34	54.96	0:08:36
Payson	Santaquin	-	-	-	-	-	-	-	-	-	-	49.41	0:05:45

18 Appendix C Baseline Simulation Time-Distance ("String") Charts and Station Occupancy Charts

18.1 Baseline Simulation Results without Perturbations (Ideal Day)

18.1.1 Station Occupancy Charts – Salt Lake Central

Most trains in the simulation can be seen arriving and departing on time at Salt Lake Central Station. Of note is train 8-03 which is running approximately 10 minutes behind schedule in the baseline simulation without any added perturbations, shown in Figure 18-2.

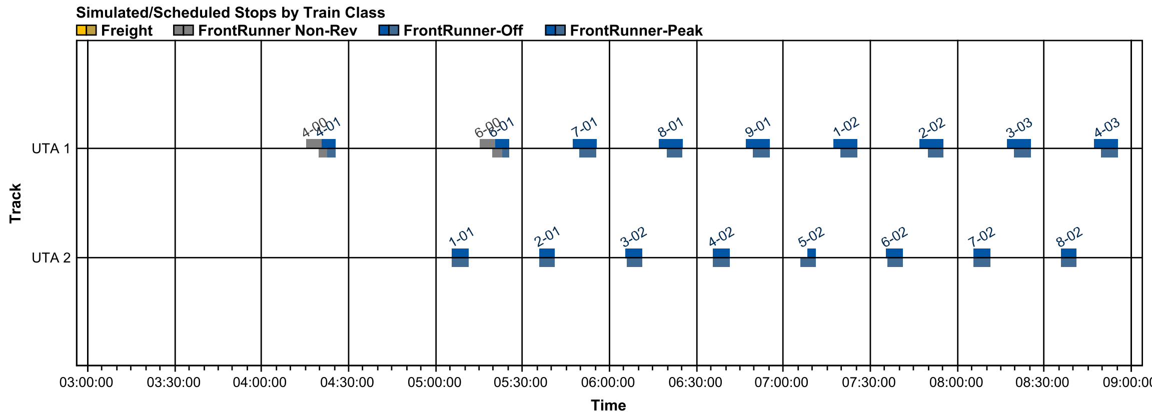


Figure 18-1: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – No Added Perturbations

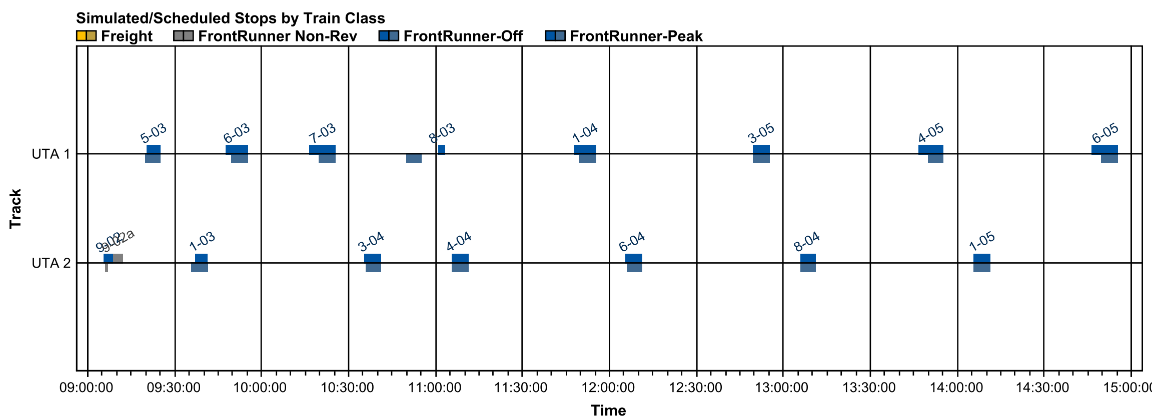


Figure 18-2: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – No Added Perturbations

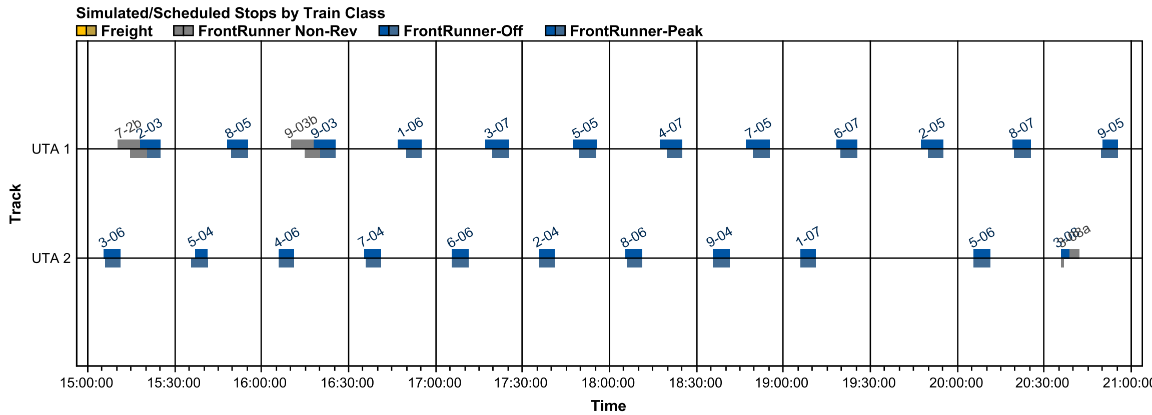


Figure 18-3: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – No Added Perturbations

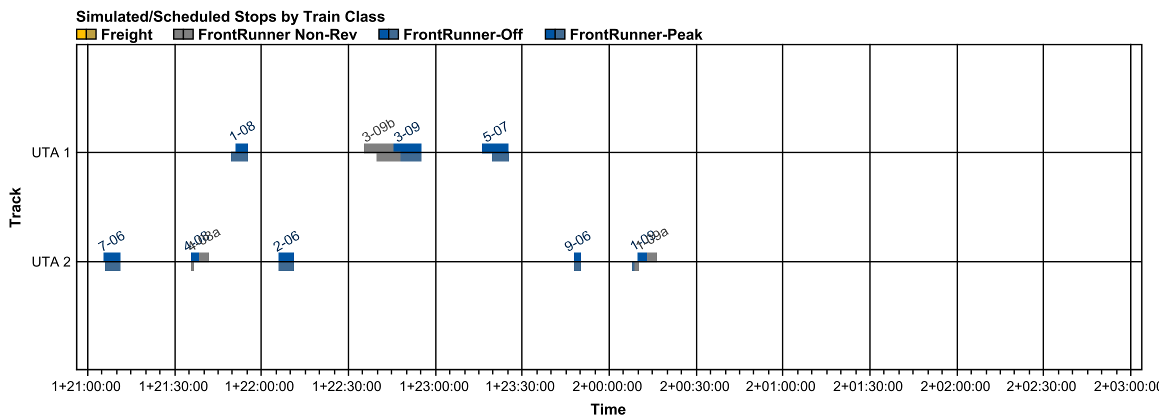


Figure 18-4: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – No Added Perturbations

18.1.2 String Charts

Delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones. The trains run very close to on-time in the No Added Perturbations run. Figure 18-6 shows that train 1-03 and train 4-04 are randomly assigned long dwells at Draper. Additionally, Train 8-03 receives a long dwell at Lehi. Train 1-03 recovers to schedule by the time it turns at Provo as train 1-04, as does train 4-04. Train 8-03 is able to make up its delay by the time it reaches Roy.

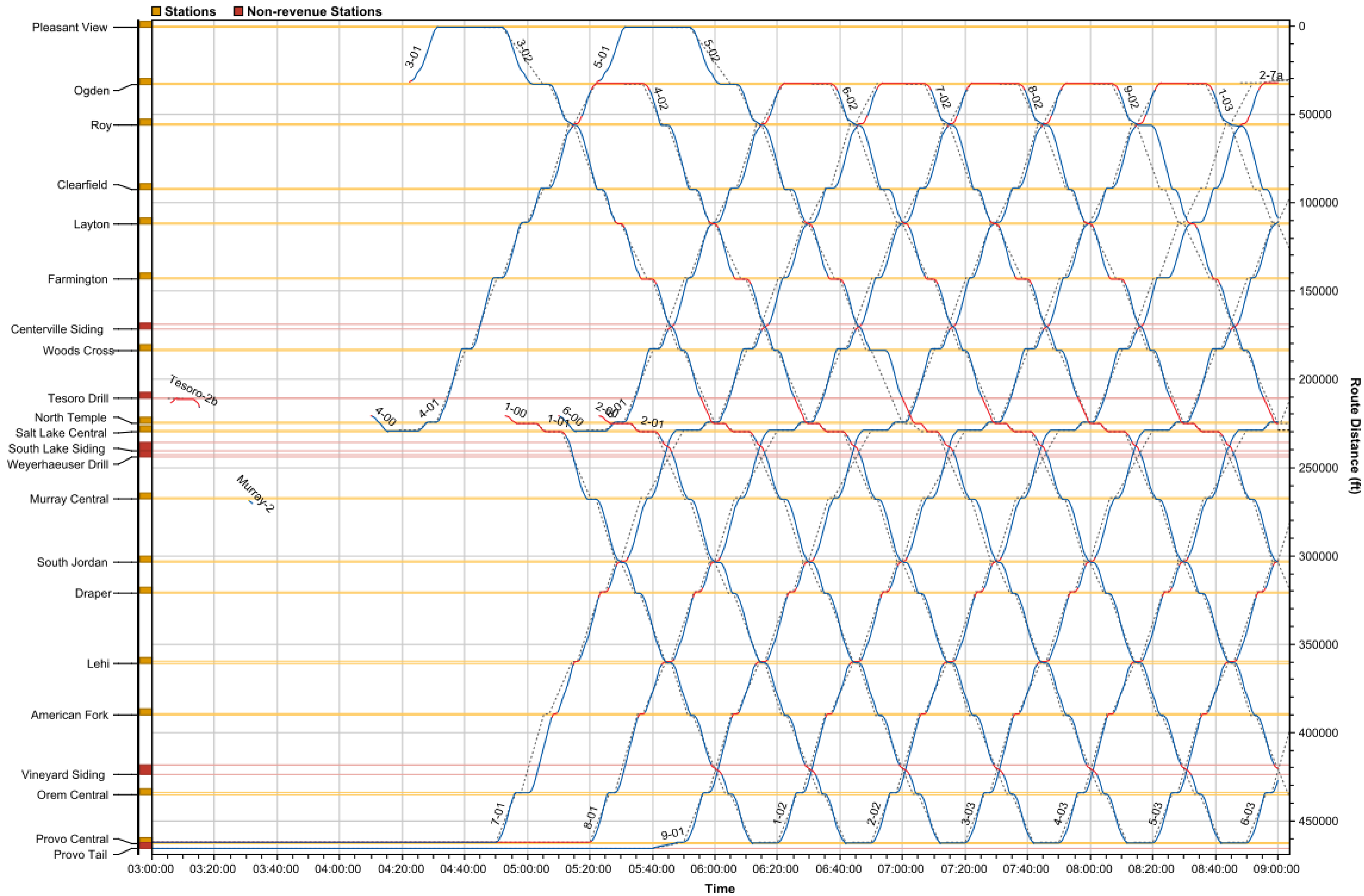


Figure 18-5: Time-Distance ("String") Chart – 3 AM – 9 AM – No Added Perturbations

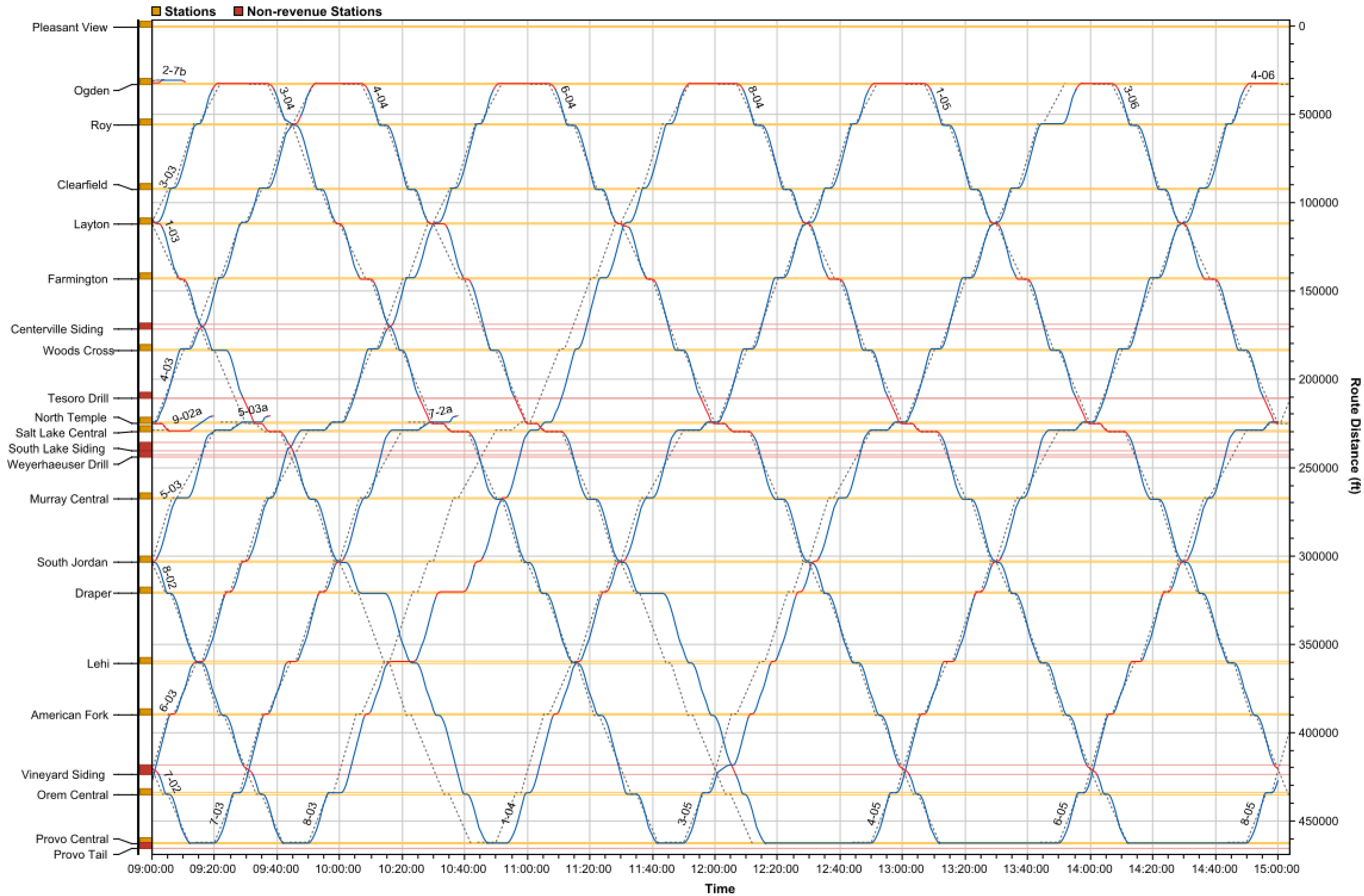


Figure 18-6: Time-Distance ("String") Chart – 9 AM – 3 PM – No Added Perturbations

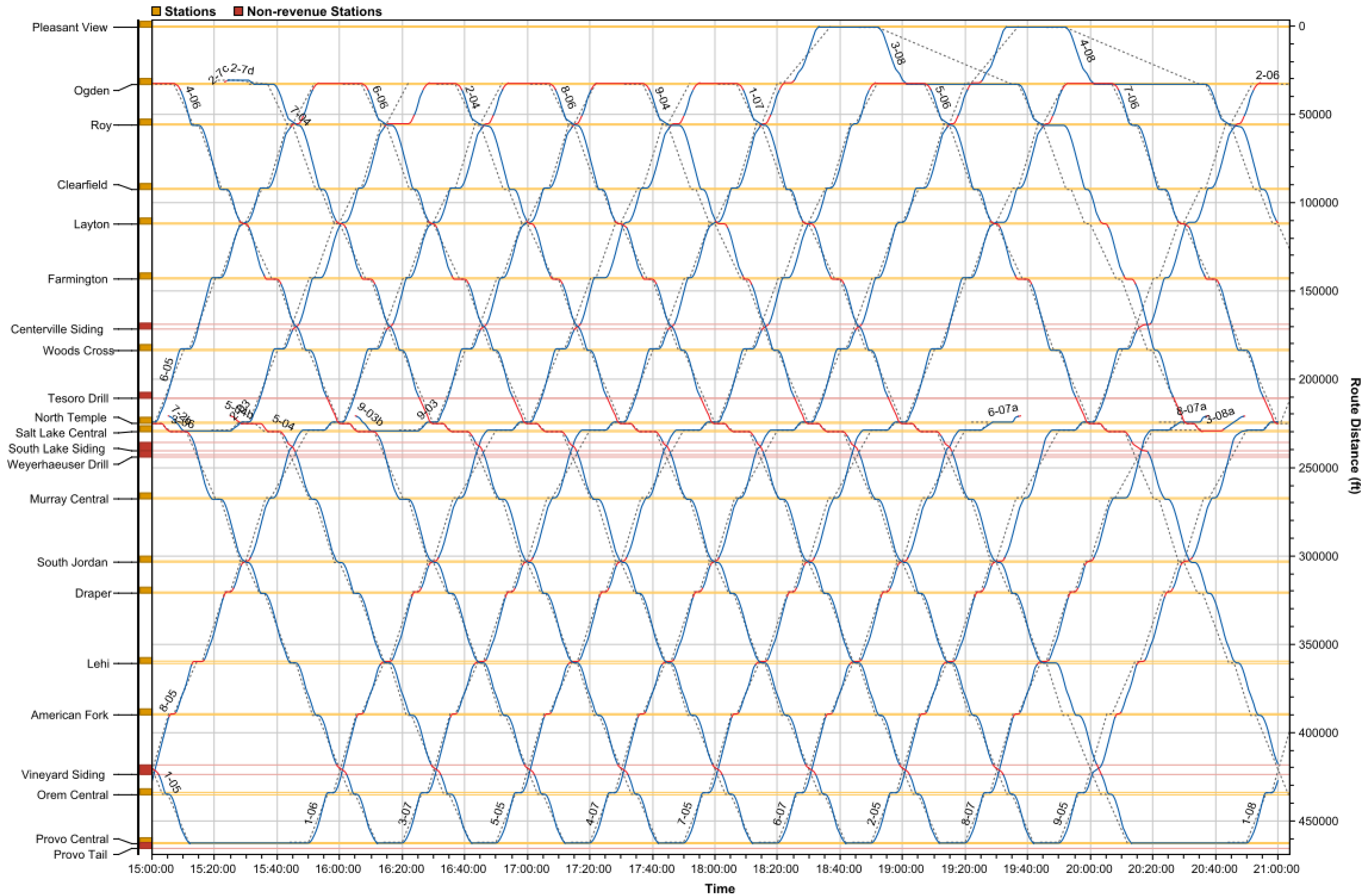


Figure 18-7: Time-Distance ("String") Chart – 3 PM – 9 PM – No Added Perturbations

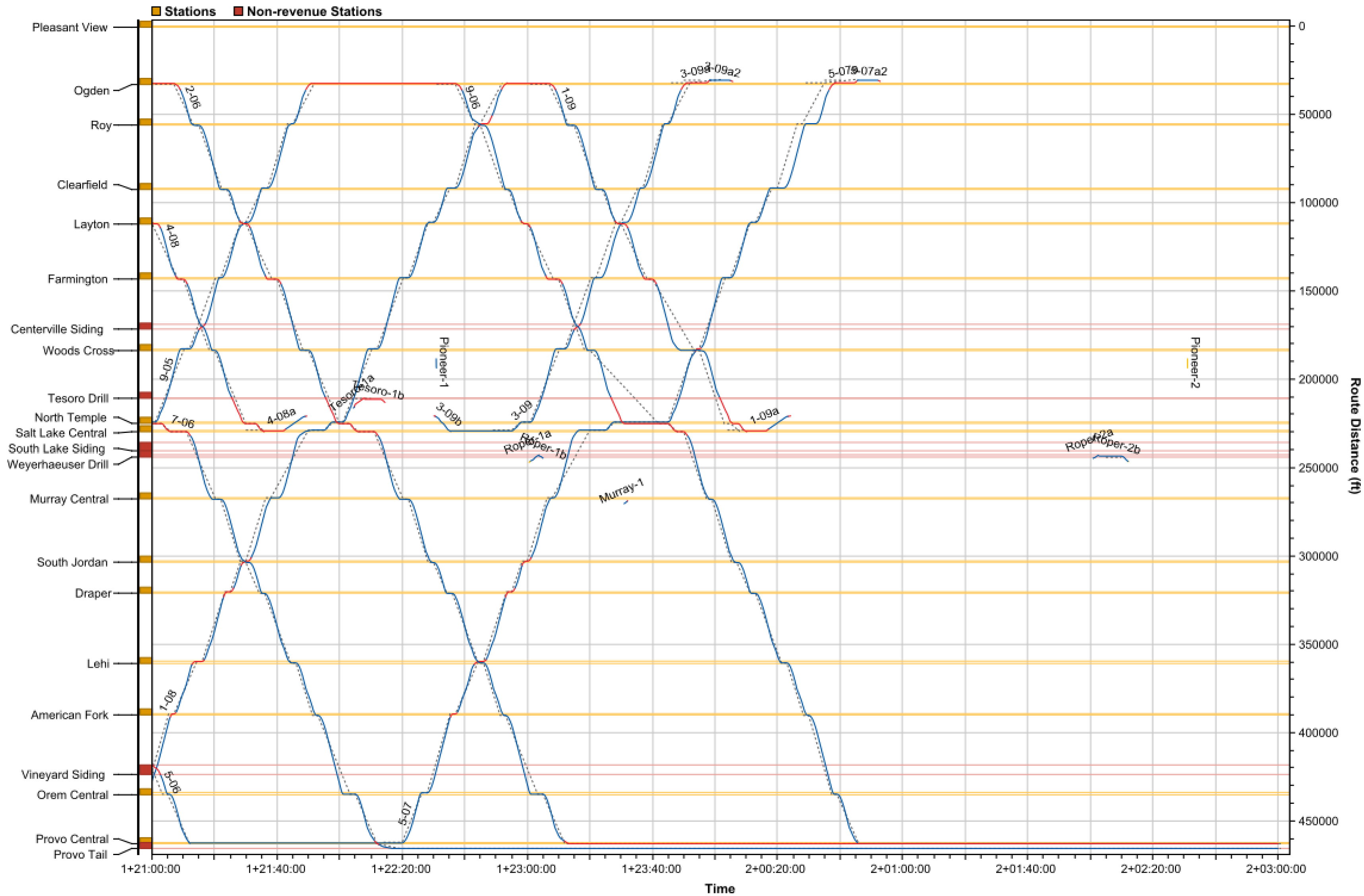


Figure 18-8: Time-Distance ("String") Chart – 9 PM – 3 AM – No Added Perturbations

18.2 Day 1 Baseline Simulation Results with Perturbations

The FrontRunner - Day 1 operating plan includes a randomly-assigned door failure for train 9-04 at South Jordan station. This causes a 7-minute extended dwell. Day 1 also includes a 5-minute delay for train 1-02 at North Temple due to the randomly-assigned need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

18.2.1 Station Occupancy Charts – Salt Lake Central

The Salt Lake Central station occupancy charts below show a total of six trains that arrive late enough that they also depart the station late. The cause of some of these delays is shown in the string charts in section 18.2.2.

Figure 18-9 shows all trains leaving Salt Lake City on time.

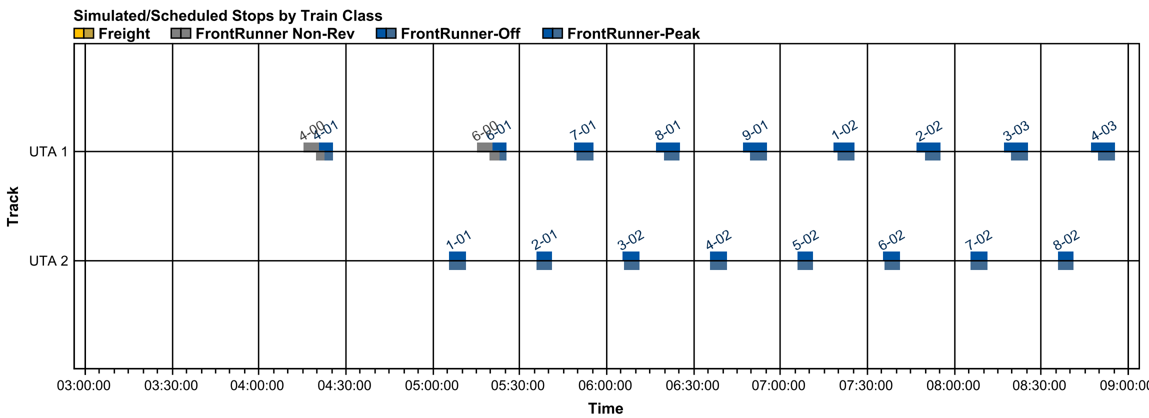


Figure 18-9: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Day 1 Simulation Results with Perturbations

Figure 18-10 shows train 1-03 and train 1-04 arriving and leaving late.

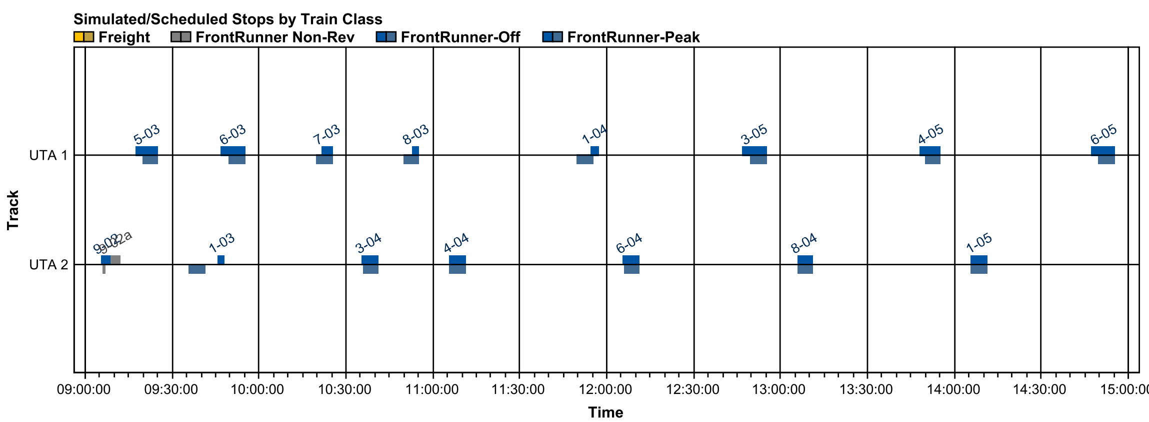


Figure 18-10: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Day 1 Simulation Results with Perturbations

Figure 18-11 shows train 6-07, train 2-05 and train 3-08 arriving and leaving late.

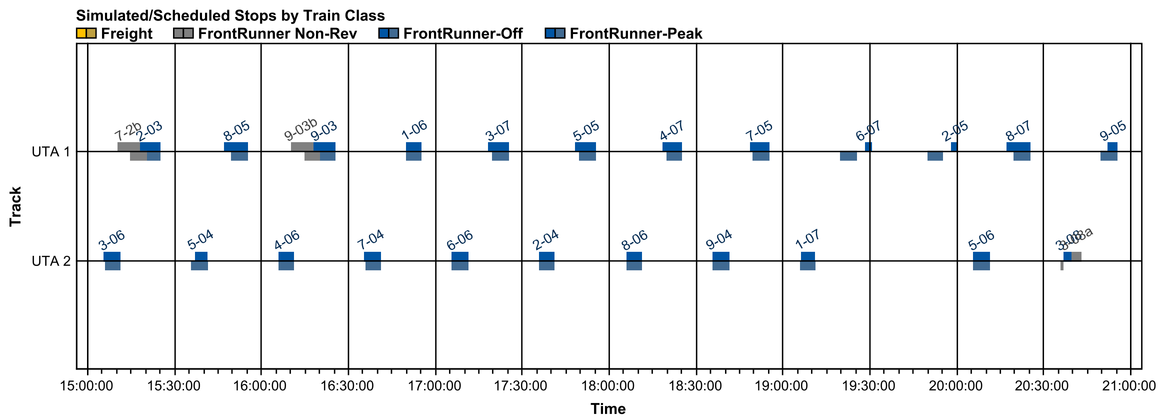


Figure 18-11: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Day 1 Simulation Results with Perturbations

Figure 18-12 shows train 1-09 arriving and leaving late.

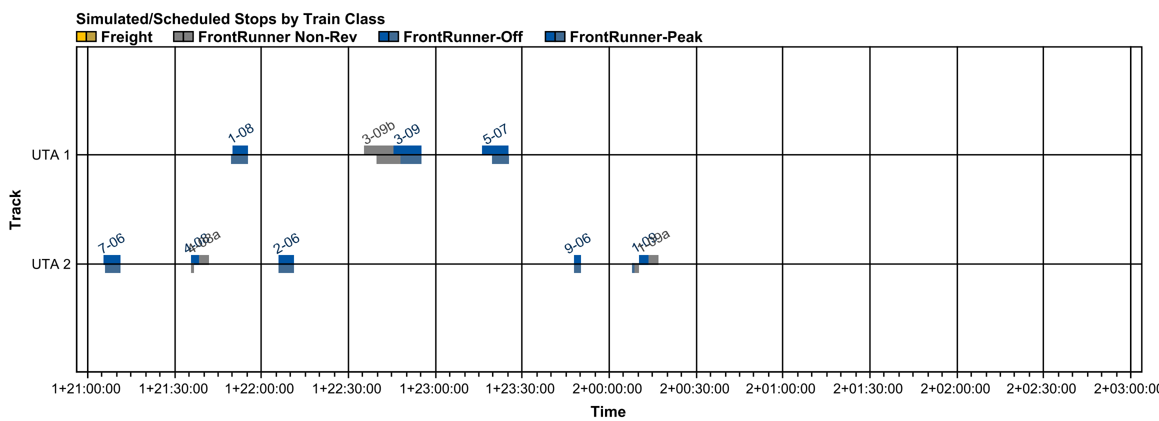


Figure 18-12: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Day 1 Simulation Results with Perturbations

18.2.2 String Charts

Figure 18-13, shows the randomly-assigned 5-minute delay for train 1-02 at North Temple due to the need to hold for a late TRAX connection. Due to this prolonged delay, train 1-02 meets train 7-02 at Woods Cross, train 8-02 at Kaysville Siding and a prolonged wait at Clearfield for train 9-02 to pass instead of passing at Roy. Train 1-02 arrives late enough to Ogden that the return trip, train 1-03 departs Ogden late and train 2-02 waits at Roy for train 1-03 to pass. Figure 18-14 shows the collateral impacts of this delay as train 1-03 meets train 3-03 at Clearfield instead of Layton. Train 1-03 also causes train 7-03 to wait at South Jordan for the meet and train 8-03 to wait at Lehi for the meet.

Figure 18-15 shows the 7-minute extended dwell perturbation to train 9-04. This causes a delay to train 2-05 as it waits at Lehi station for the meet with train 9-04. After train 9-04 turns into train 9-05 at Provo Central station, it is running late enough that it holds up train 1-07 at Vineyard siding.

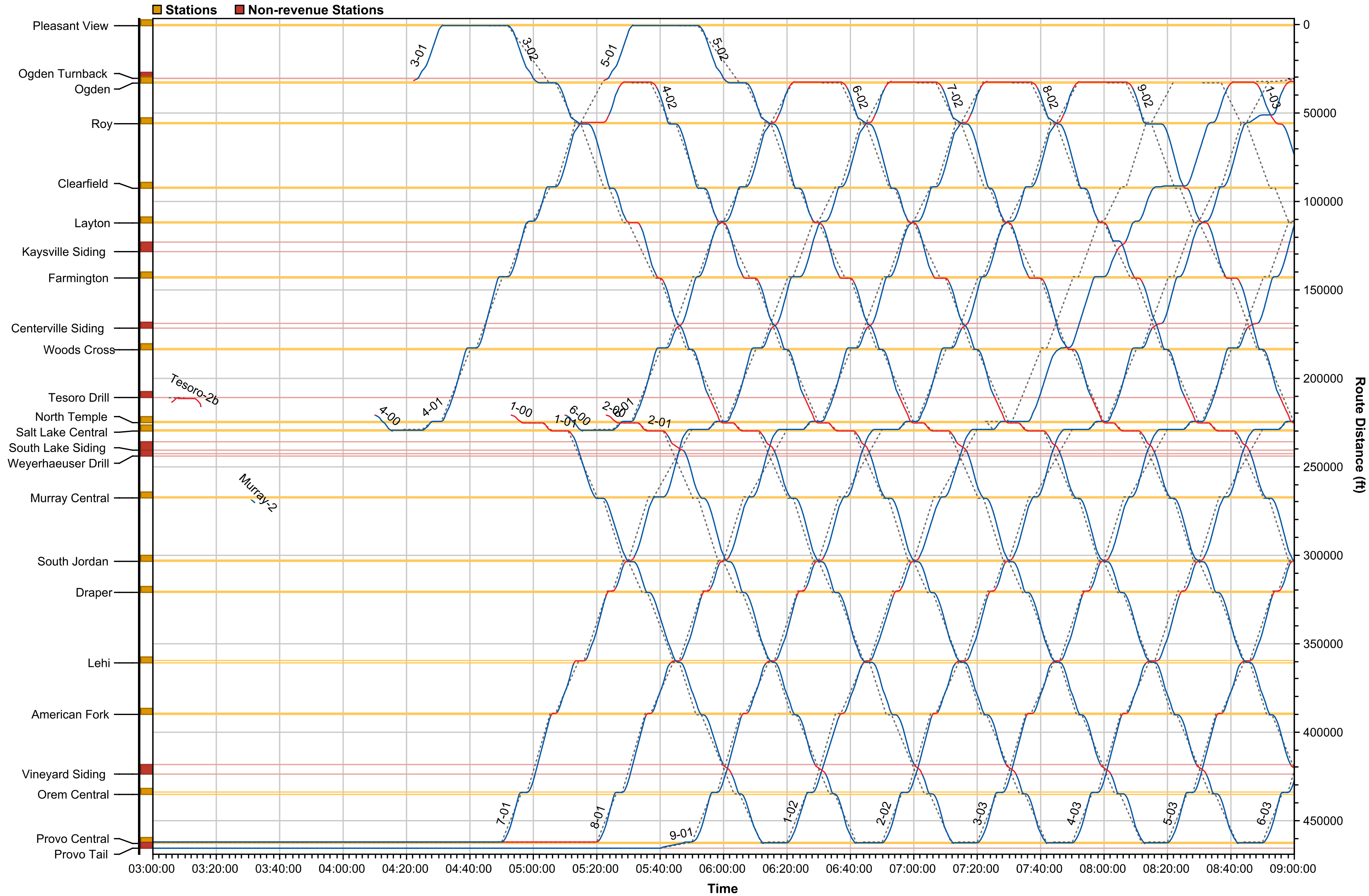


Figure 18-13: Time-Distance ("String") Chart – 3 AM – 9 AM – Day 1 Simulation Results with Perturbations

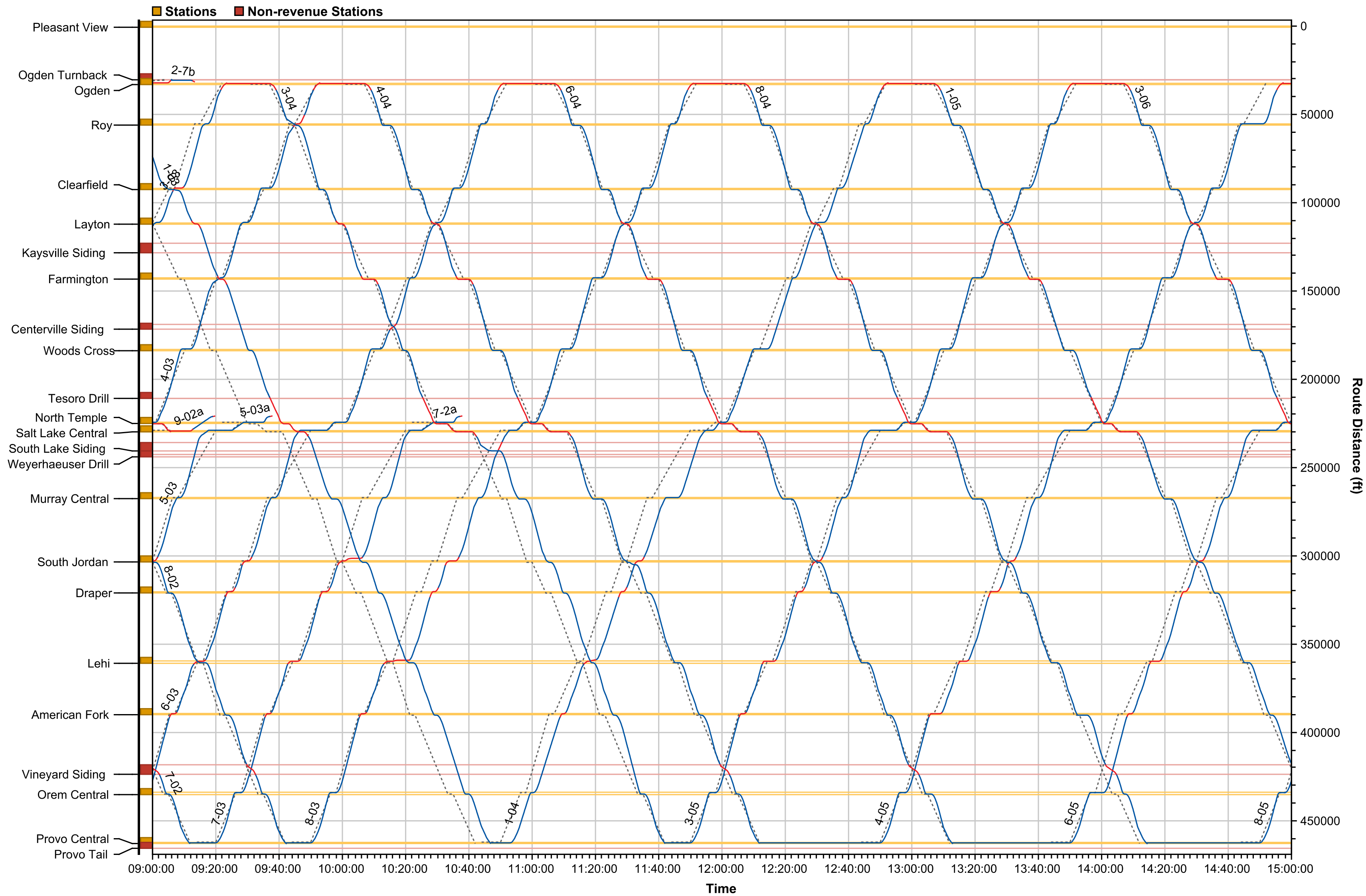


Figure 18-14: Time-Distance ("String") Chart – 9 AM – 3 PM – Day 1 Simulation Results with Perturbations

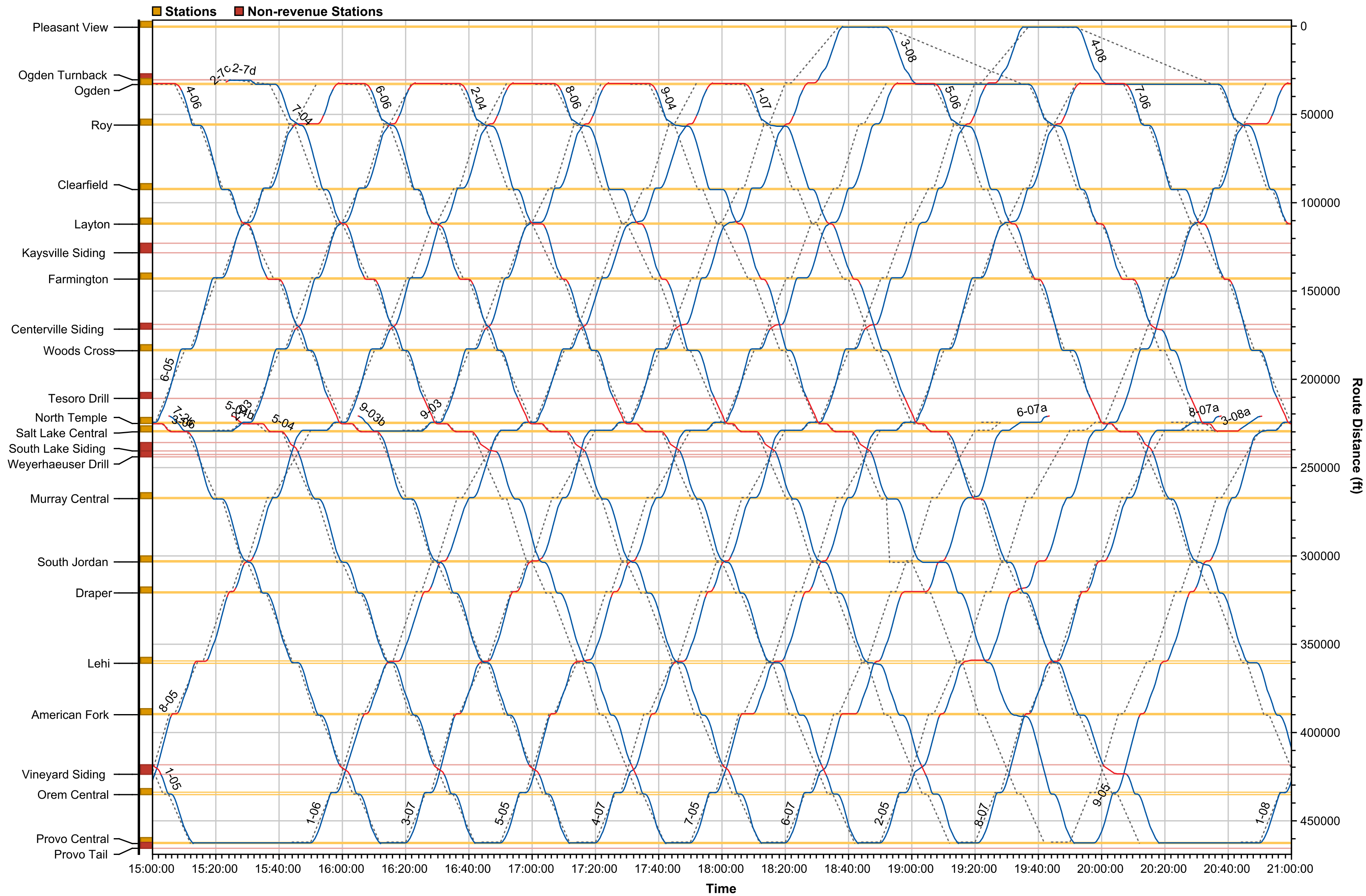


Figure 18-15: Time-Distance ("String") Chart – 3 PM – 9 PM – Day 1 Simulation Results with Perturbations

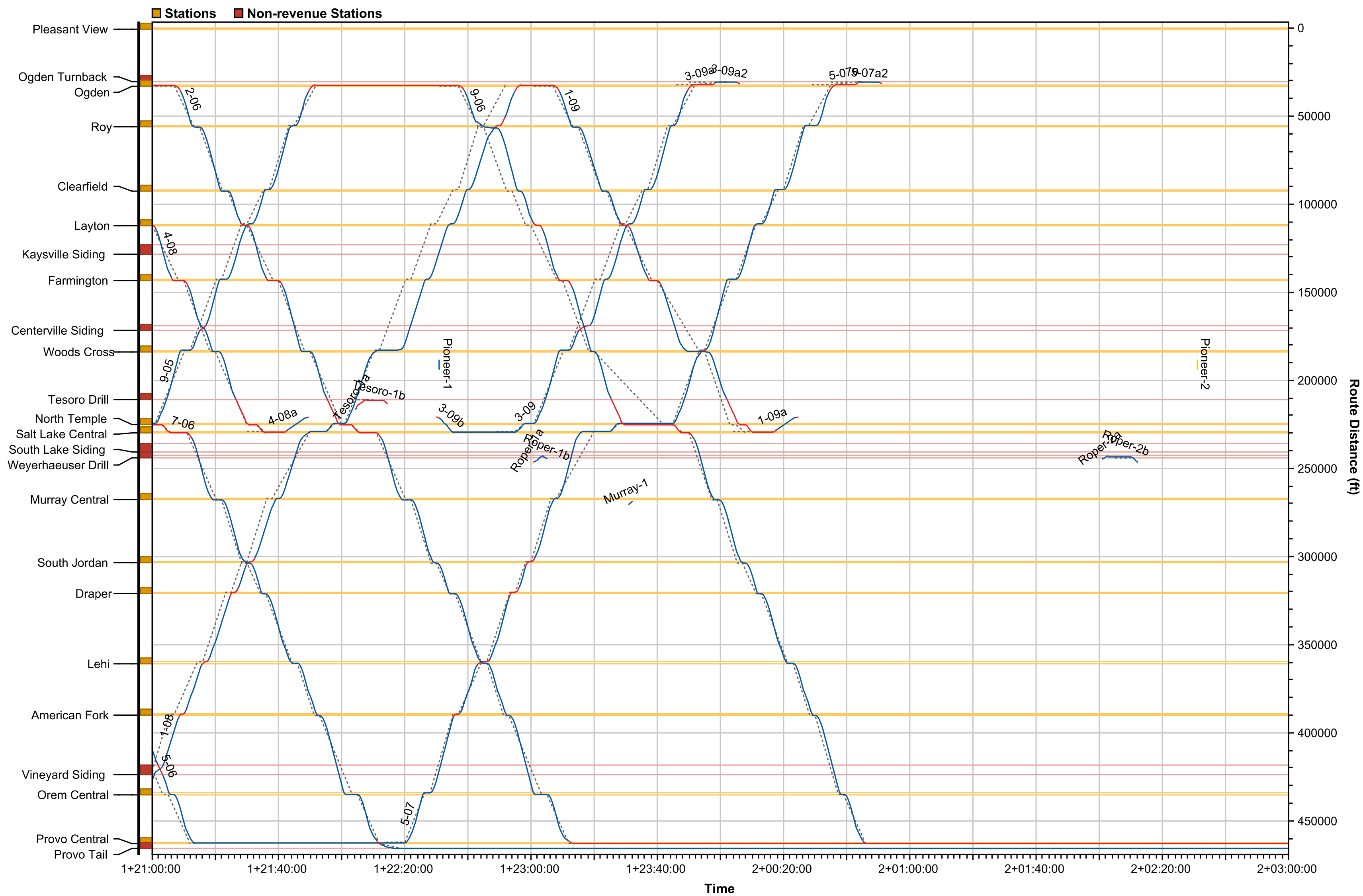


Figure 18-16: Time-Distance ("String") Chart – 9 PM – 3 AM – Day 1 Simulation Results with Perturbations

18.3 Day 2 Baseline Simulation Results with Perturbations

The FrontRunner - Day 2 operating plan perturbations include a 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM due to a crossing failure/broken gate. Day 2 also includes a 5-minute delay for train 3-03 at North Temple due to the need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

18.3.1 Station Occupancy Charts – Salt Lake Central

The Salt Lake Central station occupancy charts below show a total of seven trains that arrive late enough that they also depart the station late.

Figure 18-17 shows train 8-01 arriving and leaving late.

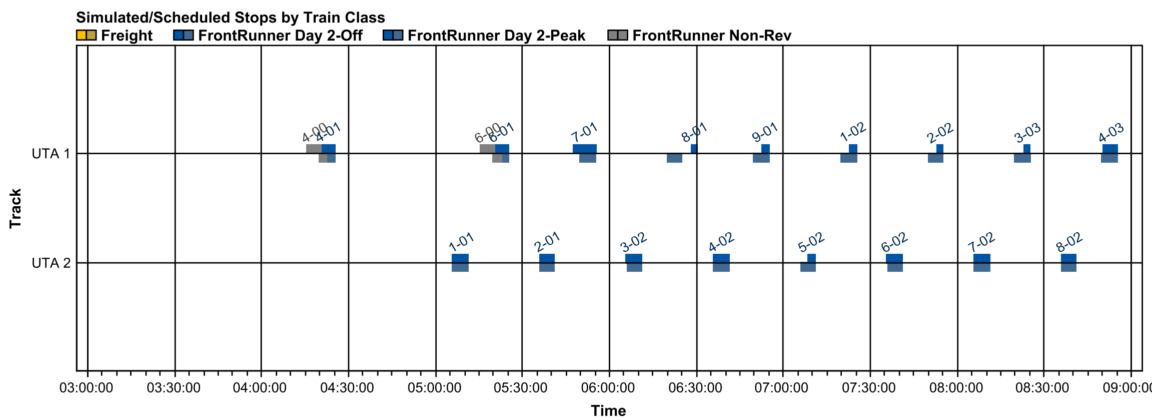


Figure 18-17: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Day 2 Simulation Results with Perturbations

Figure 18-18 shows train 9-02 arriving and leaving late.

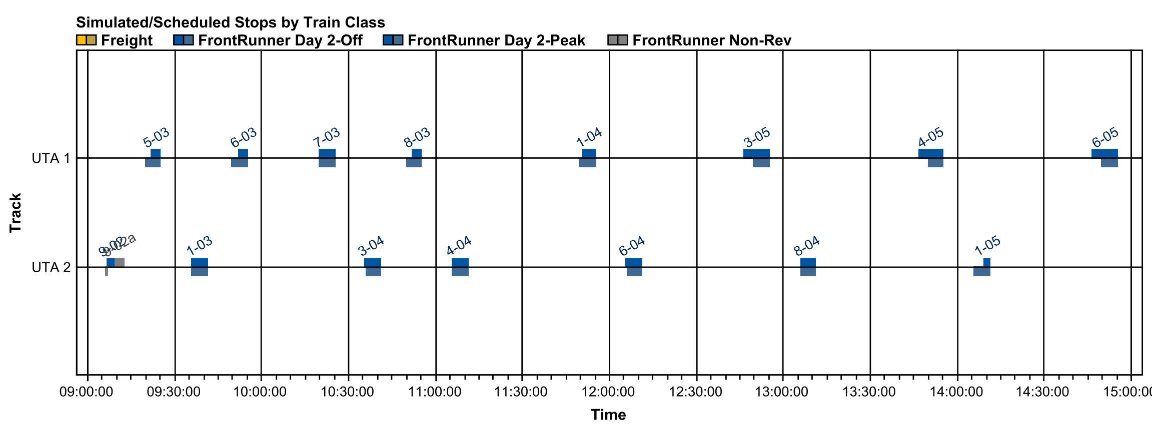


Figure 18-18: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Day 2 Simulation Results with Perturbations

Figure 18-19 shows train 3-07, train 5-05, train 4-07 and train 6-07 arriving and leaving late.

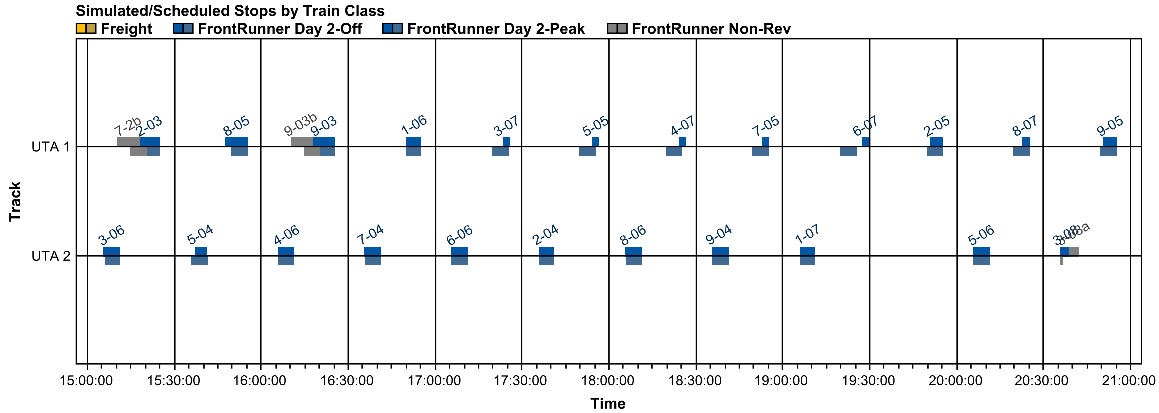


Figure 18-19: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Day 2 Simulation Results with Perturbations

Figure 18-20 shows train 1-09 arriving and leaving late.

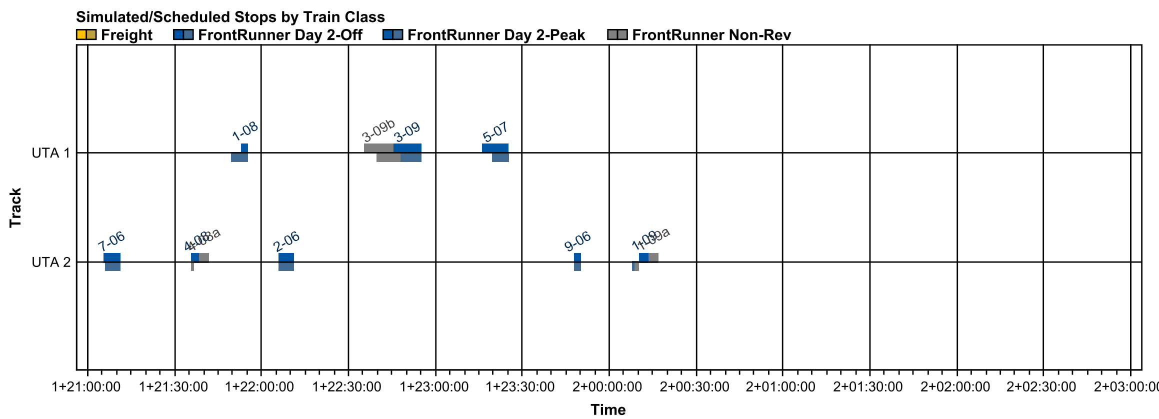


Figure 18-20: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Day 2 Simulation Results with Perturbations

18.3.2 String Charts

Figure 18-21 shows the randomly-assigned 5-minute delay for train 3-03 at North Temple due to the need to hold for a late TRAX connection. There are very few consequences from this delay, as can be seen in Figure 18-22.

Figure 18-21 also shows that train 1-01 at Draper station has randomly been assigned a significantly long dwell. This 7-minute dwell causes train 8-01 to wait at Lehi station for the meet. The delay to train 8-01 causes delays to all of the trains 8-01 meets with while in the South End. All of the trains delayed by 8-01then delay other trains they meet with causing cascading delays on the South End until noon (see Figure 18-22).

The string chart in Figure 18-23 shows the 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM. The lower speed is evident in the more horizontal slopes of the string lines through this period. Train 1-06 is the first train to get this speed restriction. Train 7-04 waits in Salt Lake Siding for train 1-06 to pass, causing train 3-07 to be delayed at South Jordan station while waiting for 7-04 to pass. These delays can be seen cascading through the South End for several hours.

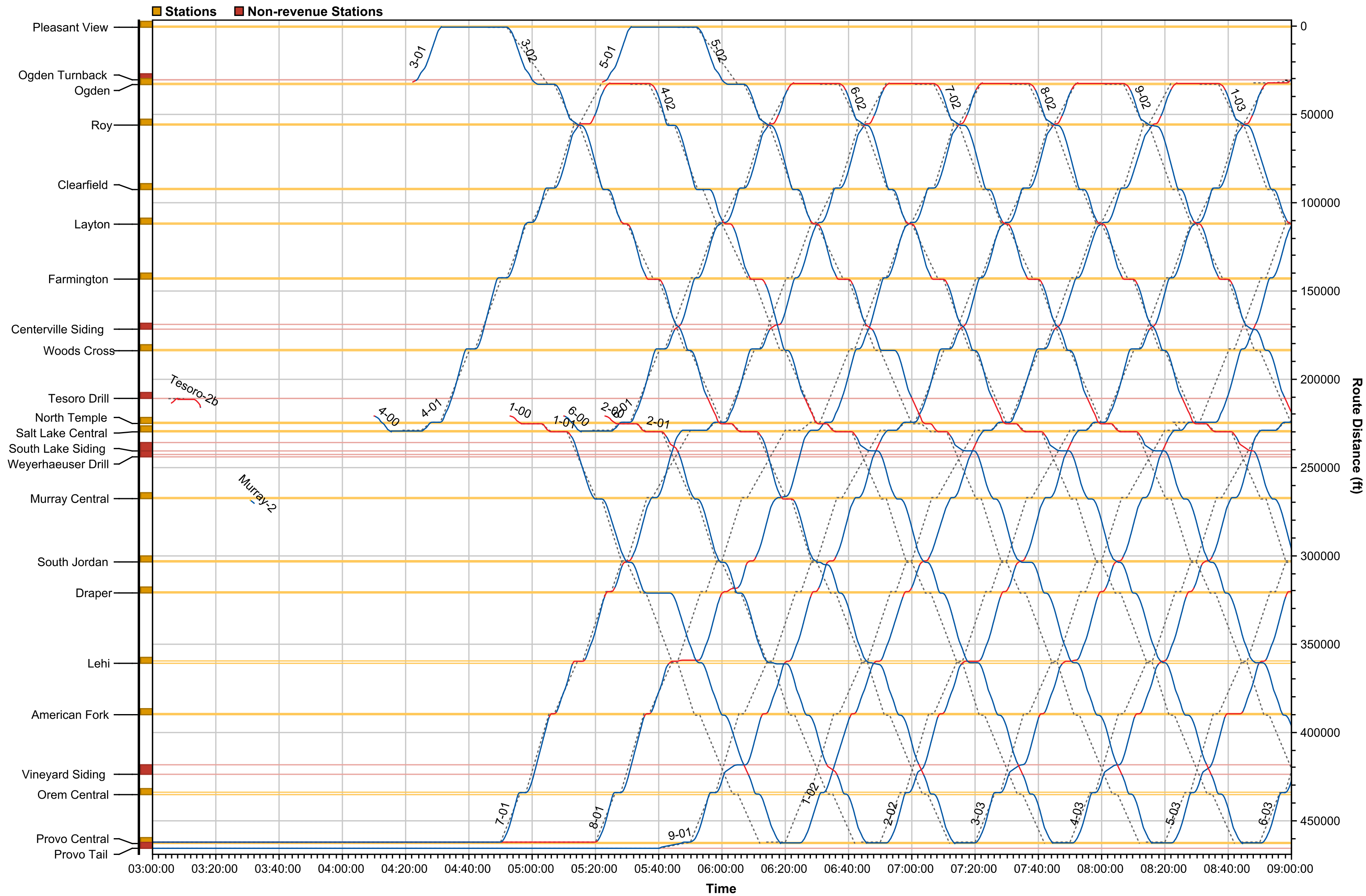


Figure 18-21: Time-Distance ("String") Chart – 3 AM – 9 AM – Day 2 Simulation Results with Perturbations

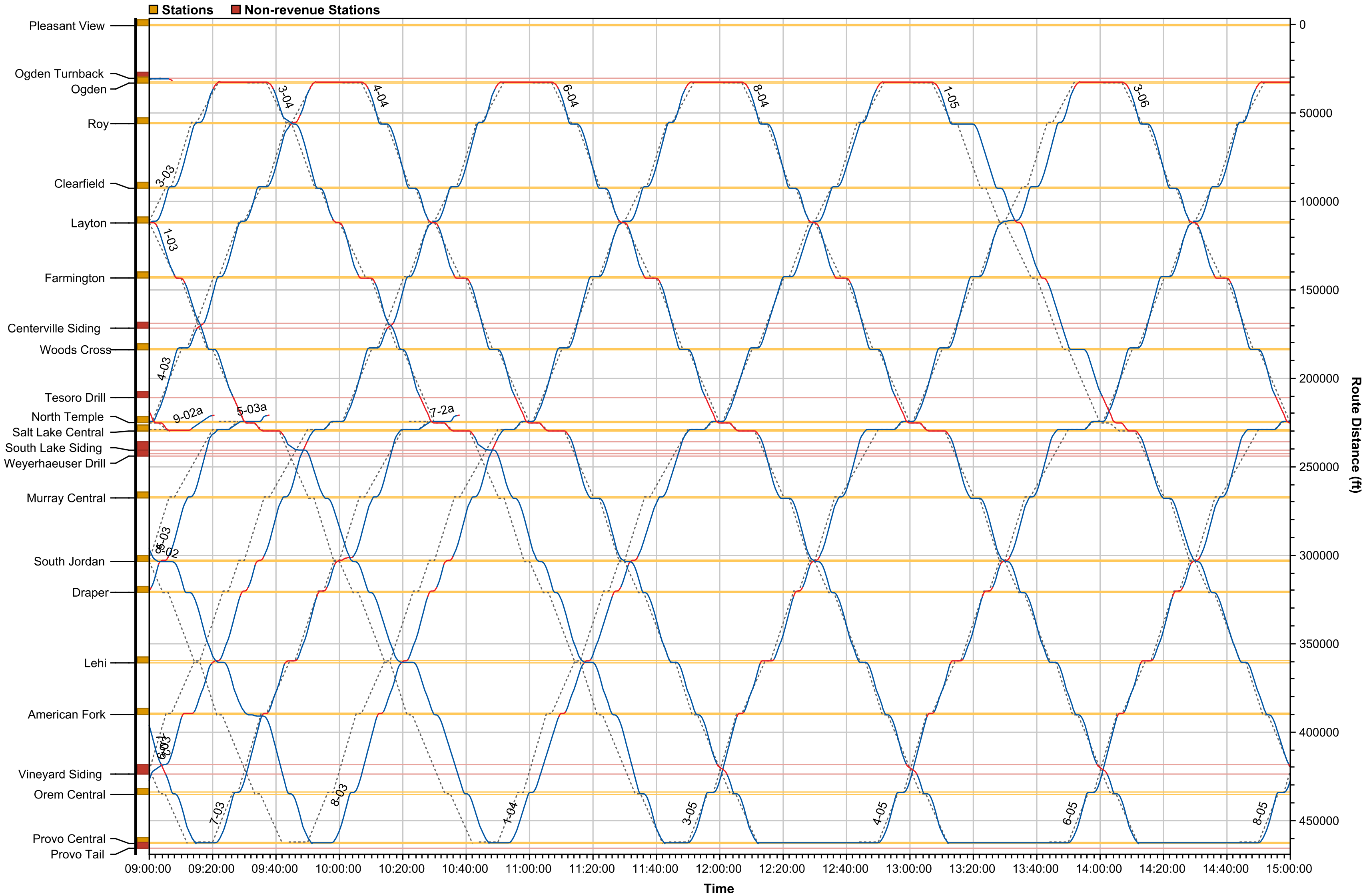


Figure 18-22: Time-Distance ("String") Chart – 9 AM – 3 PM – Day 2 Simulation Results with Perturbations

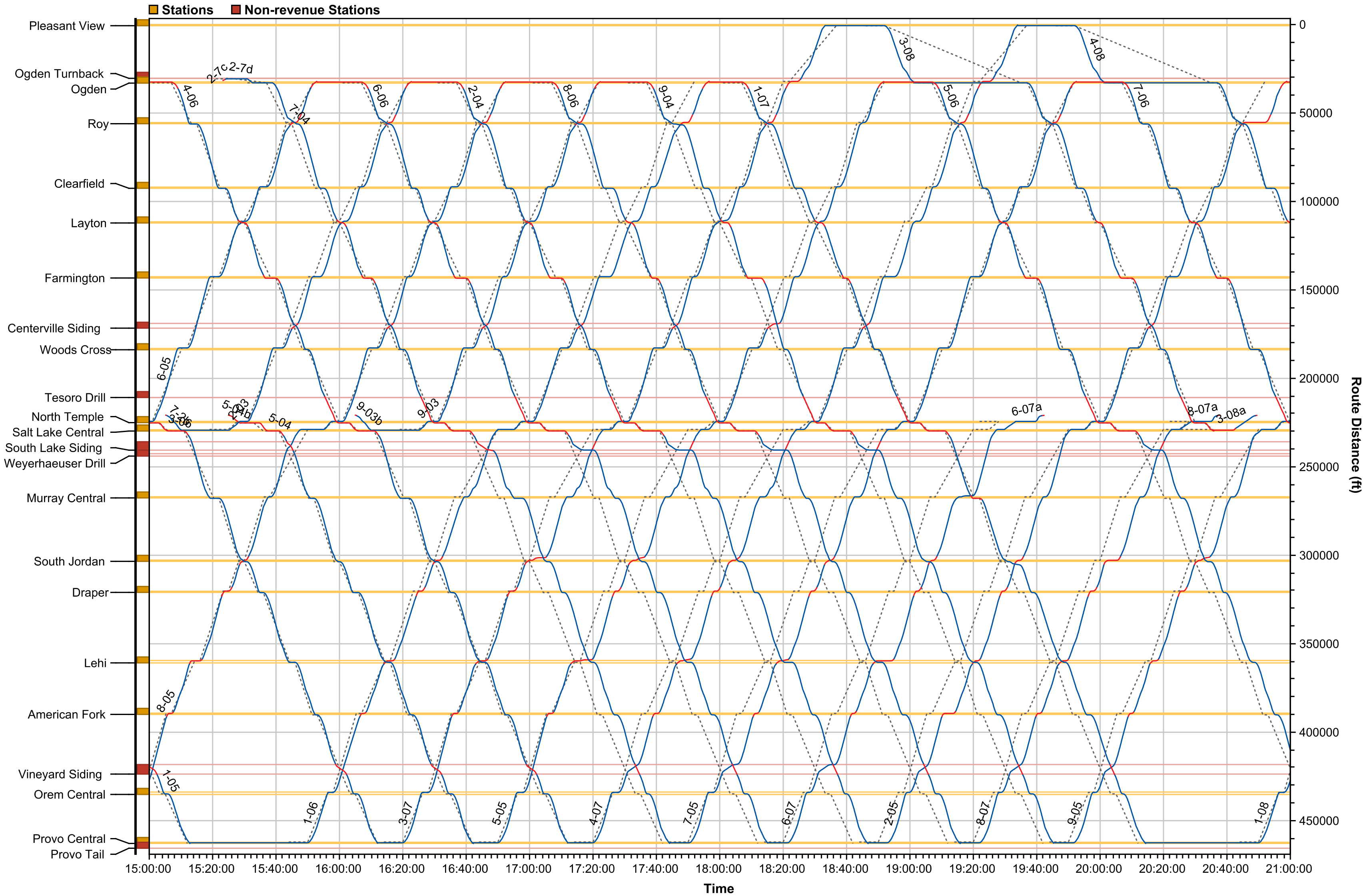


Figure 18-23: Time-Distance ("String") Chart – 3 PM – 9 PM – Day 2 Simulation Results with Perturbations

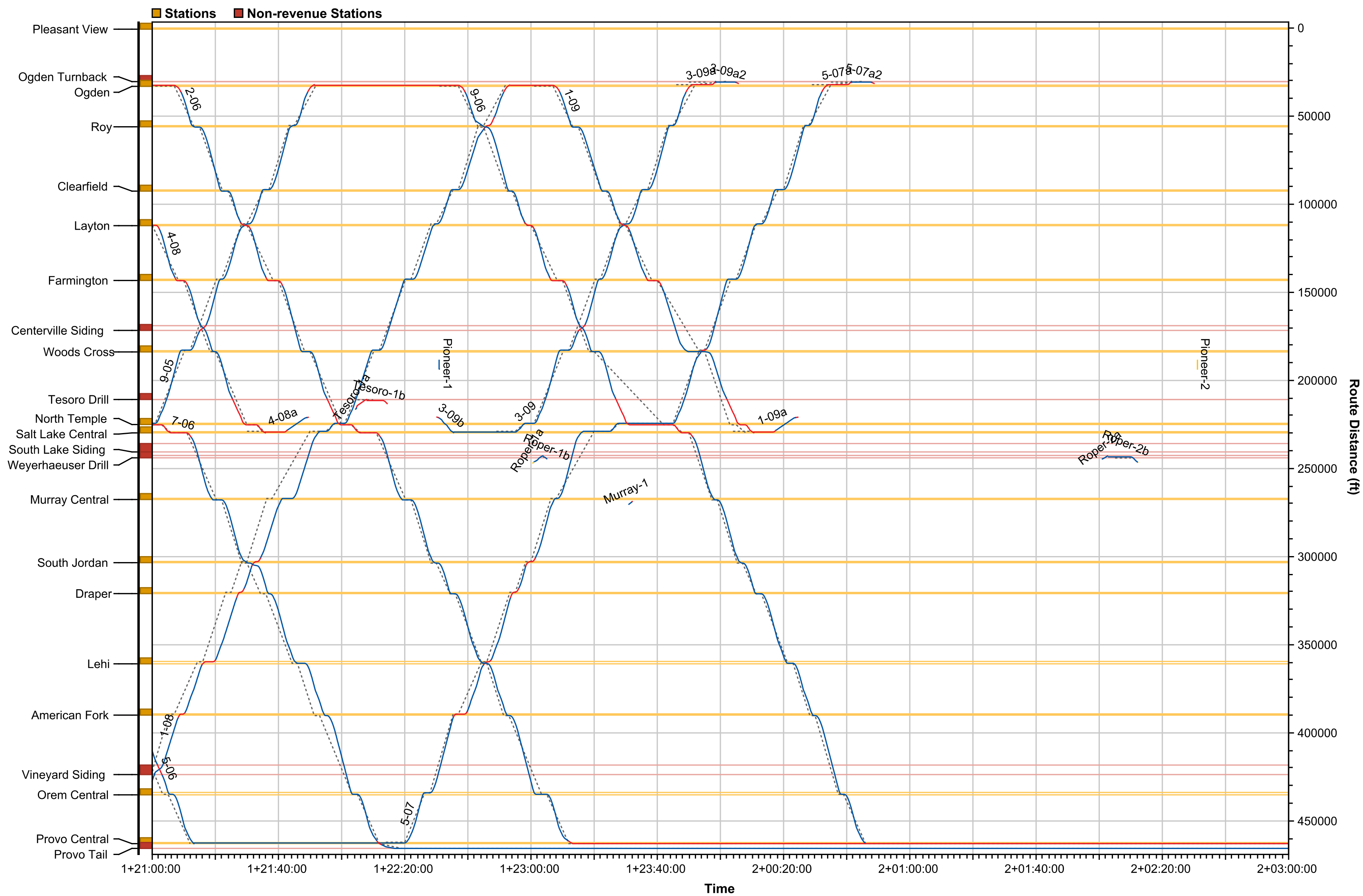


Figure 18-24: Time-Distance ("String") Chart – 9 PM – 3 AM – Day 2 Simulation Results with Perturbations

18.4 Day 3 Baseline Simulation Results with Perturbations

The FrontRunner - Day 3 operating plan includes a locomotive failure on train 1-03 between Layton station and Clearfield station causing the train to stop for 10-minutes while the locomotive is reset. Day 3 also includes a door failure for train 6-03 at Woods Cross Station. This causes an assumed 7-minute extended dwell while the door is cut out and removed from service. Station occupancy charts and string charts are included in the following sections.

18.4.1 Station Occupancy Charts – Salt Lake Central

The Salt Lake Central station occupancy charts below show four trains that arrive late enough that they also depart the station late. The causes of some of these delays are shown in the string charts in section 18.4.2.

Figure 18-25 shows train 2-02 arriving and leaving late.

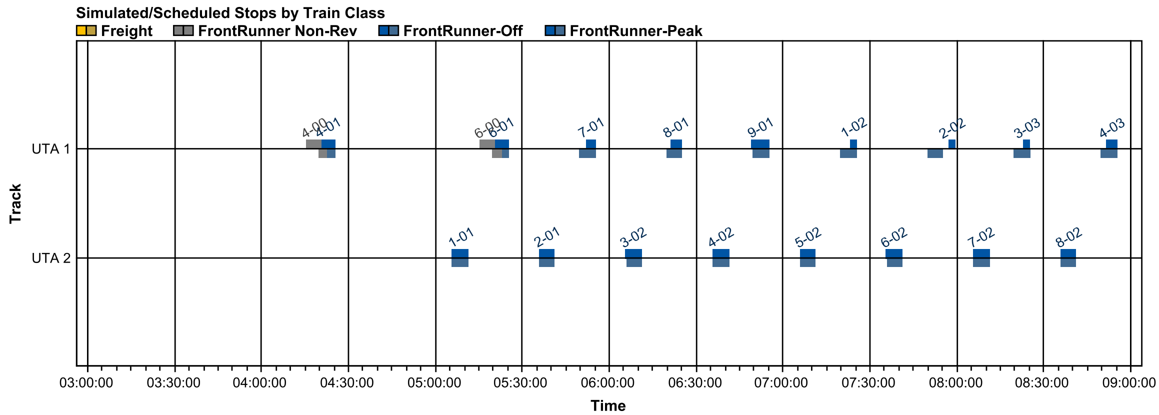


Figure 18-25: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Day 3 Simulation Results with Perturbations

Figure 18-26 shows train 1-03 and train 8-03 arriving and leaving late.

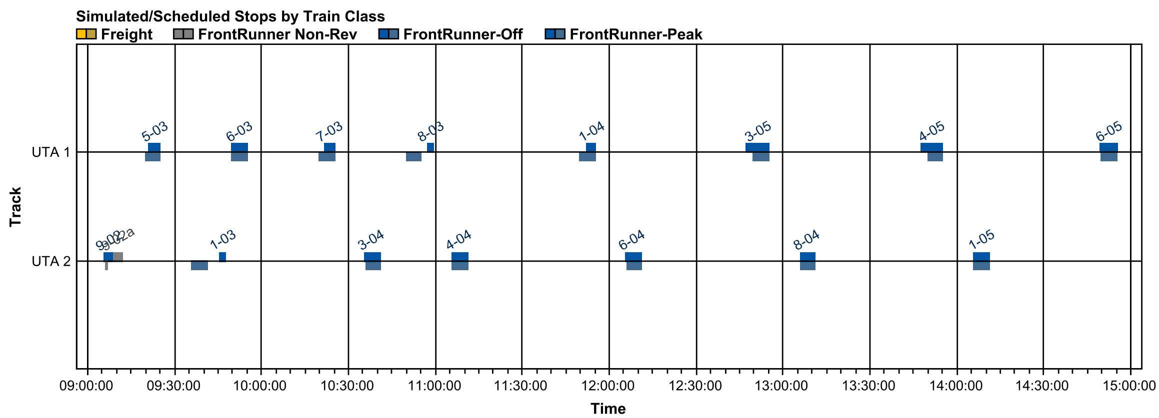


Figure 18-26: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Day 3 Simulation Results with Perturbations

Figure 18-27 shows all trains leaving Salt Lake Central on time.

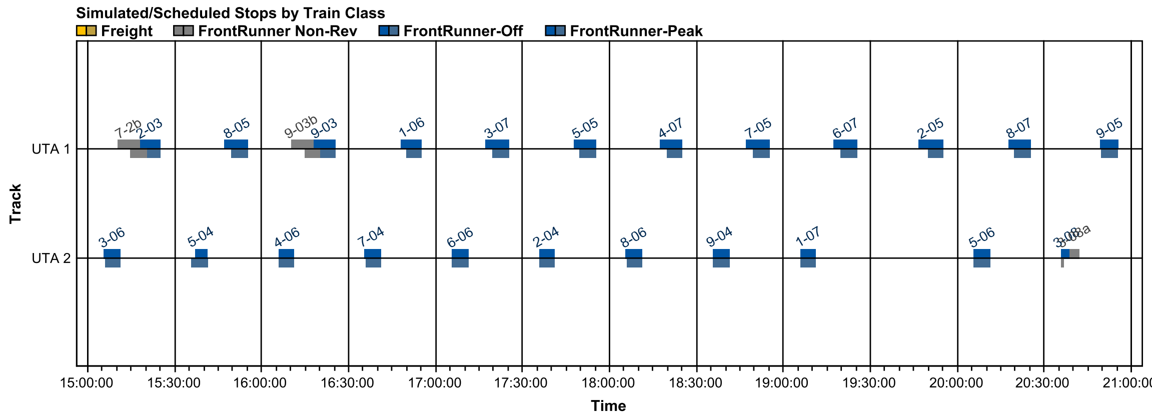


Figure 18-27: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Day 3 Simulation Results with Perturbations

Figure 18-28 shows train 1-09 arriving and leaving late.

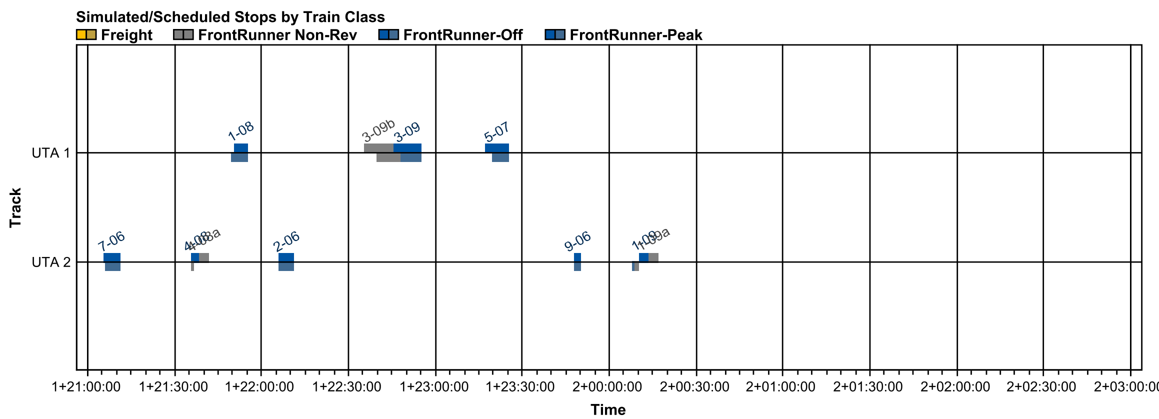


Figure 18-28: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Day 3 Simulation Results with Perturbations

18.4.2 String Charts

In Figure 18-29, train 2-01 at Draper station has randomly been assigned a significantly long dwell. Due to the prolonged dwell, train 2-01 becomes even further delayed as it waits for train 9-01 while still at Draper station. The resulting cascading delays on the South End do not resolve until noon.

The Day 3 perturbation of train 1-03 experiencing a 10-minute stop in between Clearfield station and Layton station is shown in Figure 18-29 and Figure 18-30. The 7-minute extended dwell for train 6-03 at Woods Cross station is also shown in Figure 18-30. There is enough time built into the schedule that the delay is resolved at Ogden station.

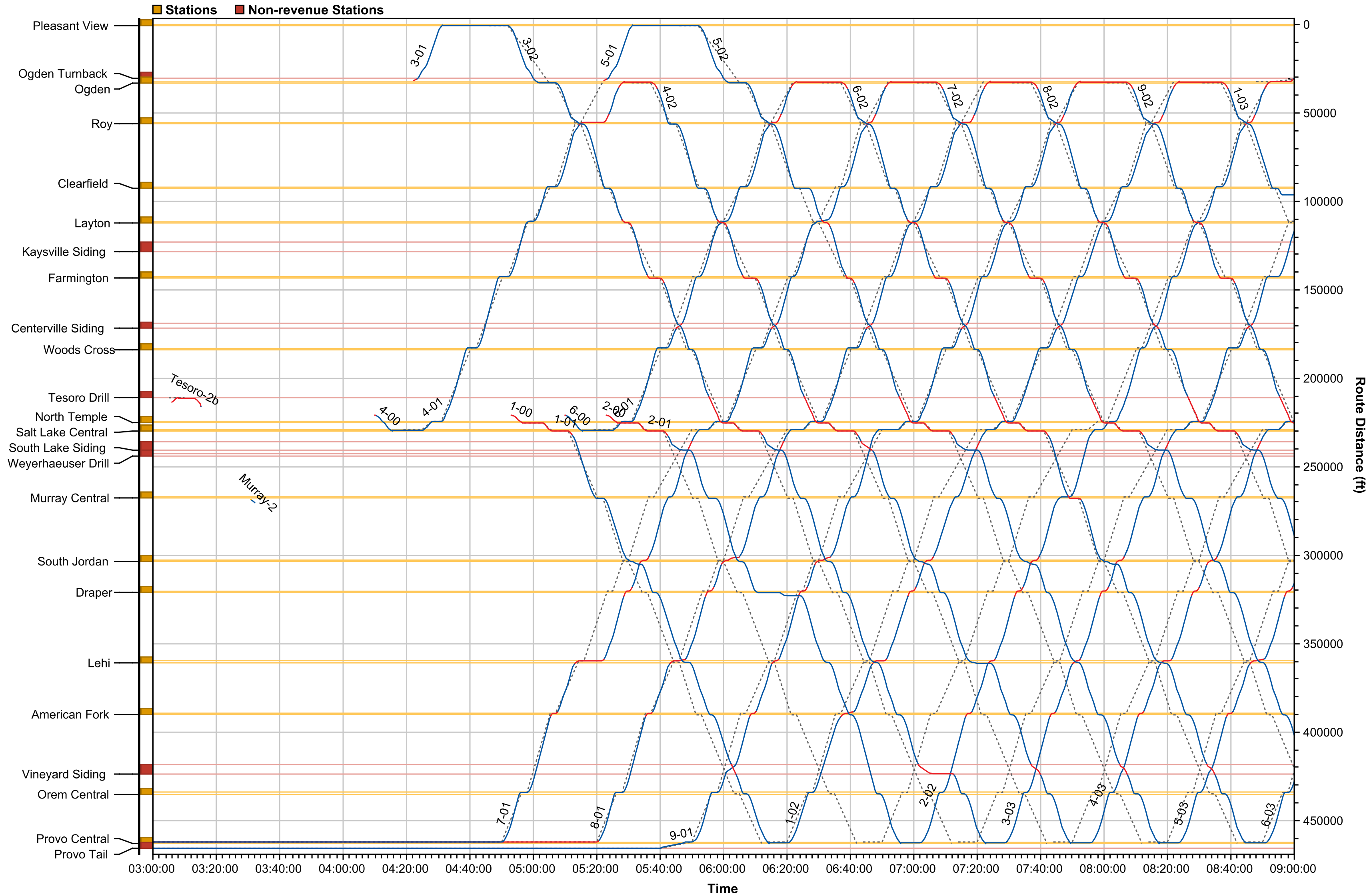


Figure 18-29: Time-Distance ("String") Chart – 3 AM – 9 AM – Day 3 Simulation Results with Perturbations

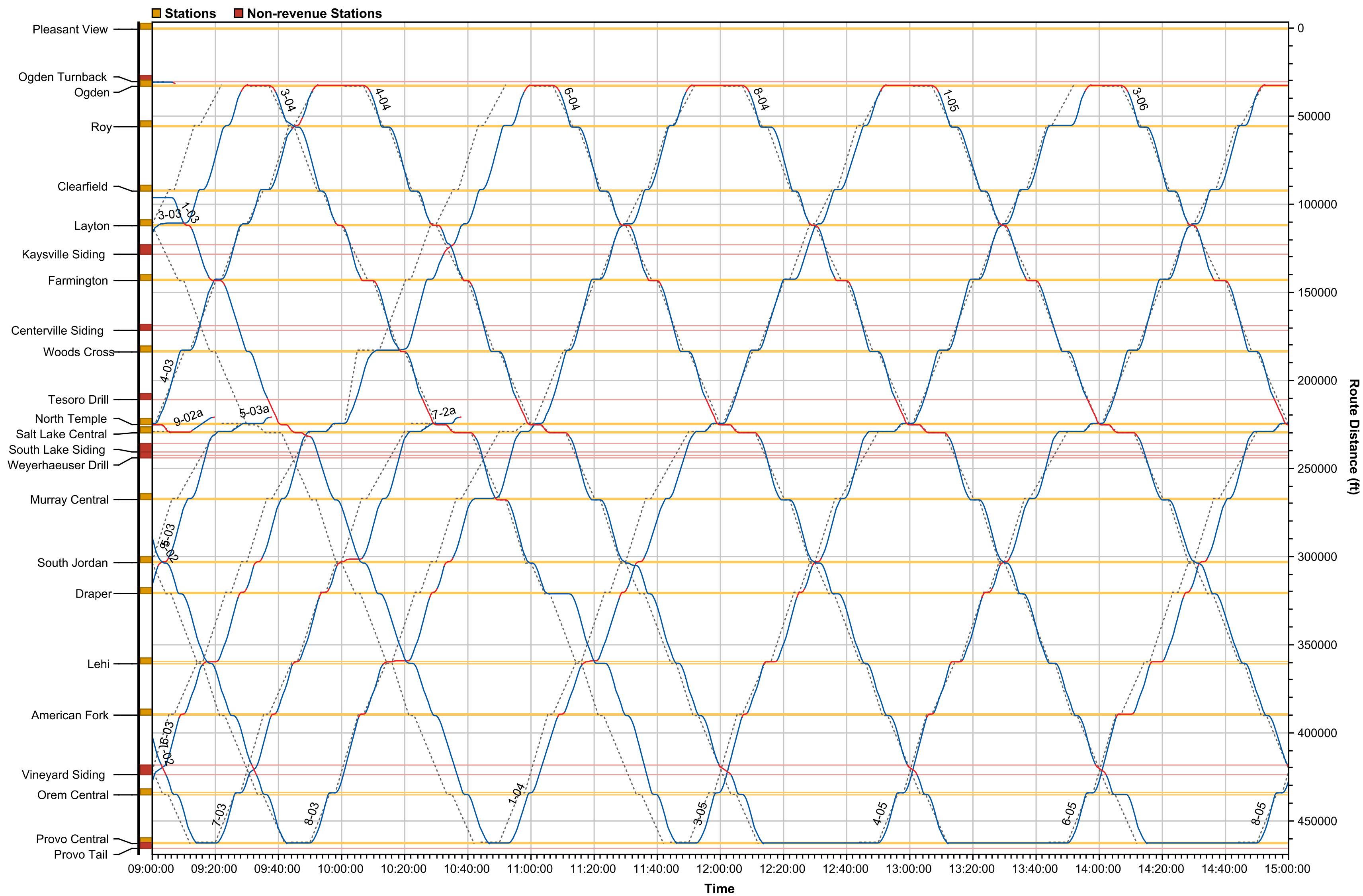


Figure 18-30: Time-Distance ("String") Chart – 9 AM – 3 PM – Day 3 Simulation Results with Perturbations

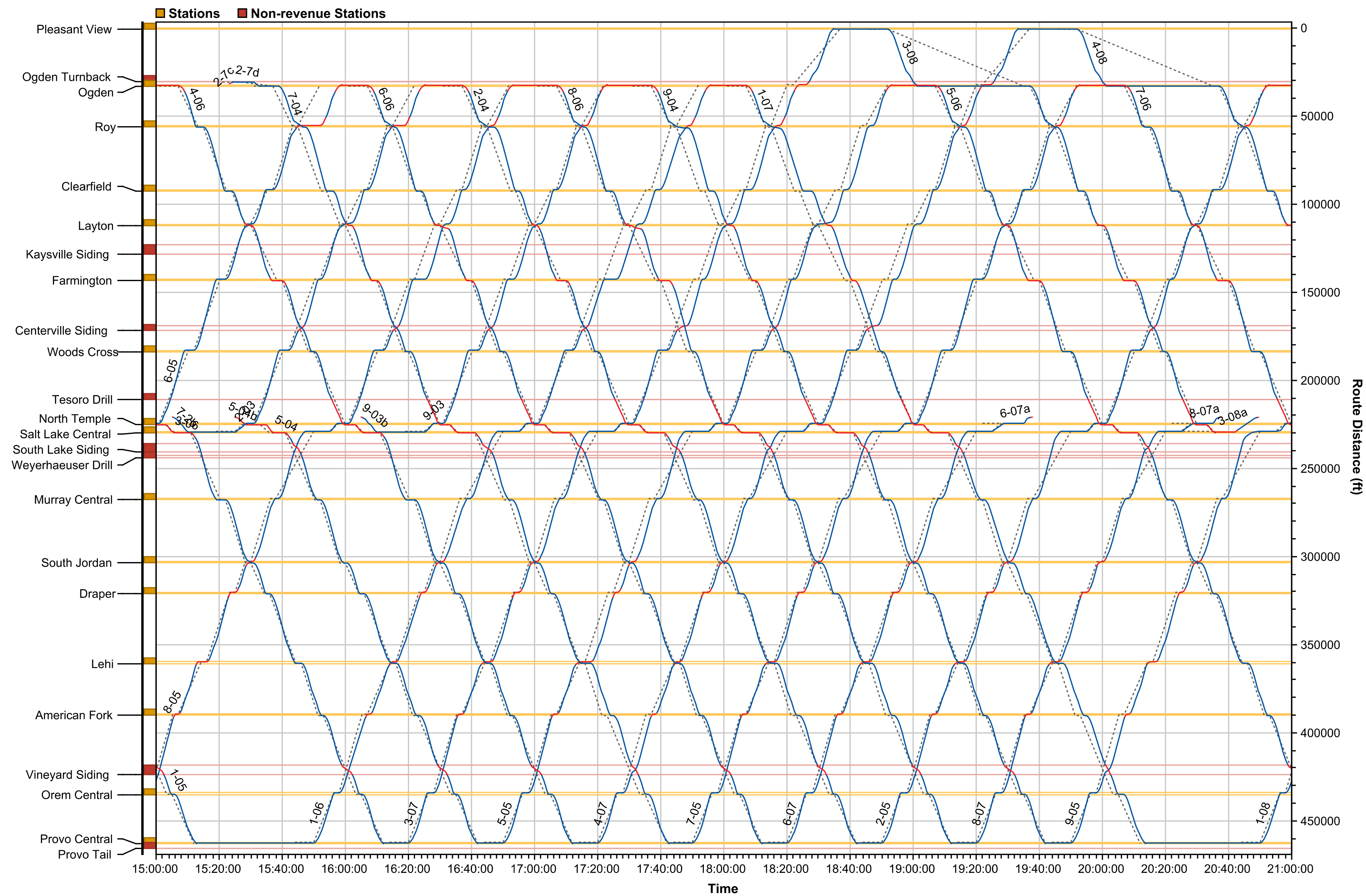


Figure 18-31: Time-Distance ("String") Chart – 3 PM – 9 PM – Day 3 Simulation Results with Perturbations

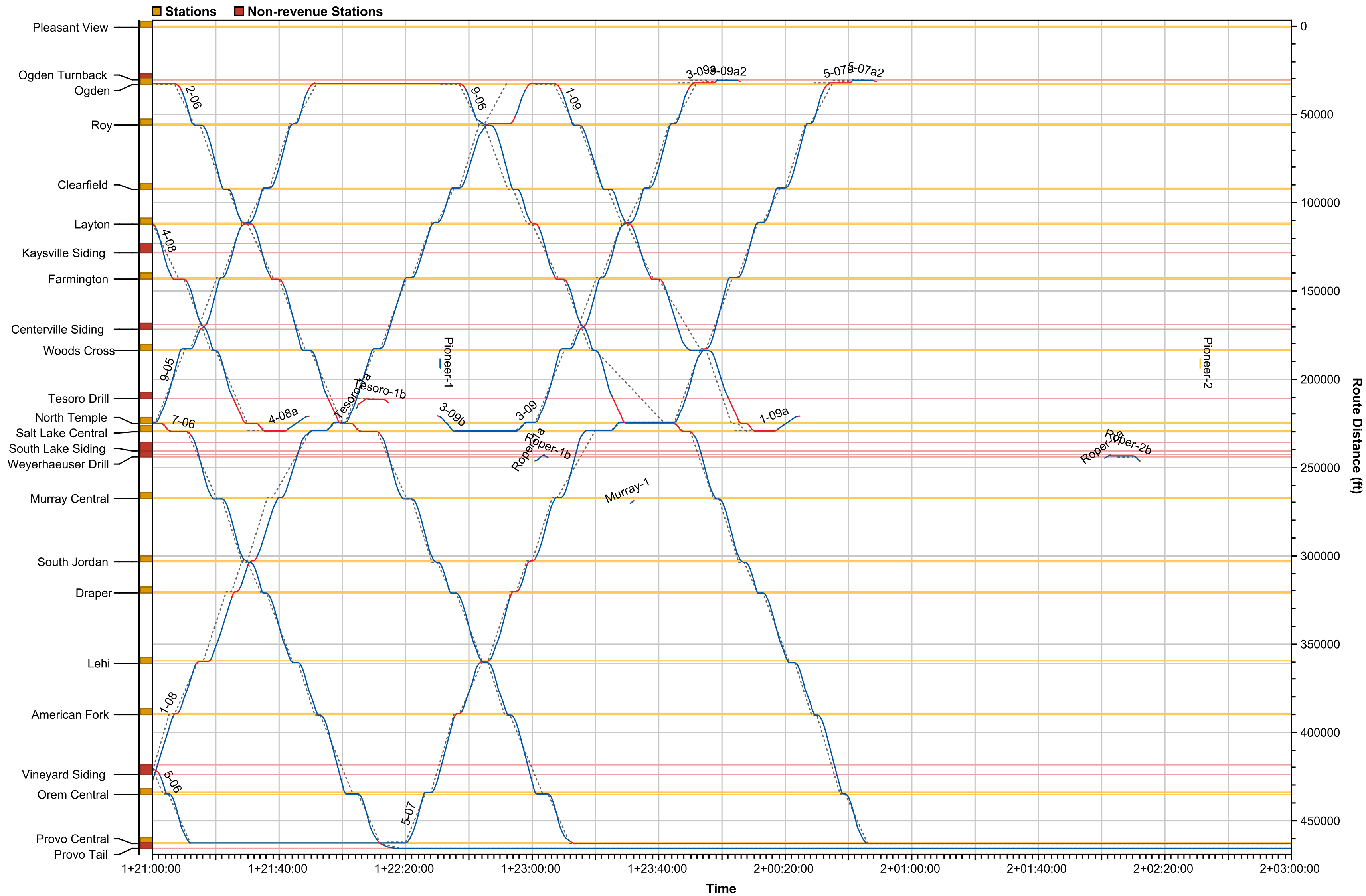


Figure 18-32: Time-Distance ("String") Chart – 9 PM – 3 AM – Day 3 Simulation Results with Perturbations

18.5 Day 4 Baseline Simulation Results with Perturbations

The FrontRunner - Day 4 operating plan includes a door failure for train 7-03 at Orem Station. This causes an assumed 7-minute extended dwell while the door failure is resolved. Day 4 also includes a 15 MPH speed restriction through 9400 South Grade Crossing (North of South Jordan) from 6:30 AM through 8:30 AM due to a crossing failure/broken gate. Salt Lake Central station occupancy charts and full network string charts are included in the following sections.

18.5.1 Station Occupancy Charts – Salt Lake Central

The occupancy charts below show a total of eight trains that arrive late enough that they also depart the station late. Six of these are northbound trains between 7:00 AM and 11:00 AM.

Figure 18-33 shows train 8-01, train 9-01 and train 1-02 arriving and leaving late.

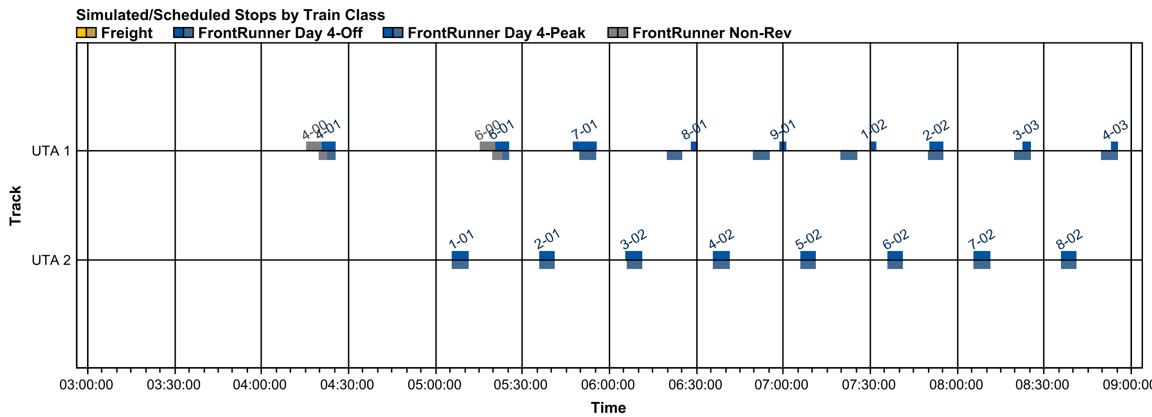


Figure 18-33: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Day 4 Simulation Results with Perturbations

Figure 18-34 shows train 9-02, train 5-03, train 7-03 and train 8-03 arriving and leaving late.

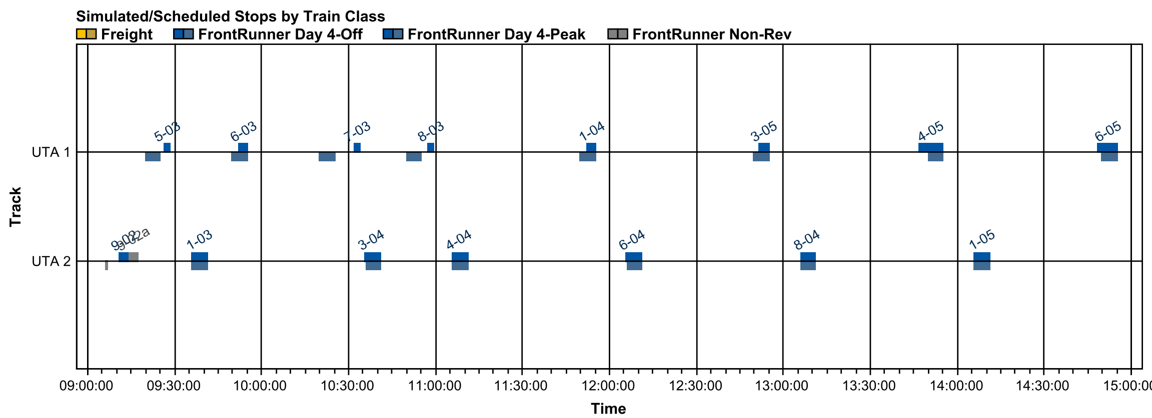


Figure 18-34: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Day 4 Simulation Results with Perturbations

Figure 18-35 shows all trains leaving on time.

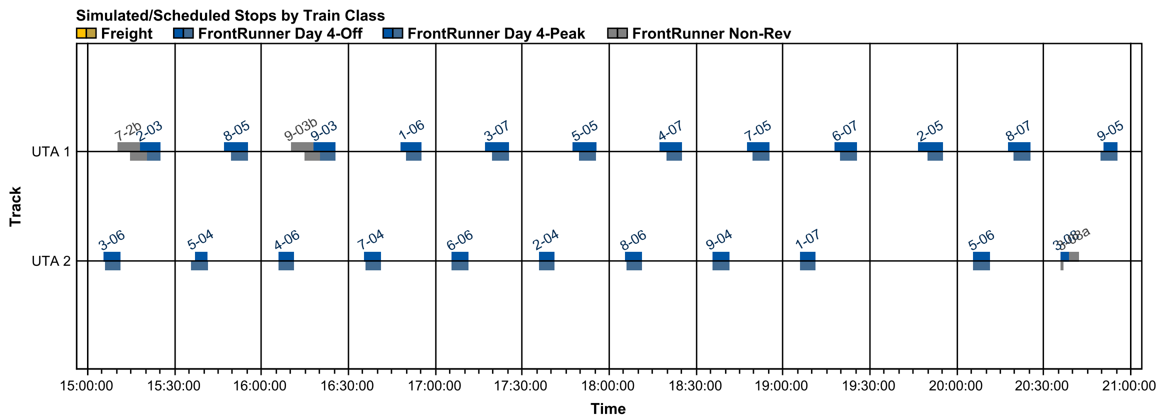


Figure 18-35: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Day 4 Simulation Results with Perturbations

Figure 18-36 shows train 1-09 arriving and leaving late.

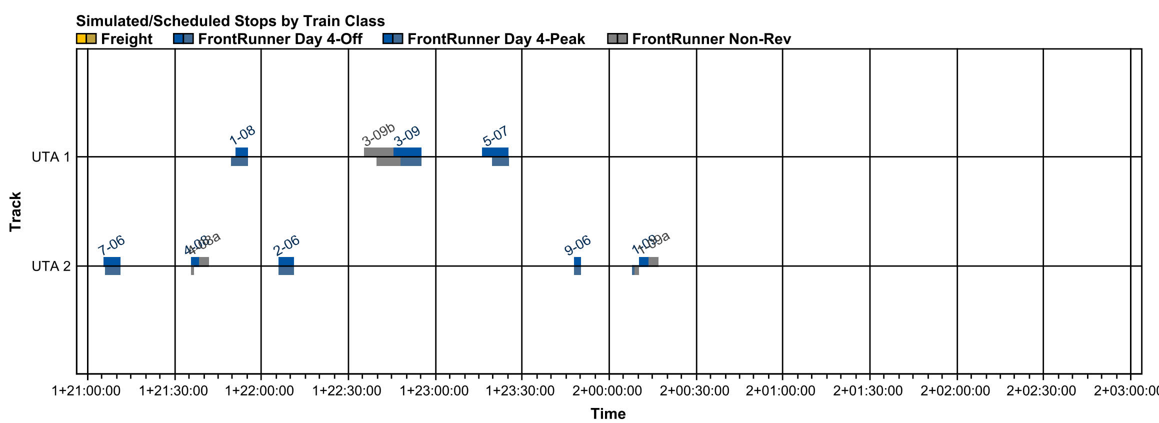


Figure 18-36: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Day 4 Simulation Results with Perturbations

18.5.2 String Charts

The Day 4 perturbation of a 15 MPH speed restriction through a grade crossing just north of South Jordan is shown in Figure 18-37. This along with a significantly long dwell randomly assigned to train 1-01 at Draper causes cascading delays to the northbound trains throughout the morning peak period.

Figure 18-38 shows the door failure for train 7-03 at Orem Station. This assumed 7-minute extended dwell while the door is disabled causes train 8-02 to wait on Vineyard siding for the meet and then to leave Provo late as a result.

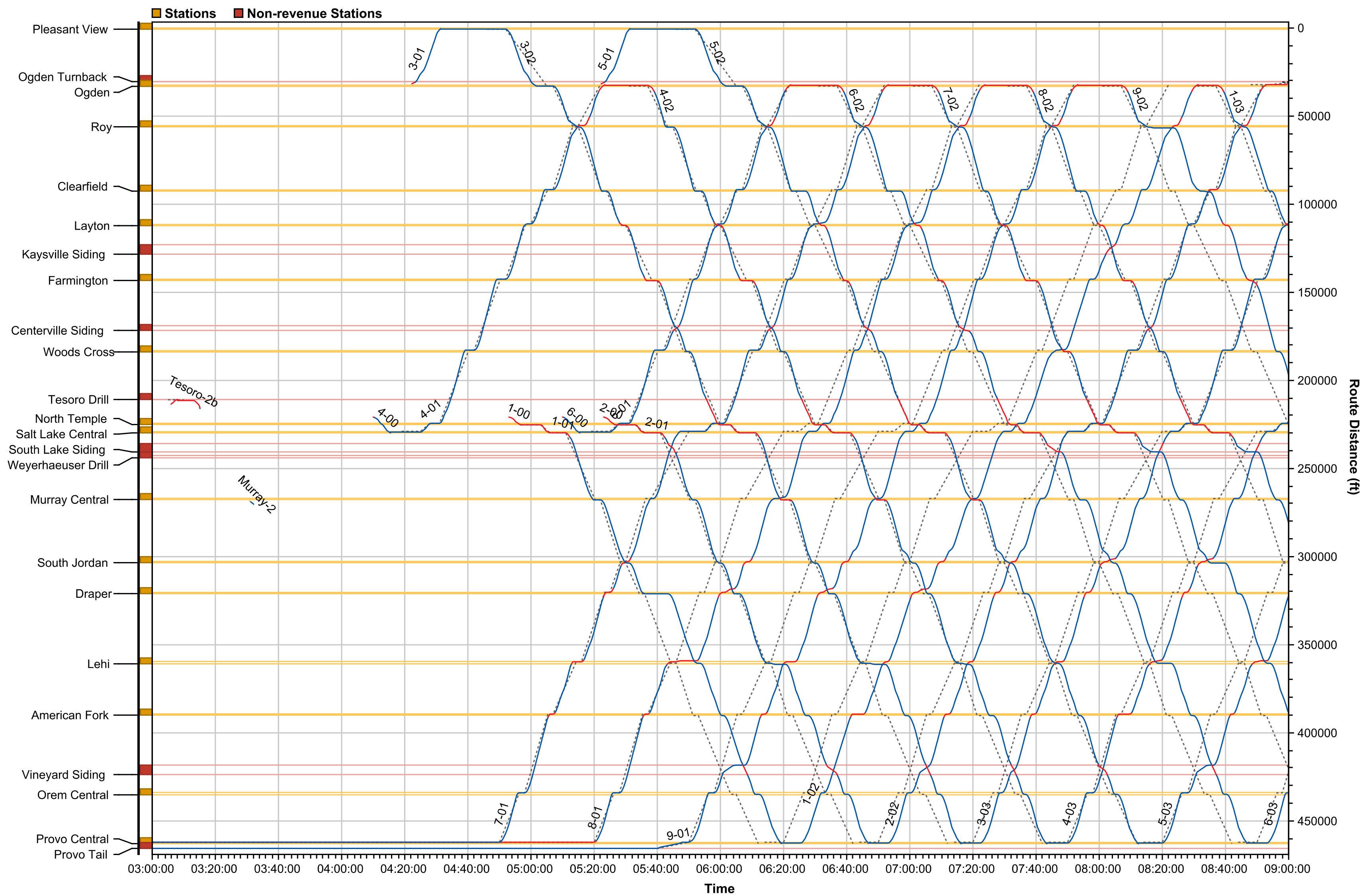


Figure 18-37: Time-Distance ("String") Chart – 3 AM – 9 AM – Day 4 Simulation Results with Perturbations

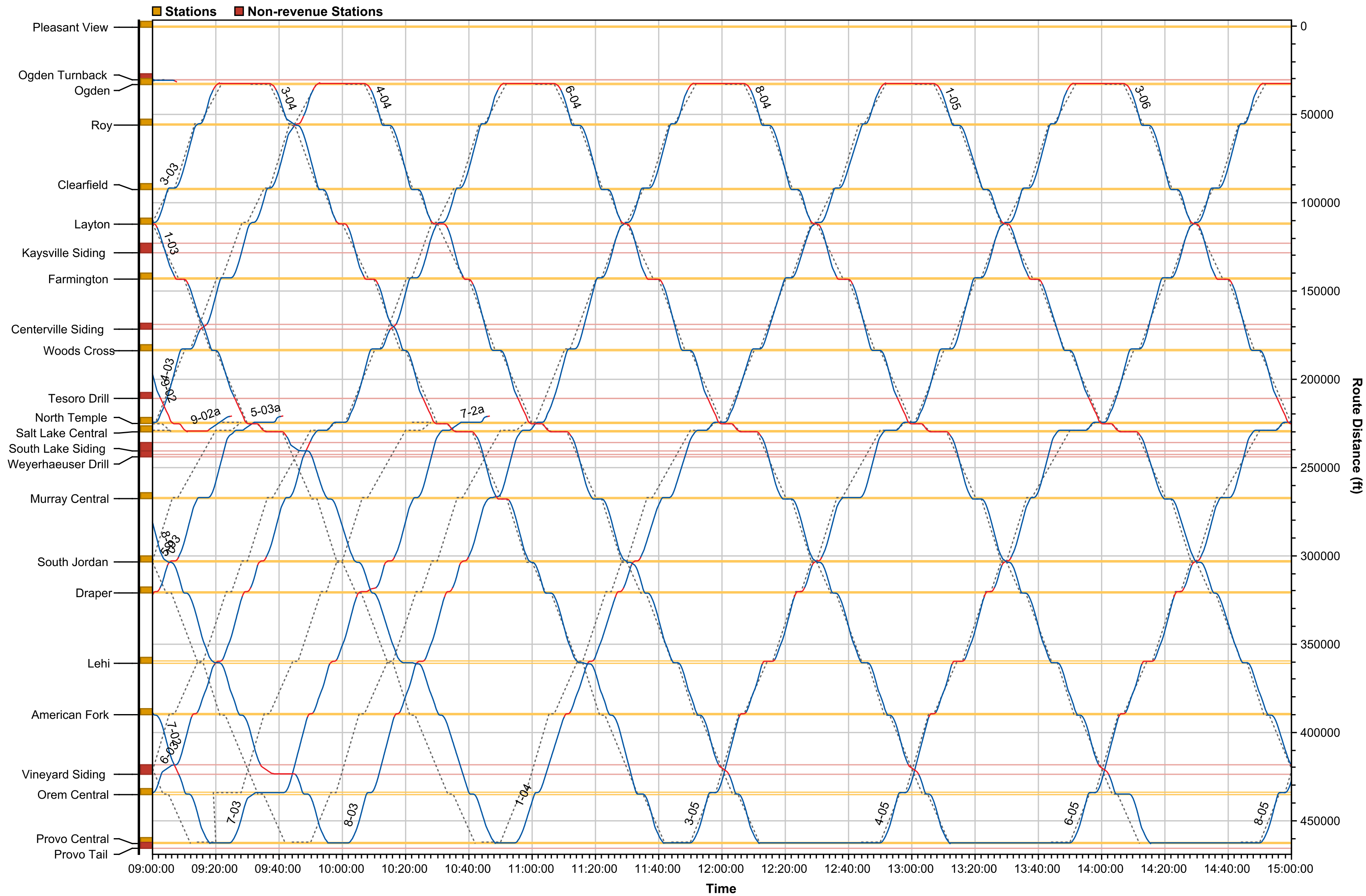


Figure 18-38: Time-Distance ("String") Chart – 9 AM – 3 PM – Day 4 Simulation Results with Perturbations

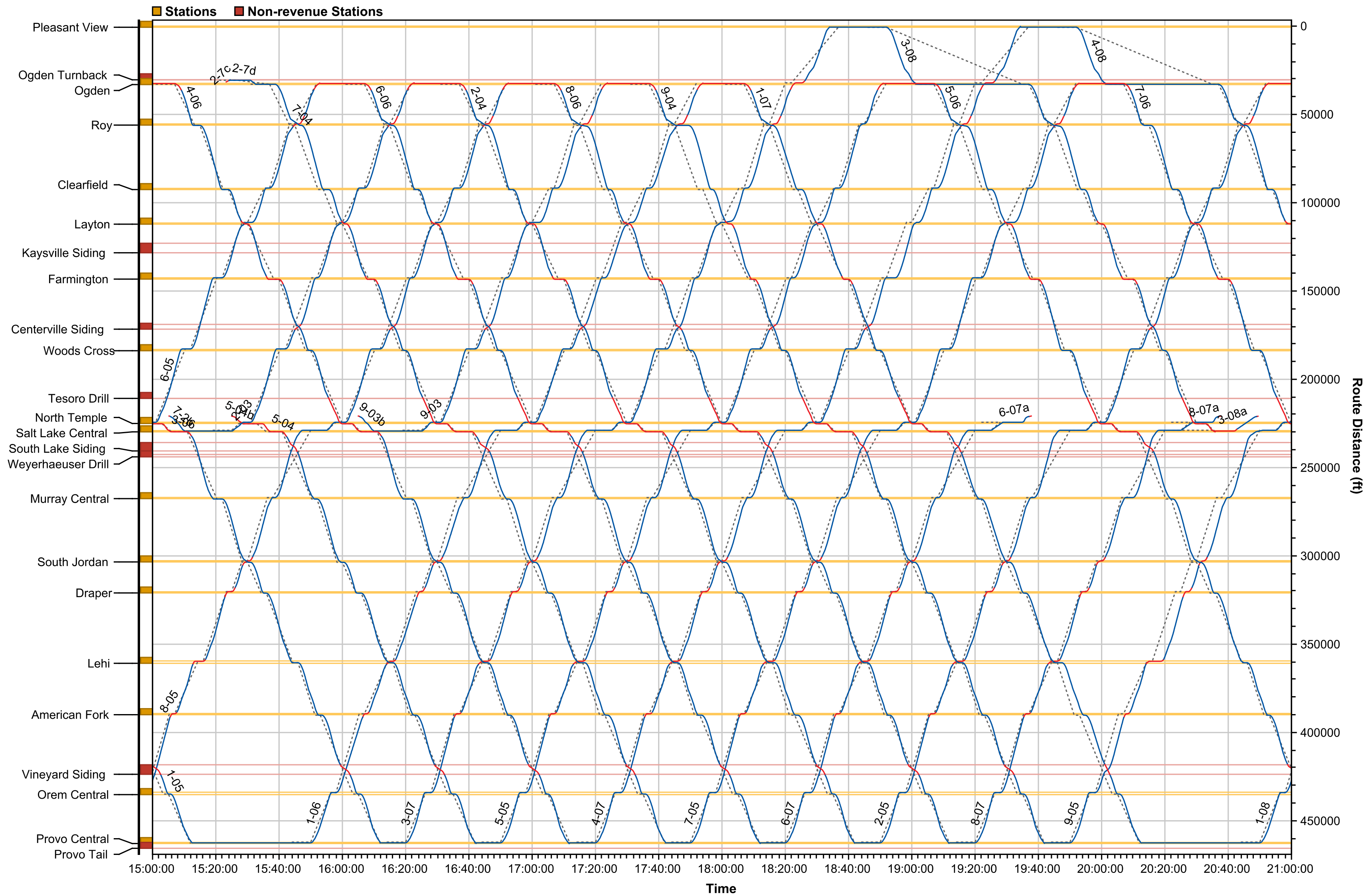


Figure 18-39: Time-Distance (“String”) Chart – 3 PM – 9 PM – Day 4 Simulation Results with Perturbations

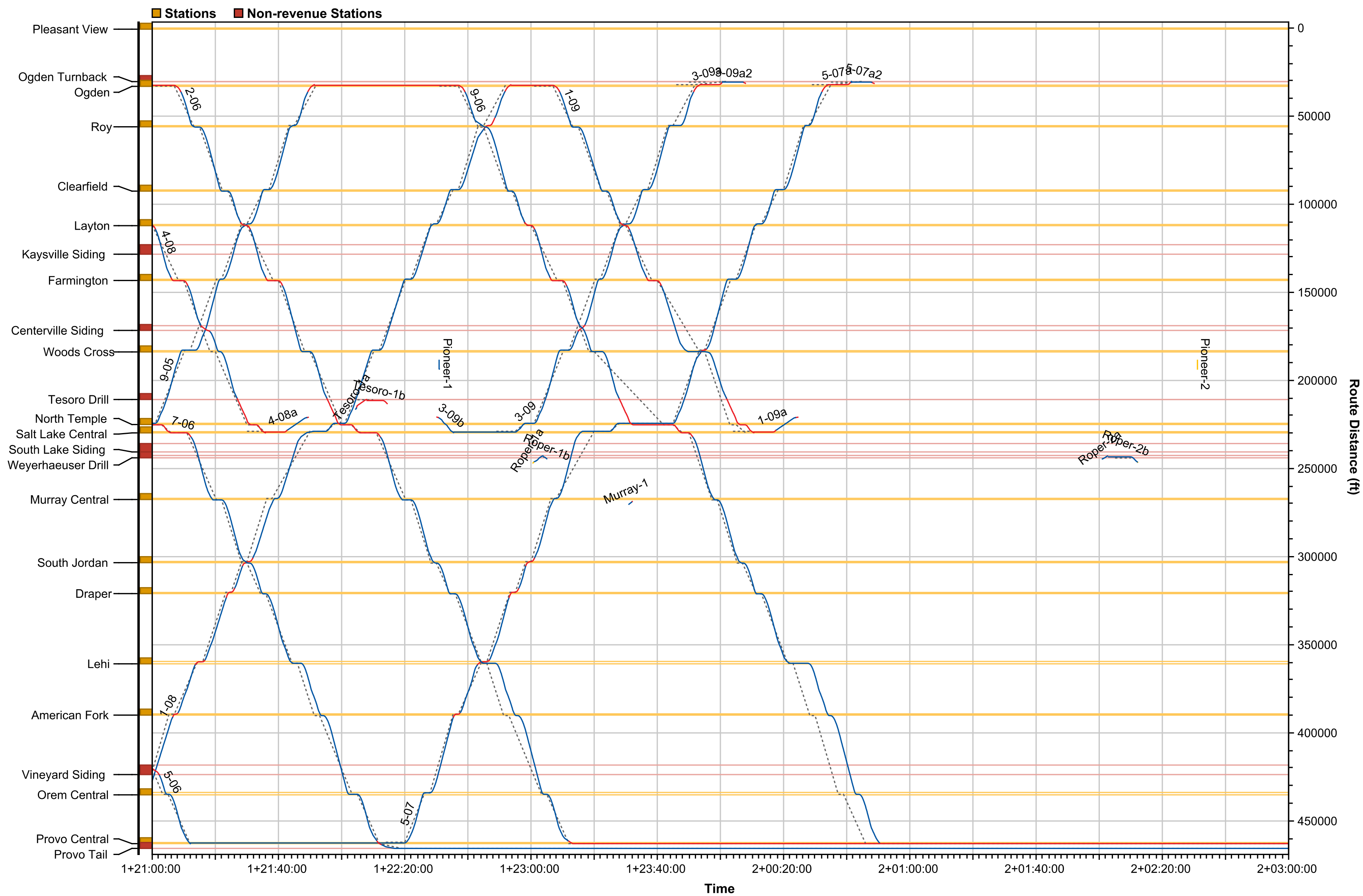


Figure 18-40: Time-Distance ("String") Chart – 9 PM – 3 AM – Day 4 Simulation Results with Perturbations

18.6 Day 5 Baseline Simulation Results with Perturbations

The FrontRunner - Day 5 operating plan includes a 5-minute delay for train 1-02 at North Temple due to assumed need to hold for a late connecting TRAX train. Day 5 also includes a locomotive failure on train 7-04 between Lehi station and American Fork station causing the train to stop for 10-minutes while the locomotive is reset. Station occupancy charts and string charts are included in the following sections.

18.6.1 Station Occupancy Charts – Salt Lake Central

The Salt Lake Central station occupancy charts below show a total of six trains that arrive late enough that they also depart the station late.

Figure 18-41 shows all trains leaving Salt Lake Central Station on time.

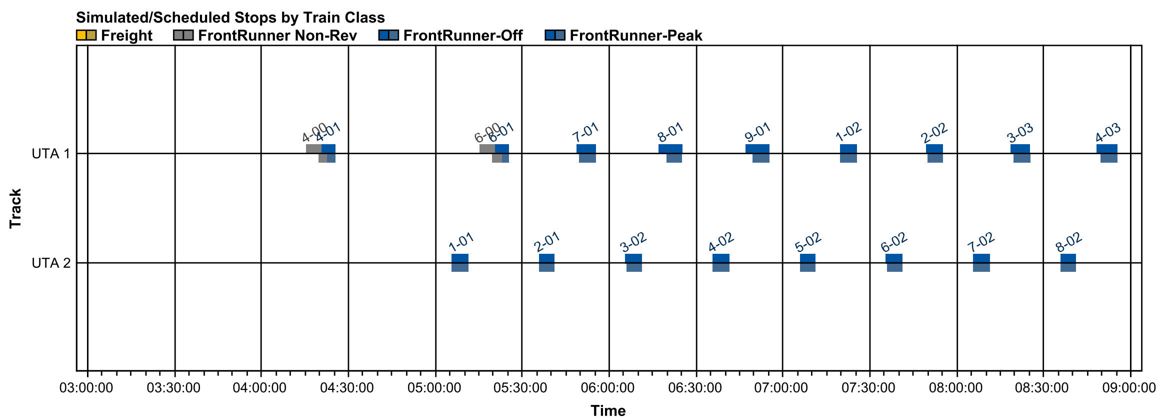


Figure 18-41: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Day 5 Simulation Results with Perturbations

Figure 18-42 shows train 9-02 arriving and leaving late.

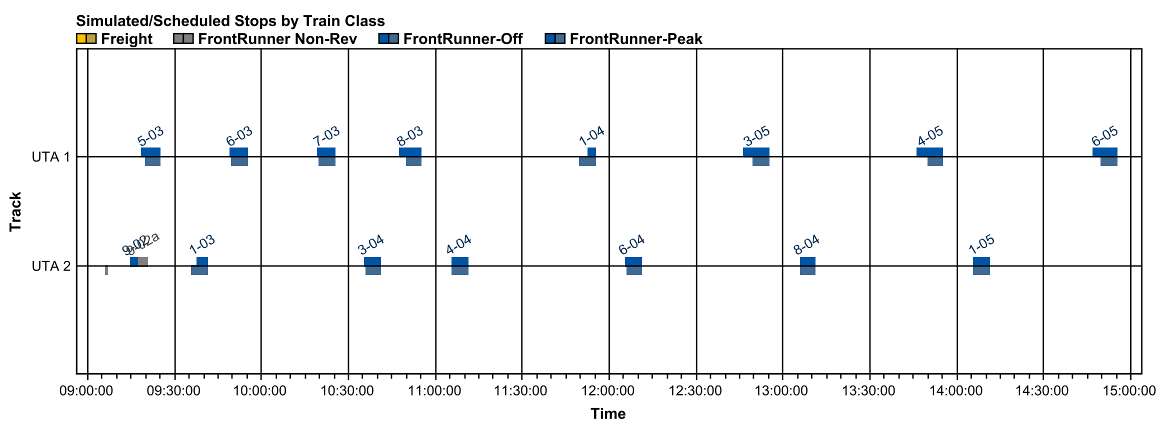


Figure 18-42: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Day 5 Simulation Results with Perturbations

Figure 18-43 shows train 1-06, train 7-05 and train 2-05 arriving and leaving late.

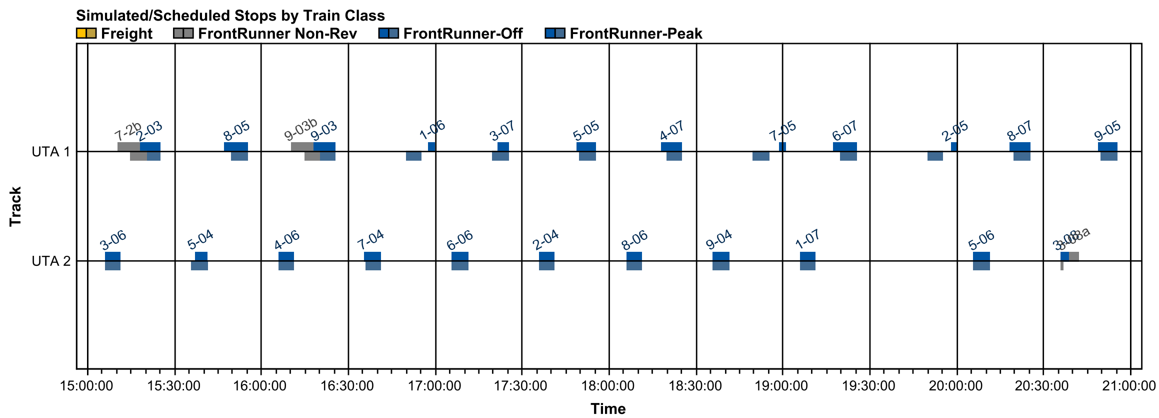


Figure 18-43: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Day 5 Simulation Results with Perturbations

Figure 18-44 shows train 4-08 and train 1-09 arriving and leaving late.

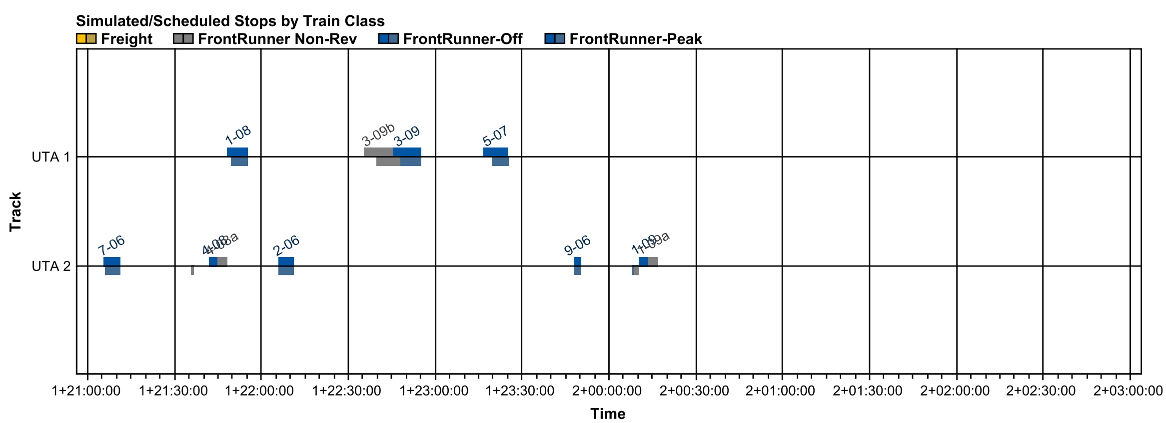


Figure 18-44: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Day 5 Simulation Results with Perturbations

18.6.2 String Charts

Figure 18-45 shows that train 1-02 has been randomly assigned the 5-minute delay perturbation at North Temple station. Train 9-02 is significantly delayed at Roy station waiting for the meet with train 1-02. This cascades and causes delays for each train that train 9-02 meets until it lays up at Warm Springs Yard.

Train 5-04 is randomly assigned a significantly long dwell at South Jordan station. This causes delays for train 1-06 while it waits at Lehi station. Under the Day 5 perturbations, train 7-05 is randomly assigned a locomotive failure and stops for 10-minutes between Lehi station and American Fork station as shown in Figure 18-47.

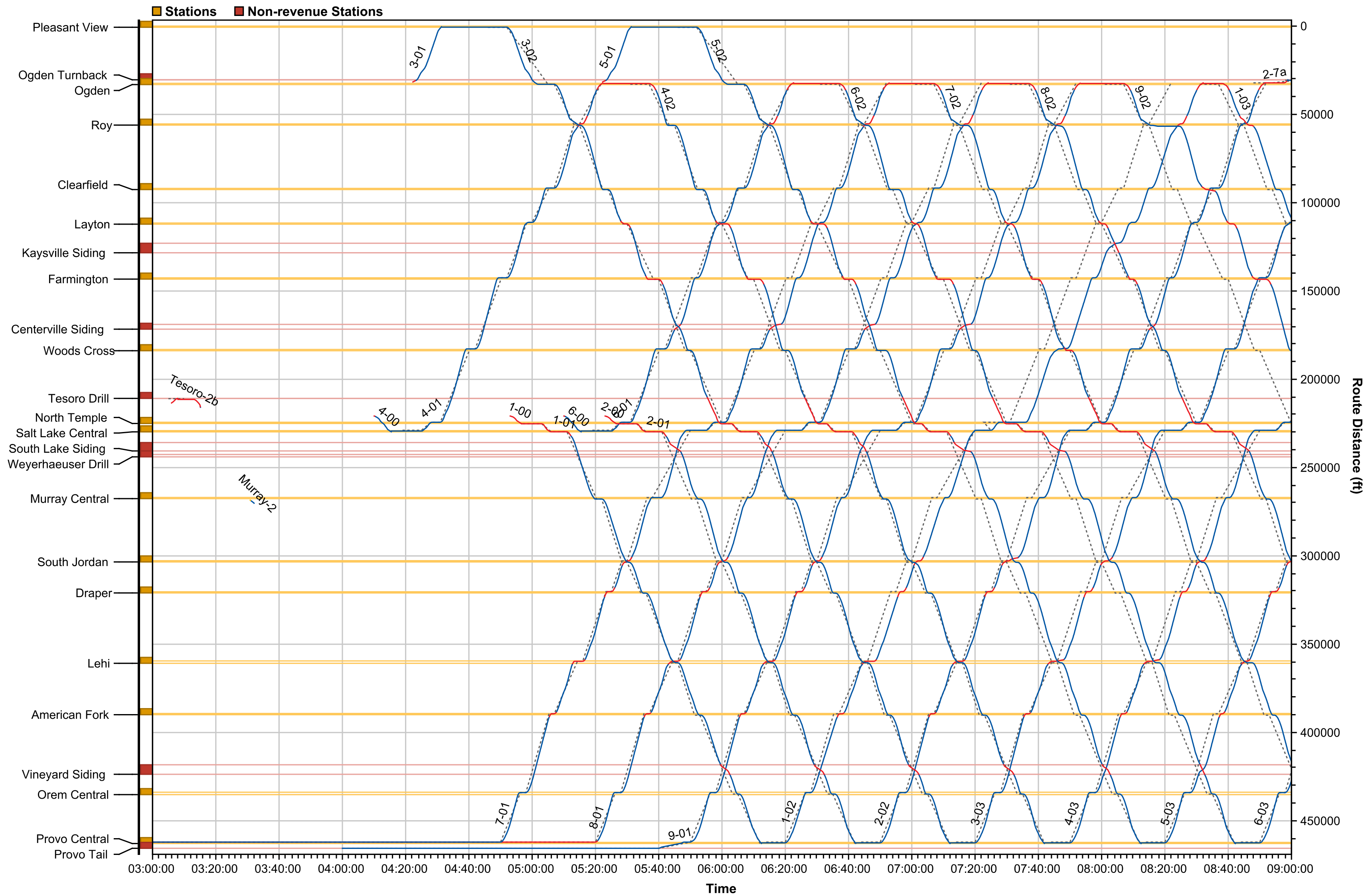


Figure 18-45: Time-Distance ("String") Chart – 3 AM – 9 AM – Day 5 Simulation Results with Perturbations

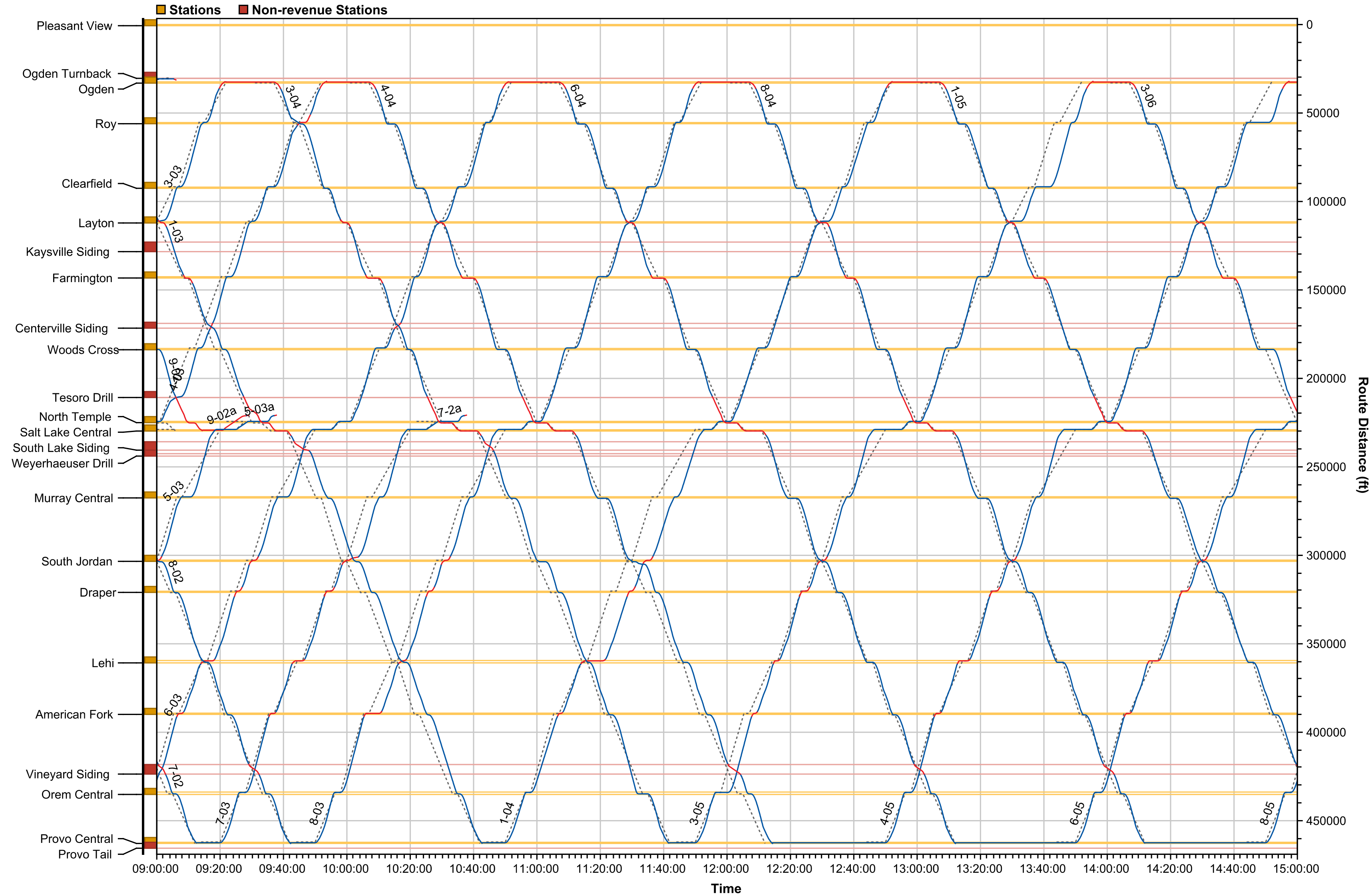


Figure 18-46: Time-Distance ("String") Chart – 9 AM – 3 PM – Day 5 Simulation Results with Perturbations

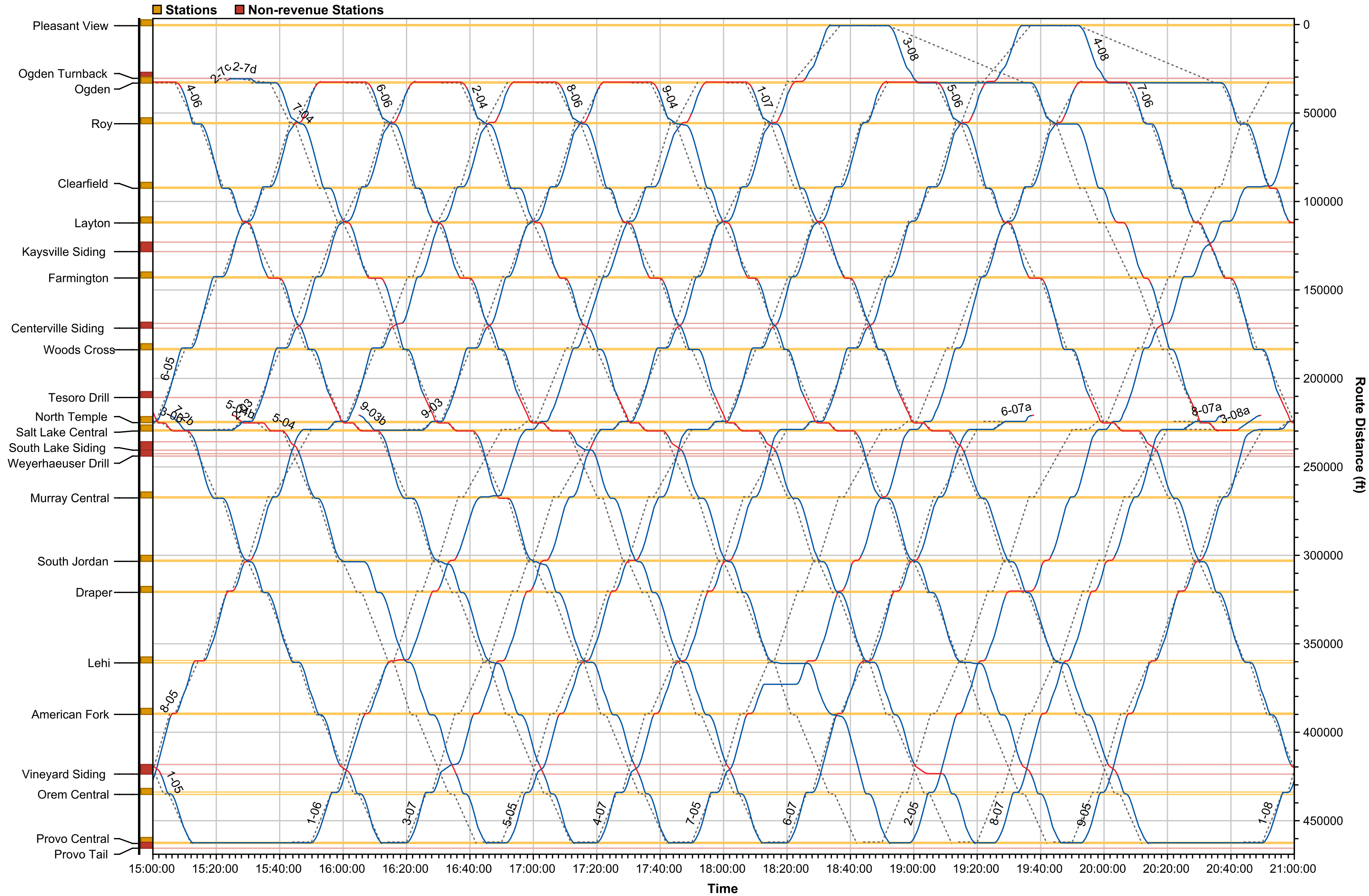


Figure 18-47: Time-Distance ("String") Chart – 3 PM – 9 PM – Day 5 Simulation Results with Perturbations

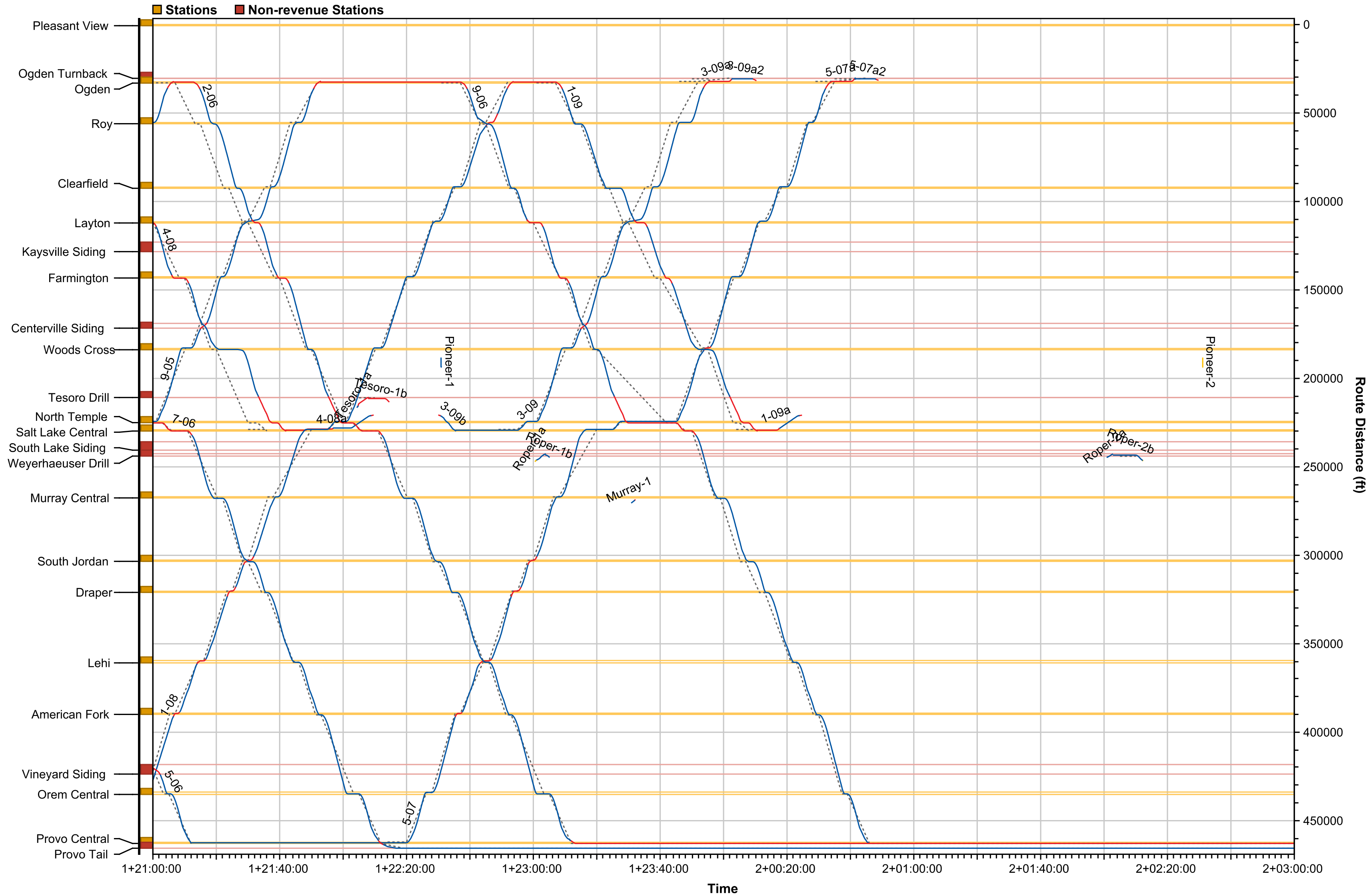


Figure 18-48: Time-Distance ("String") Chart – 9 PM – 3 AM – Day 5 Simulation Results with Perturbations

19 Appendix D Future Baseline Time-Distance (“String”) Charts and Station Occupancy Charts

19.1 Future Baseline with PTC Simulation Results without Perturbations (Ideal Day)

19.1.1 Station Occupancy Charts – Salt Lake Central

Northbound trains are shown on UTA1 with southbound trains on UTA2. Unlike the Baseline No Added Perturbations results, most trains in the simulation are not seen arriving and departing on time at Salt Lake Central Station. The northbound trains have a six-minute dwell built into their schedule. When the northbound trains arrive late, almost all are able to recover and still leave on time. The exception is train 6-07 shown in Figure 19-3. The southbound trains have just a three-minute dwell scheduled that in this simulation results in almost half of the through trains arriving and departing late.

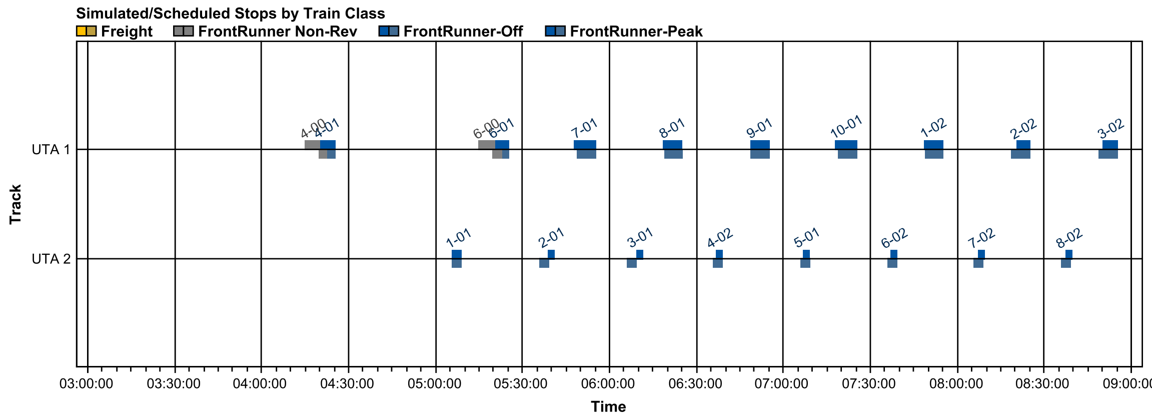


Figure 19-1: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Future with PTC No Added Perturbations

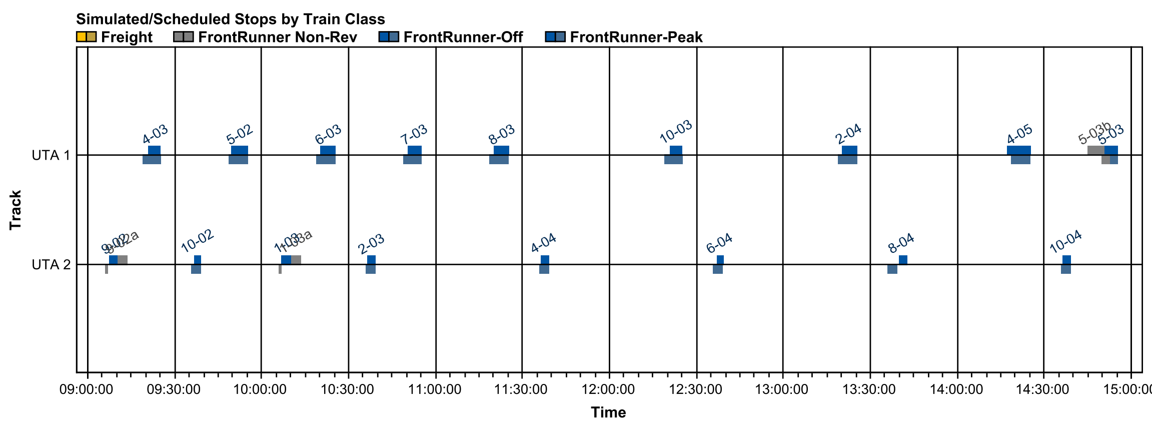


Figure 19-2: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Future with PTC No Added Perturbations

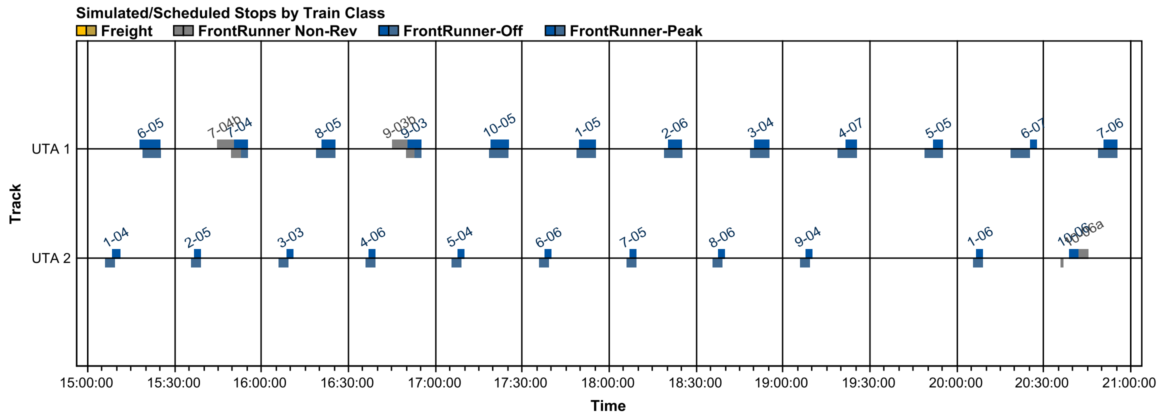


Figure 19-3: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Future with PTC No Added Perturbations

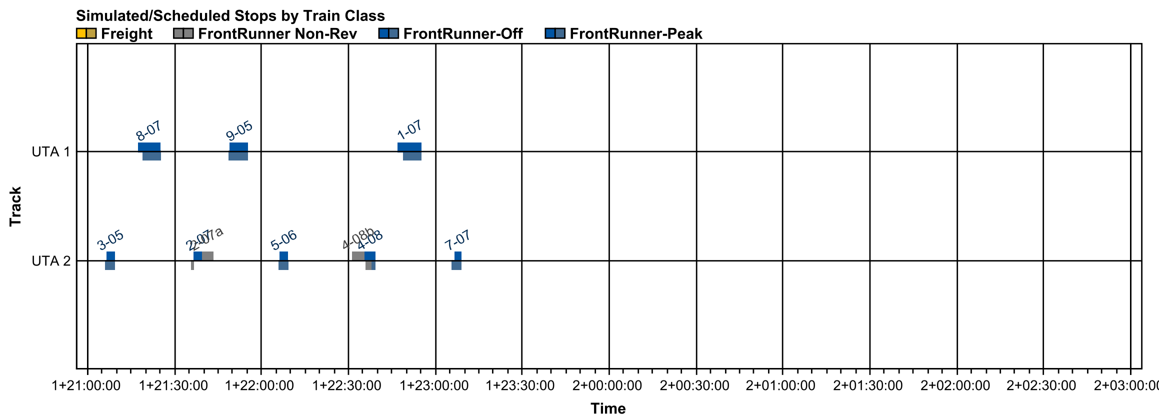


Figure 19-4: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Future with PTC No Added Perturbations

19.1.2 String Charts

Delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones. The trains, on FrontRunner North, run very close to on-time in the No Added Perturbations run. Train 1-01, shown in Figure 19-5, got a long dwell at South Jordan (117 seconds) causing it to leave 74 seconds late. The future meets are pushed later between this train and each train it meets, as well as the trains that those meet causing a cascading delay. The cascading delay is only shown in FrontRunner South as the trains heading north are able to recover and get back on schedule around North Temple.

Figure 19-6 shows that train 6-04 and train 10-04 are randomly assigned long dwells at Roy. Additionally, Train 2-04 receives a long dwell at Lehi. All three trains recover to schedule by the time they leave North Temple.

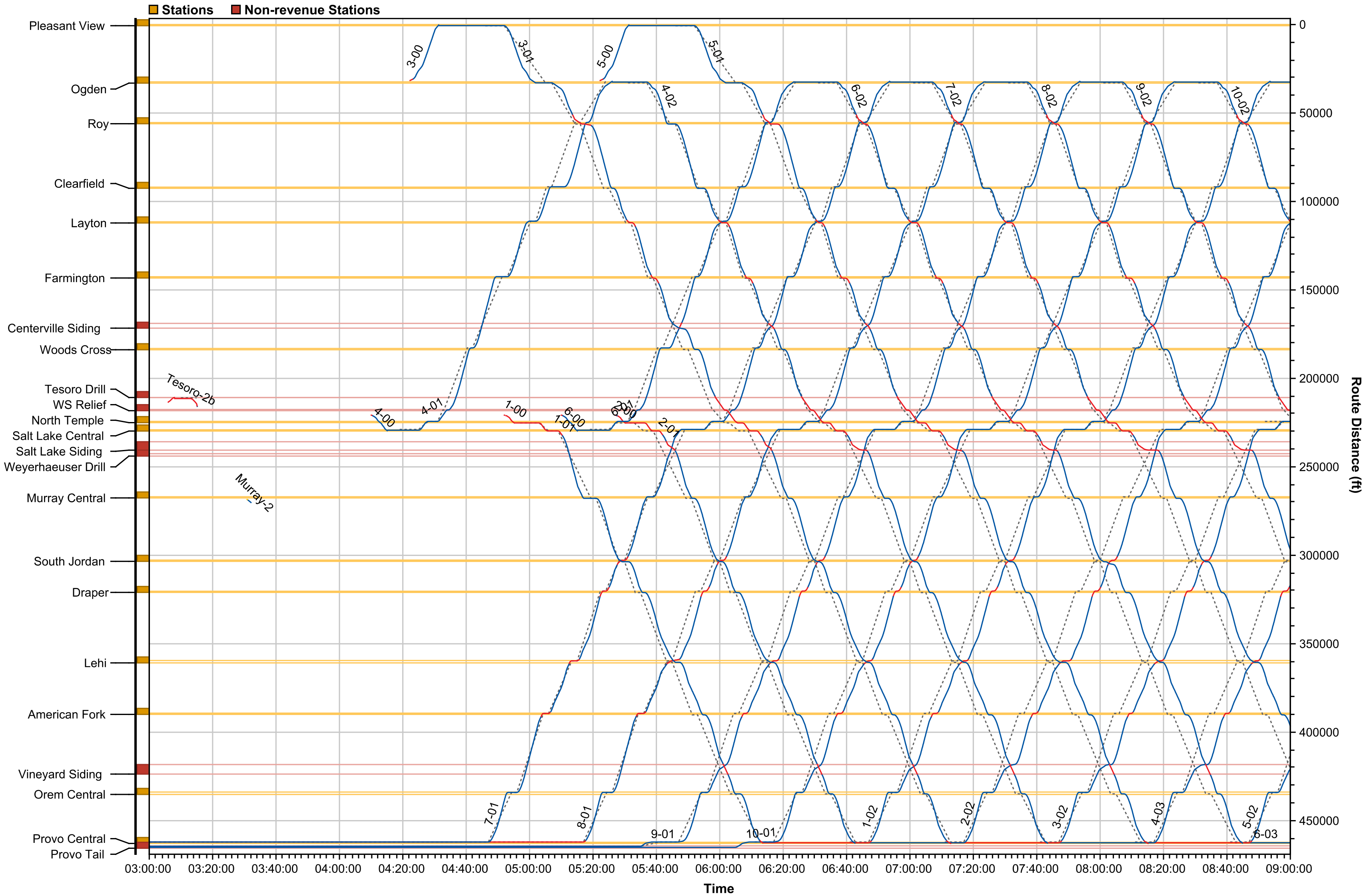


Figure 19-5: Time-Distance ("String") Chart – 3 AM – 9 AM – Future with PTC No Added Perturbations

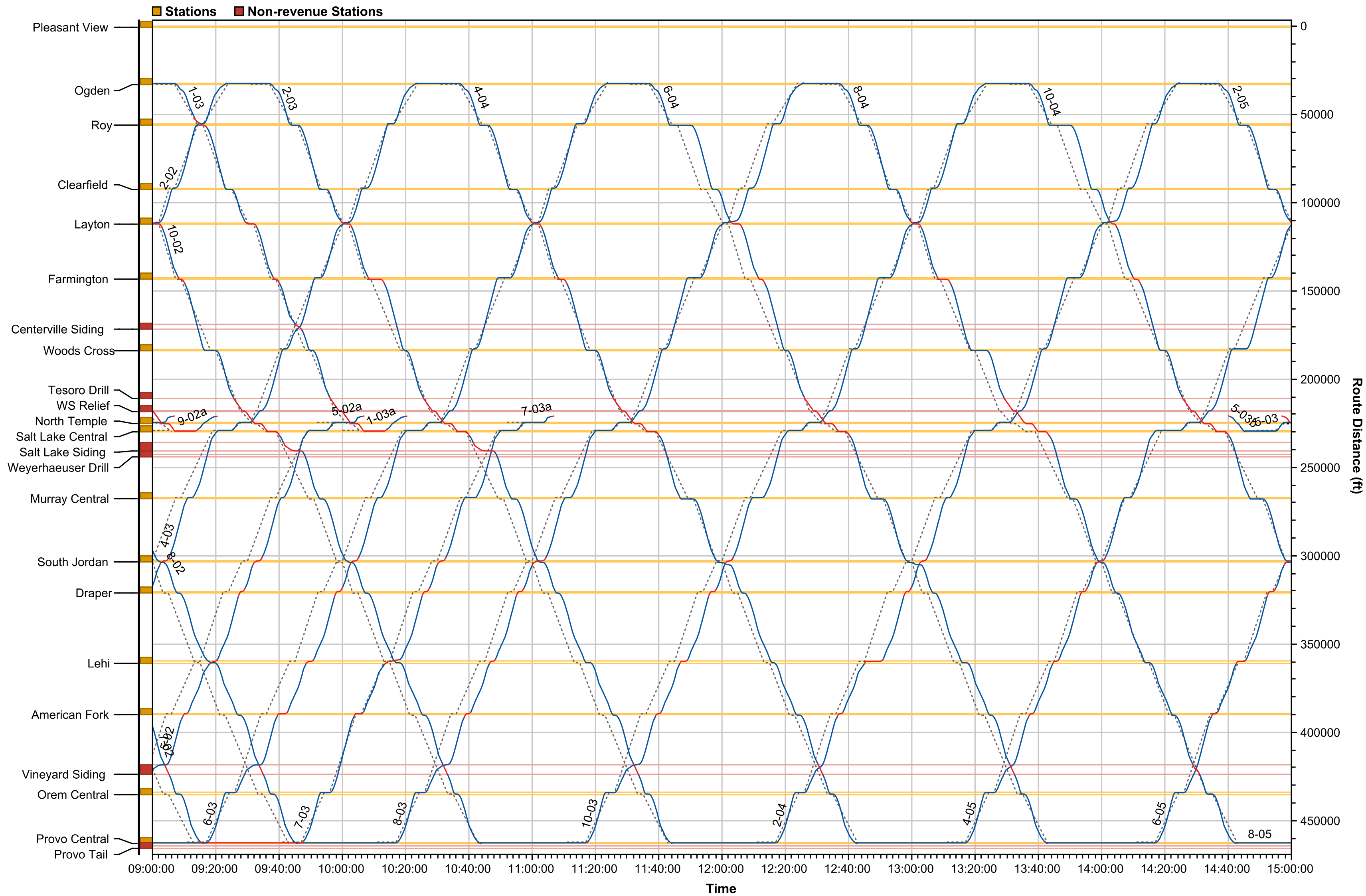


Figure 19-6: Time-Distance ("String") Chart – 9 AM – 3 PM – Future with PTC No Added Perturbations

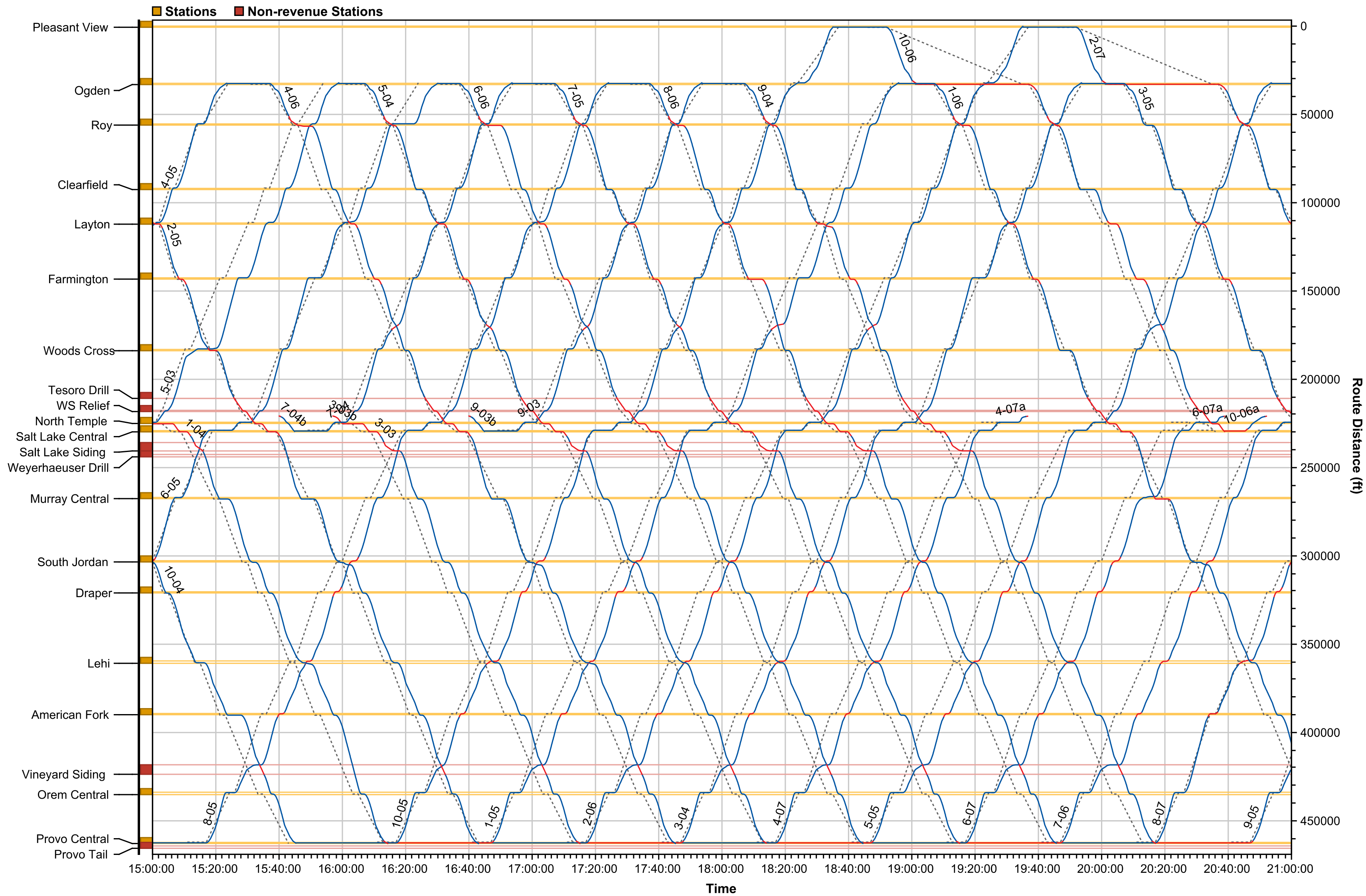


Figure 19-7: Time-Distance ("String") Chart – 3 PM – 9 PM – Future with PTC No Added Perturbations

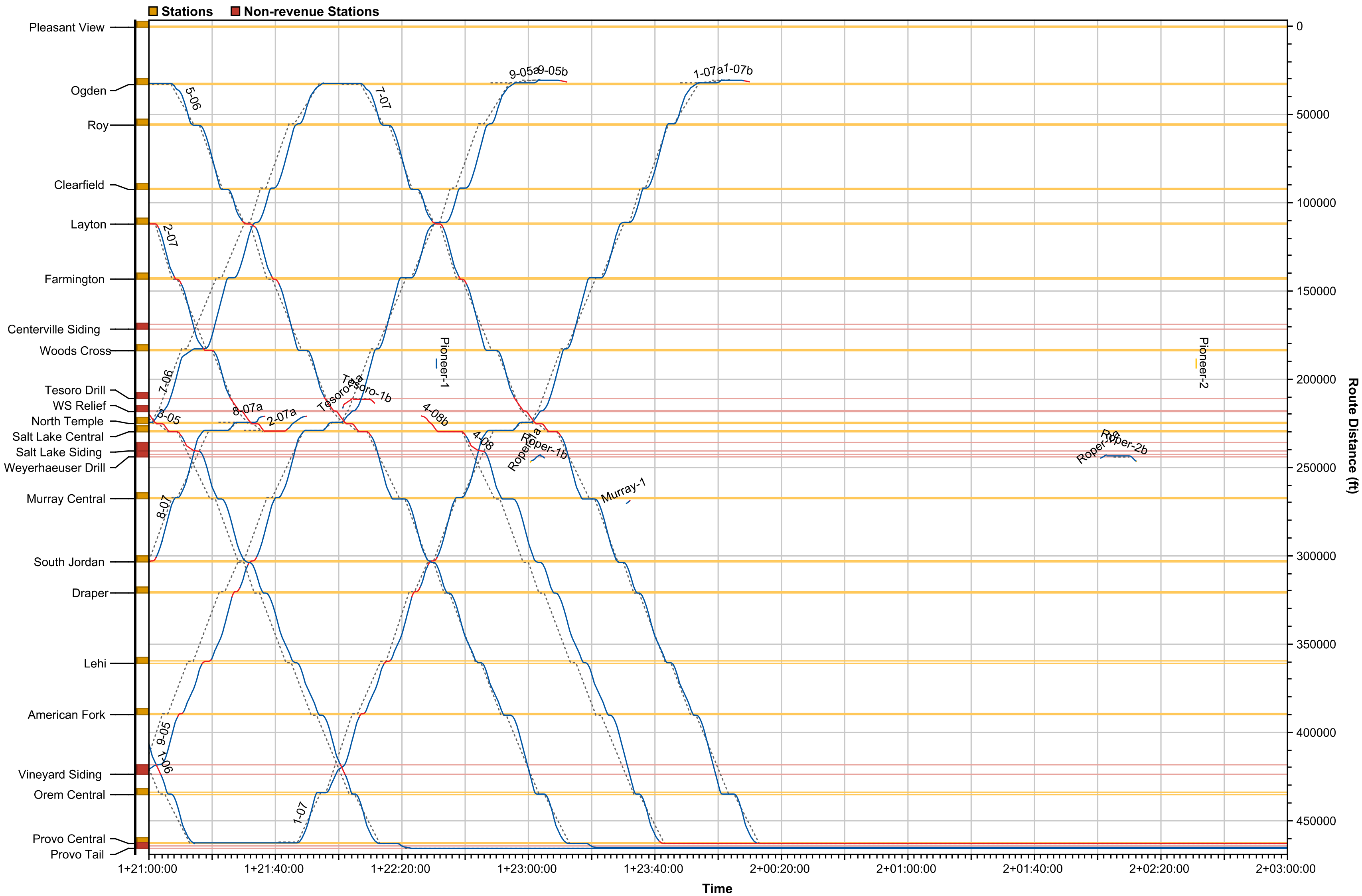


Figure 19-8: Time-Distance ("String") Chart – 9 PM – 3 AM – Future with PTC No Added Perturbations

19.2 Day 1 Future Baseline with PTC Simulation Results with Perturbations

The FrontRunner - Day 1 operating plan includes a randomly-assigned door failure for train 8-06 at South Jordan station. This causes a 7-minute extended dwell. Day 1 also includes a 5-minute delay for train 10-01 at North Temple due to the randomly-assigned need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

19.2.1 Station Occupancy Charts – Salt Lake Central

Figure 19-9 shows all northbound trains on UTA 1 leaving Salt Lake City on time. All of the southbound trains except the first one arrive and depart the station late.

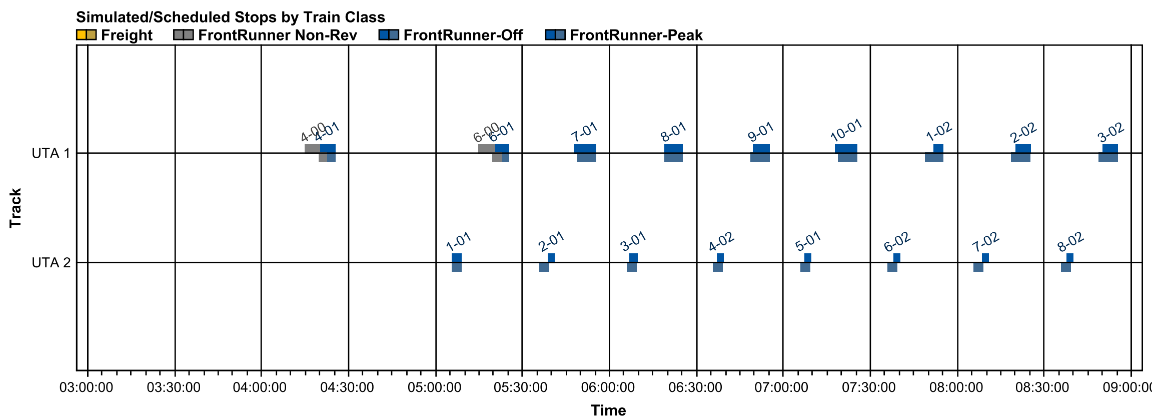


Figure 19-9: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Future with PTC Day 1 Simulation Results with Perturbations

Figure 19-10 shows just train 4-03 arriving and departing late on the northbound track. The southbound track has no trains that arrive on time.

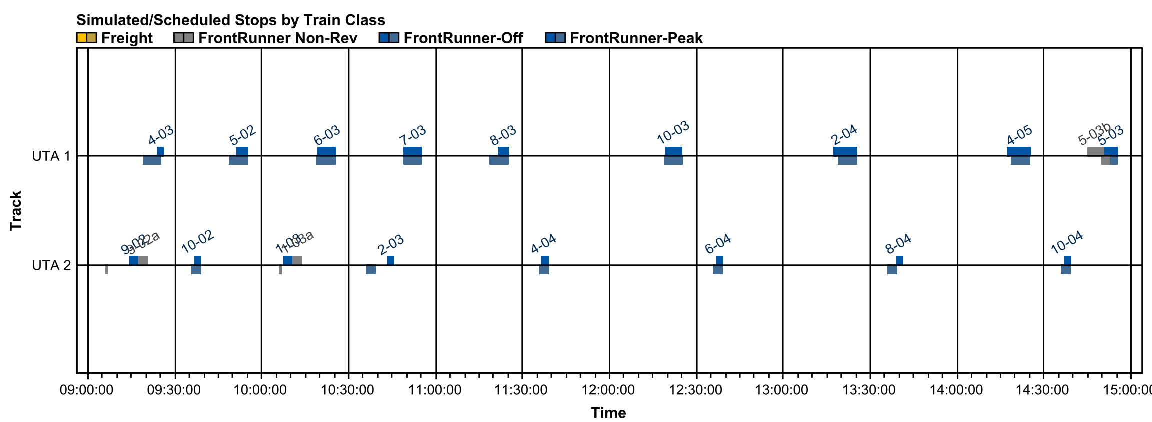


Figure 19-10: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Future with PTC Day 1 Simulation Results with Perturbations

Figure 19-11 shows train 1-05, train 2-06, train 3-04, train 4-07 and train 7-06 arriving late on the northbound track but still leaving the station on time. Train 5-05 and 6-07 arrive on the northbound track late and depart late as well. All of the trains on the southbound track arrive and depart late except for train 7-05 which arrives late but is able to depart on time.

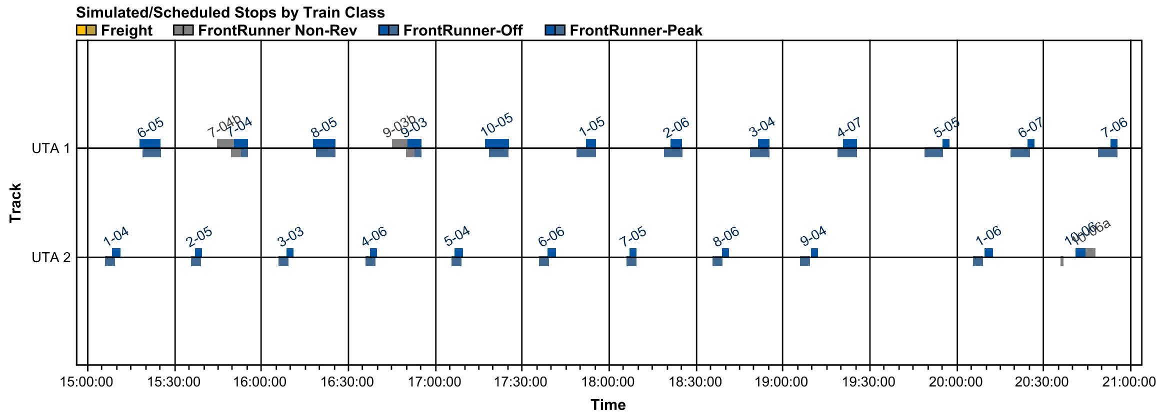


Figure 19-11: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Future with PTC Day 1 Simulation Results with Perturbations

Figure 19-12 shows train 9-05, 1-07 and 4-08 arriving and departing on time.

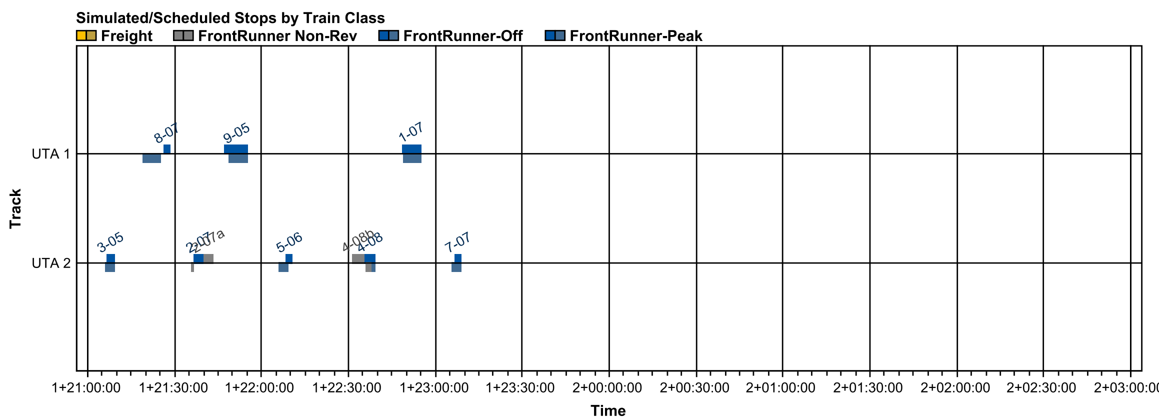


Figure 19-12: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Future with PTC Day 1 Simulation Results with Perturbations

19.2.2 String Charts

Figure 19-13, shows the randomly-assigned 5-minute delay for train 10-01 at North Temple due to the need to hold for a late TRAX connection. Due to this prolonged delay, train 10-01 meets train 7-02 at Woods Cross, train 8-02 at Kaysville Siding and a prolonged wait for train 9-02 to wait for train 10-01 to pass at Roy. Train 10-01 arrives late enough to Ogden that the return trip, train 10-02 departs Ogden late.

Figure 19-15 shows the 7-minute extended dwell perturbation to train 8-06. This causes a delay to train 5-05 as it waits at Lehi station for the meet with train 8-06. The delay to train 5-05, causes train 9-04 to wait at South Jordan to meet train 5-05. Train 6-07 is held at Lehi for a meet with train 9-04.

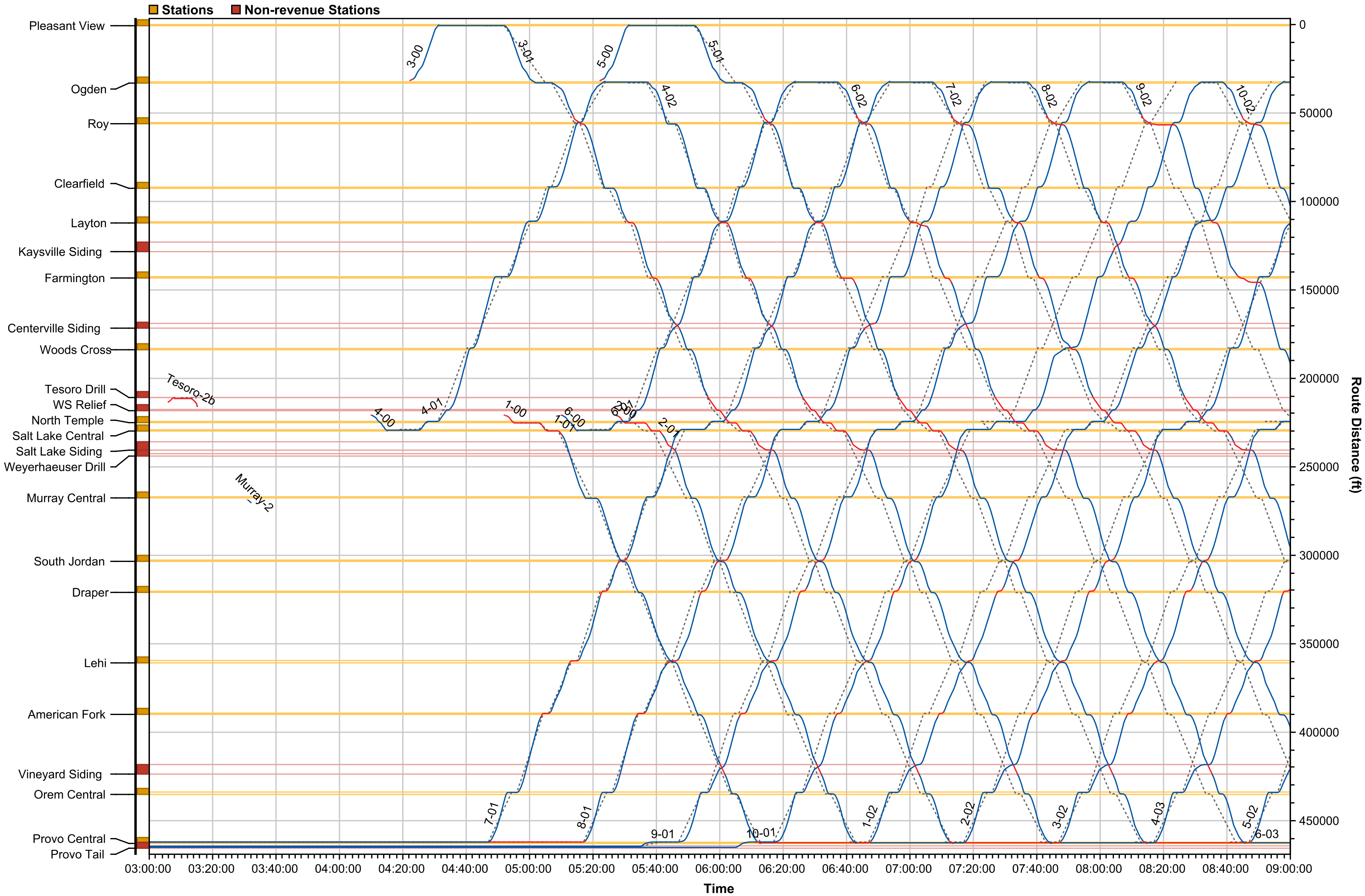


Figure 19-13: Time-Distance ("String") Chart – 3 AM – 9 AM – Future with PTC Day 1 Simulation Results with Perturbations

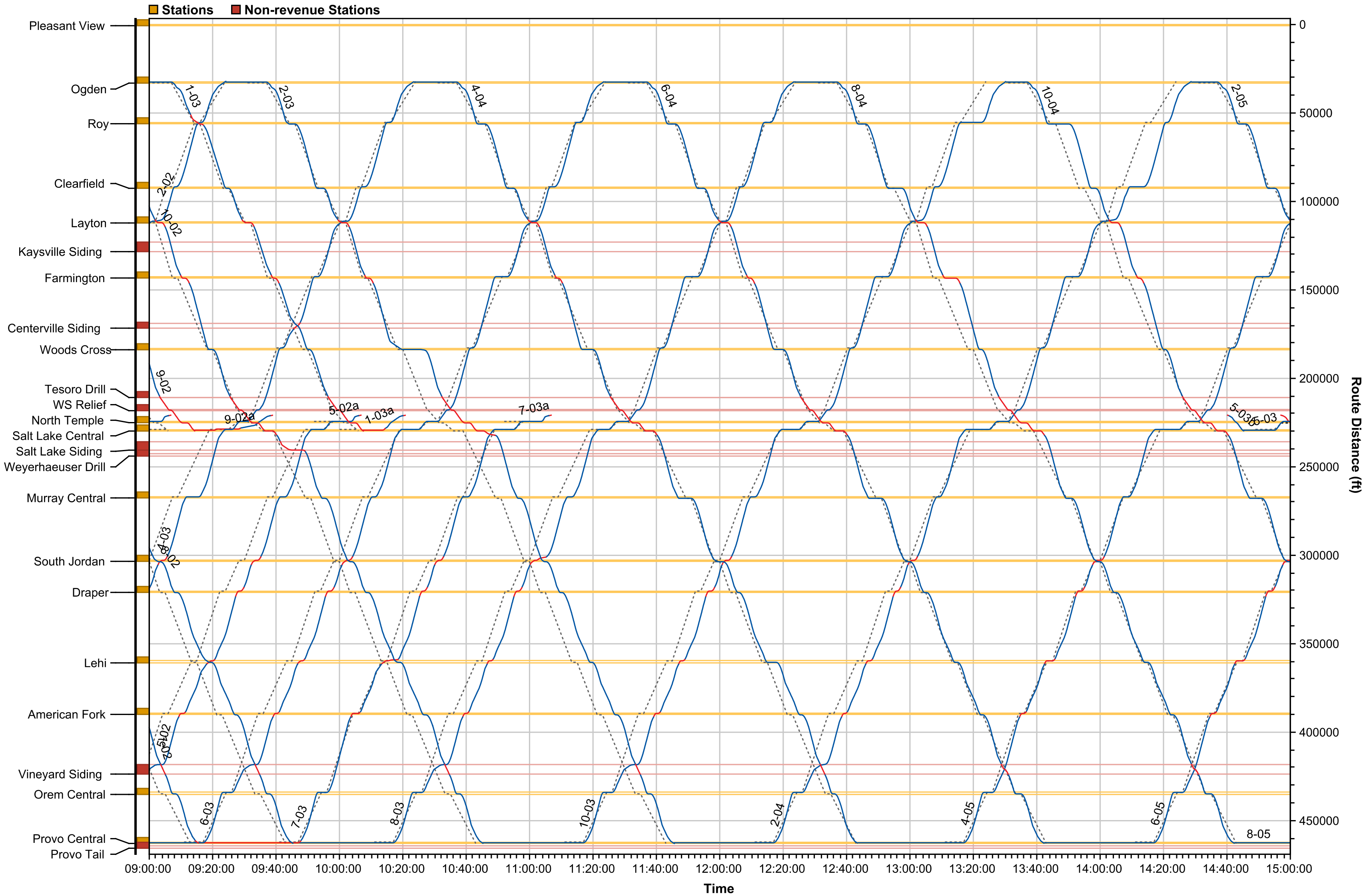


Figure 19-14: Time-Distance (“String”) Chart – 9 AM – 3 PM – Future with PTC Day 1 Simulation Results with Perturbations

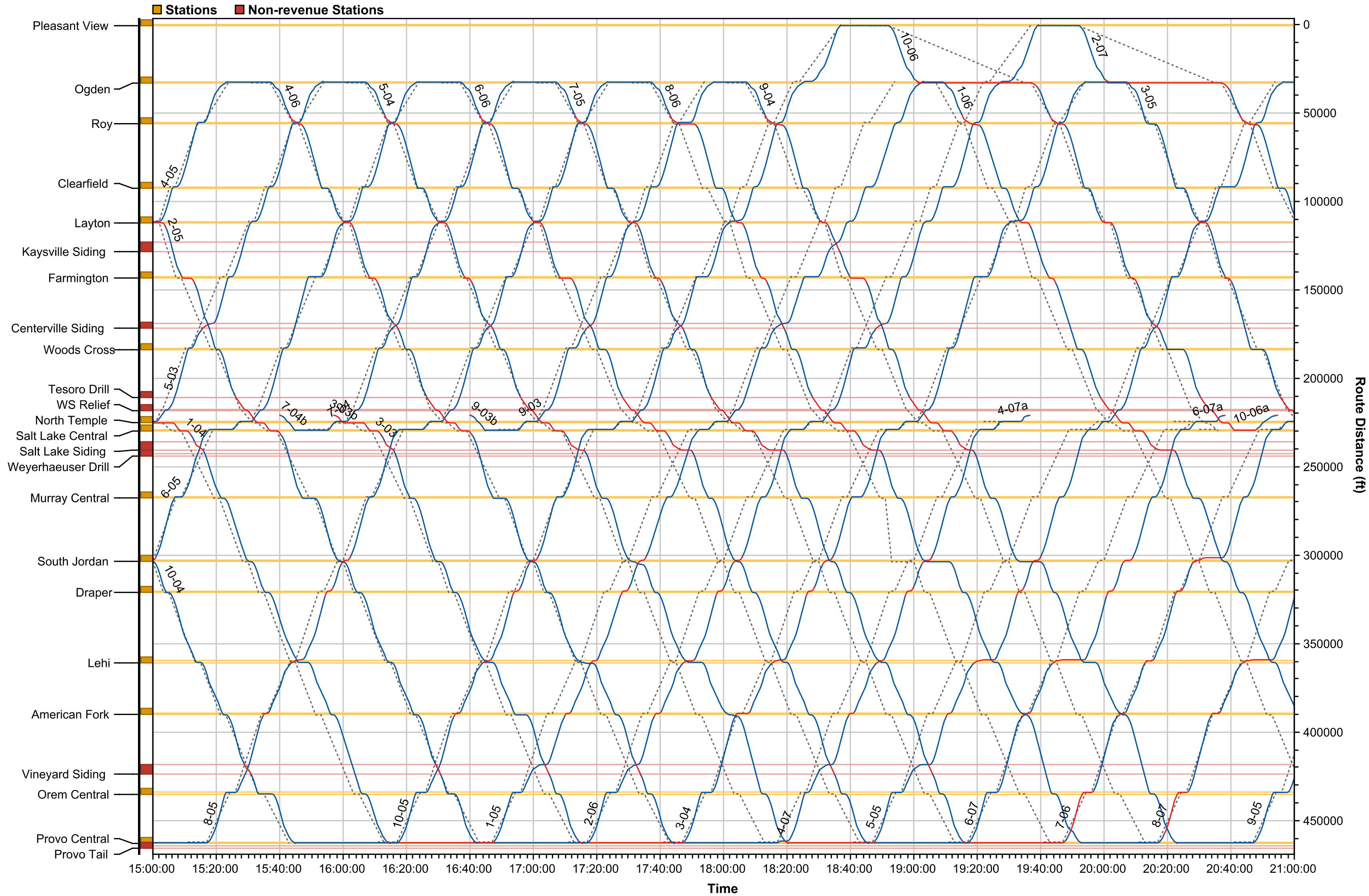


Figure 19-15: Time-Distance ("String") Chart – 3 PM – 9 PM – Future with PTC Day 1 Simulation Results with Perturbations

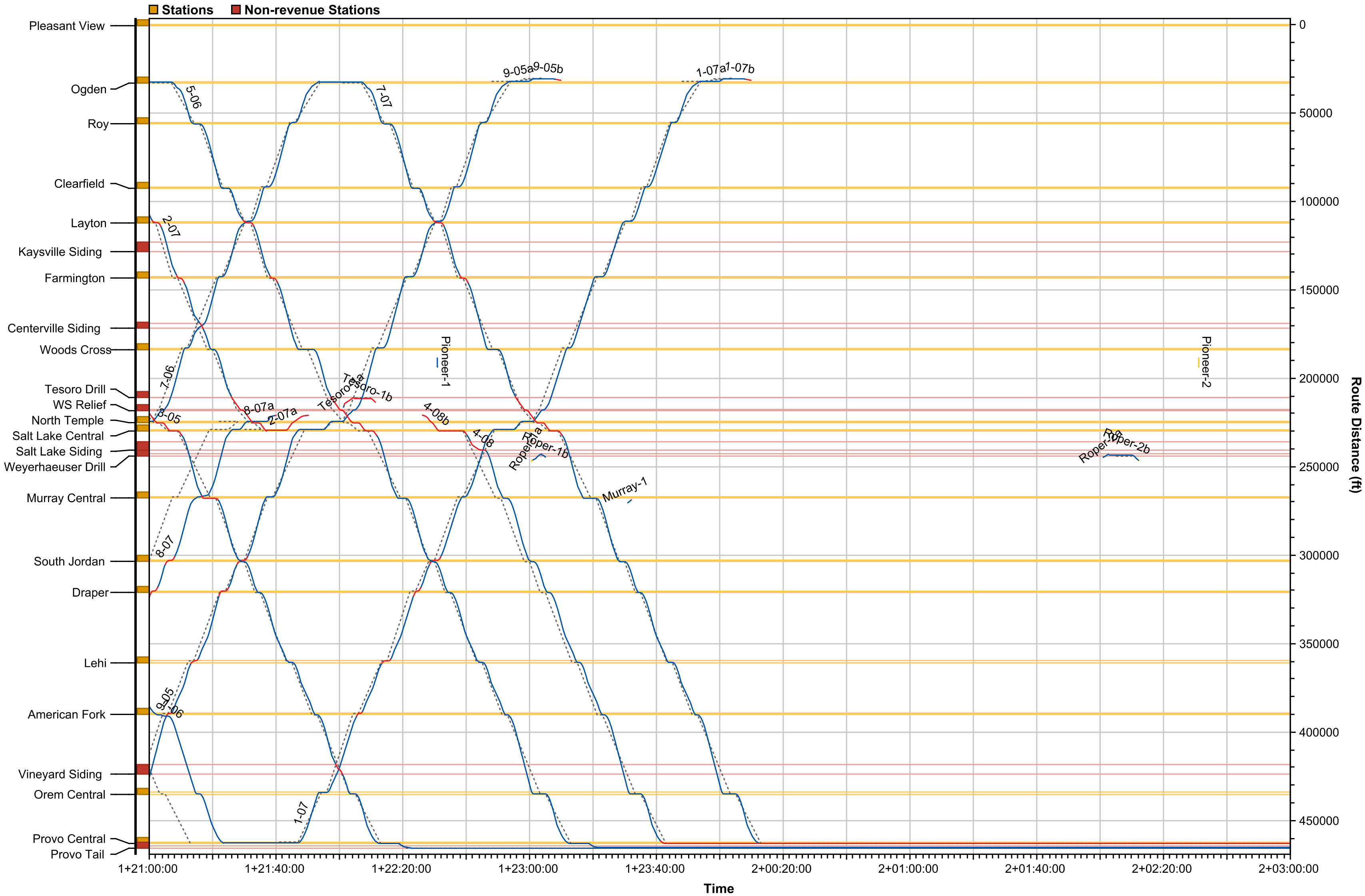


Figure 19-16: Time-Distance ("String") Chart – 9 PM – 3 AM – Future with PTC Day 1 Simulation Results with Perturbations

19.3 Day 2 Future Baseline with PTC Simulation Results with Perturbations

The FrontRunner - Day 2 operating plan perturbations include a 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM due to a crossing failure/broken gate. Day 2 also includes a 5-minute delay for train 2-02 at North Temple due to the need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

19.3.1 Station Occupancy Charts – Salt Lake Central

Of the 17 trains shown in Figure 19-17, only five arrive and depart on time. An additional five trains arrive late but still depart on time. The remaining seven trains arrive and depart the station late.

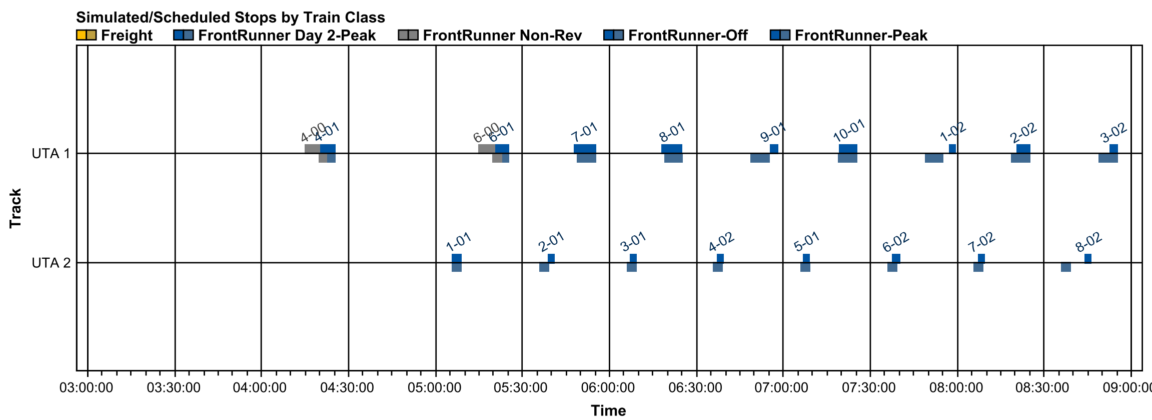


Figure 19-17: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Future with PTC Day 2 Simulation Results with Perturbations

Figure 19-18 shows just three trains arriving and departing on time.

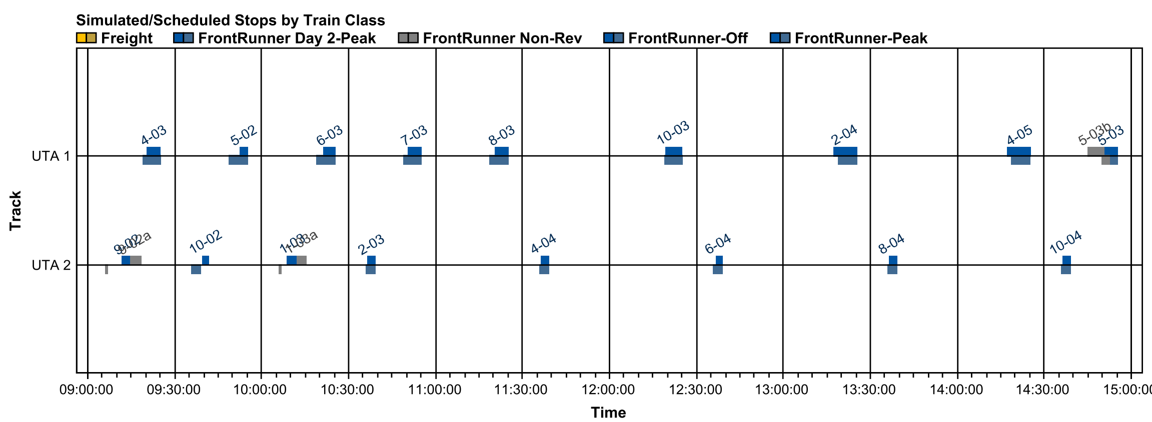


Figure 19-18: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Future with PTC Day 2 Simulation Results with Perturbations

Figure 19-19 shows the impact of the grade crossing failure (south of Salt Lake Central) starting just after 5 PM on the northbound track and just after 7 PM on the southbound track.

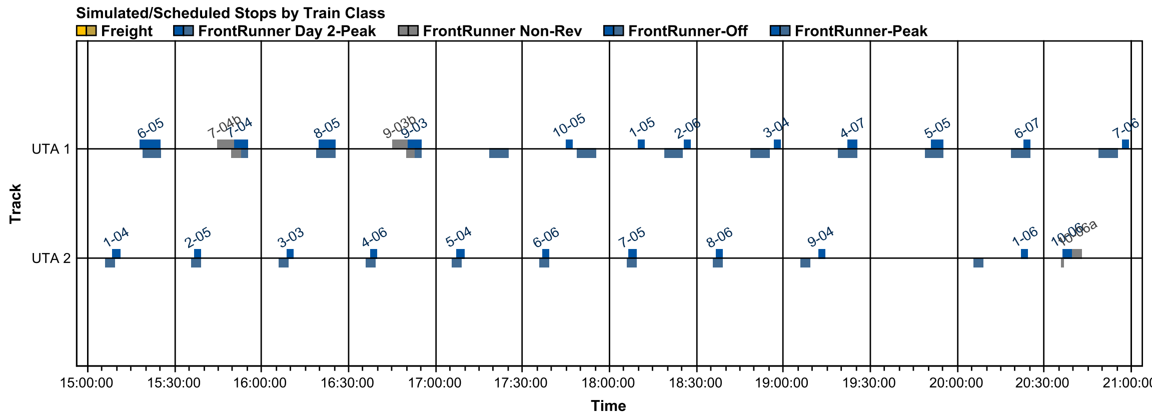


Figure 19-19: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Future with PTC Day 2 Simulation Results with Perturbations

Figure 19-20 shows the northbound trains able to recover and depart Salt Lake Central on time. The southbound trains only recover in time for the last train of the day to depart on time.

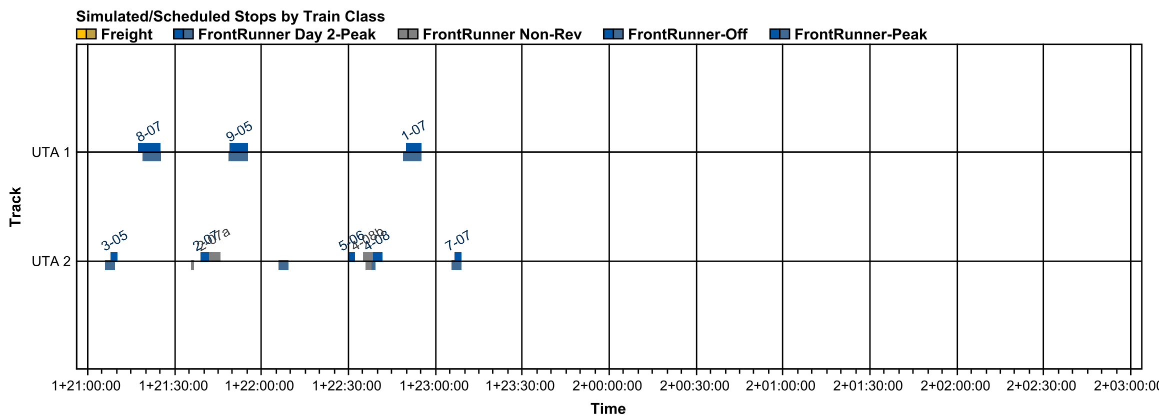


Figure 19-20: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Future with PTC Day 2 Simulation Results with Perturbations

19.3.2 String Charts

Figure 19-21 shows the randomly-assigned 5-minute delay for train 2-02 at North Temple due to the need to hold for a late TRAX connection. There are very few consequences from this delay.

Figure 19-21 also shows that train 8-02 has randomly been assigned a significantly long dwell at Roy station and Clearfield station. These dwells cause train 10-01 to wait at Layton station. Train 2-01 was also randomly assigned a significantly long dwell at South Jordan station.

Figure 19-23 shows the 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM. The lower speed is evident in the more horizontal slopes of the string lines through this period. Train 8-05 is the first train to get this speed restriction. Train 10-05 initially gets delayed at Lehi station while it waits for train 3-03 to pass. As it continues northward, train 10-05 waits at Murray Central station waiting for train 5-04 to get through the grade crossing with the 15 MPH speed restriction. Once train 10-05 gets through the grade crossing, it does not encounter any further delays but still arrives late enough at its final station that it is late leaving Pleasant View station as train 10-06.

Another example of severe delay can be seen looking at train 1-05 as it turns into train 1-06 at Ogden station.

When modeling the Grade Crossing failure in the current 2016 Baseline simulation for a train heading south, the speed drops down from the max track speed of 79 mph to 59 mph 3,872 feet before 4500 South grade crossing. The train then starts braking 1,549 feet before the grade crossing in order to be down to the 15 mph restriction when it reaches the crossing. The train then starts accelerating 424 feet after the grade crossing.

In the Future with PTC simulation, the speed step-down starts much earlier. The cab speed drops to a 45 mph max speed 15,164 feet before the grade crossing failure. The cab speed drops to a 15 mph max speed 10,215 feet before the grade crossing. The 15 MPH speed restriction is valid for the entire length of the signal block within which the grade crossing exists instead of just the length of the crossing (as is required in the Baseline simulation). The train starts accelerating 458 feet after the grade crossing.

In the northbound direction, for the Existing Baseline simulation the train starts braking 1,379 feet before and begins accelerating 413 feet after the grade crossing. In the Future with PTC simulation, the train starts braking 3,768 feet before the grade crossing and does not begin to accelerate until 5,446 feet after the grade crossing. This is caused by the 15 MPH speed restriction which is valid for the entire length of the signal block within which the grade crossing exists instead of just the length of the crossing (as is required in the Baseline simulation).

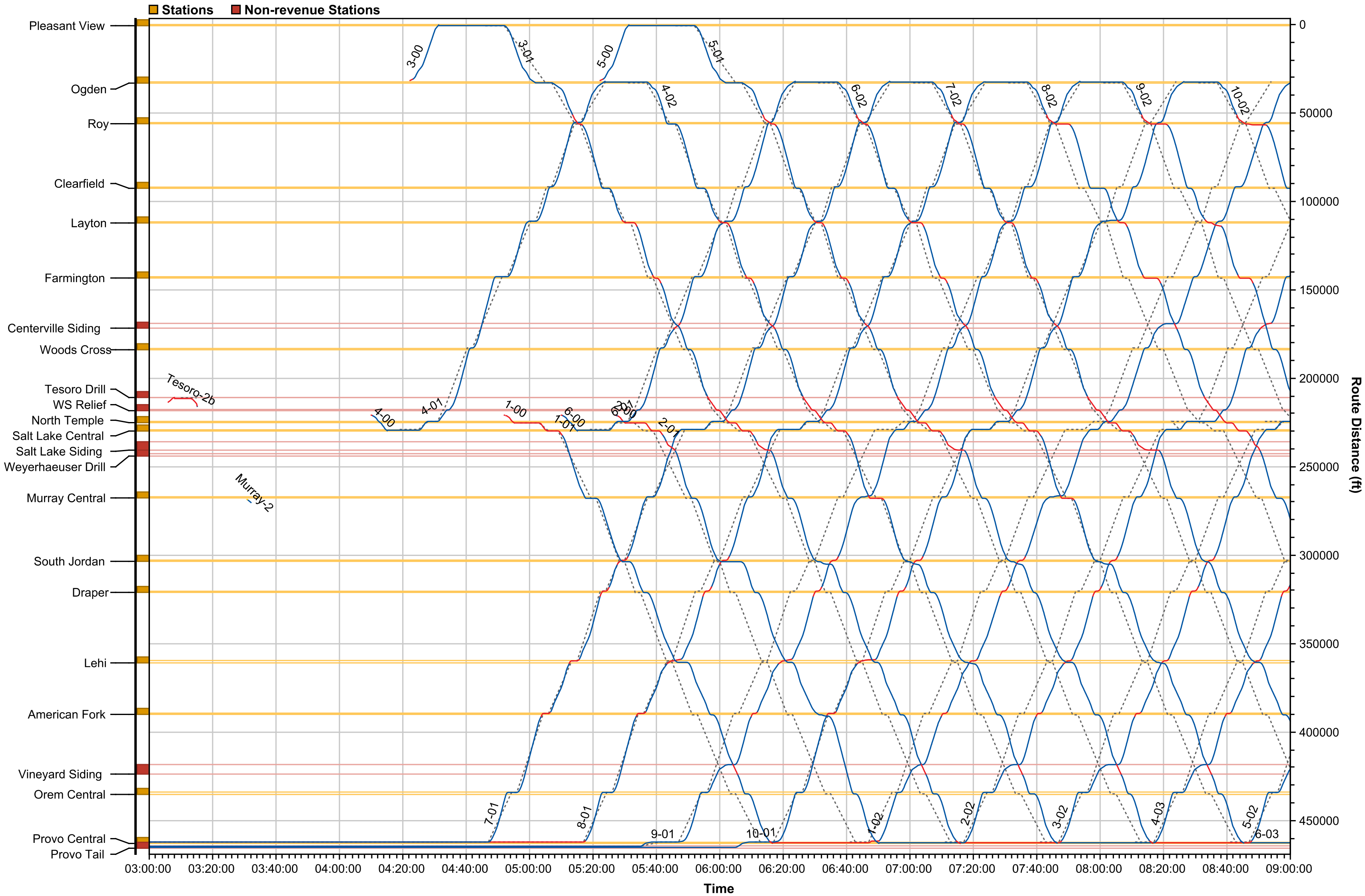


Figure 19-21: Time-Distance ("String") Chart – 3 AM – 9 AM – Future with PTC Day 2 Simulation Results with Perturbations

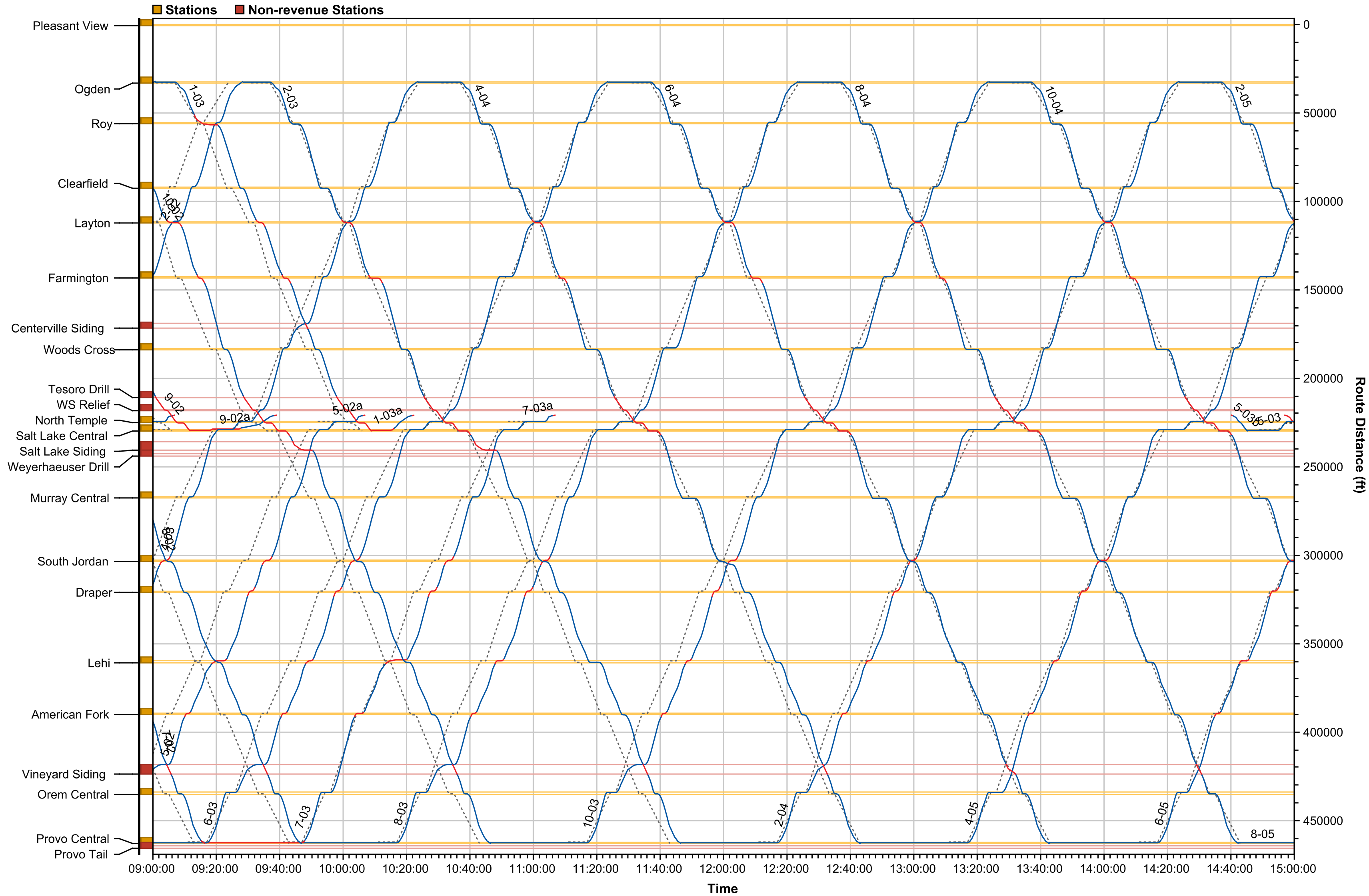


Figure 19-22: Time-Distance ("String") Chart – 9 AM – 3 PM – Future with PTC Day 2 Simulation Results with Perturbations

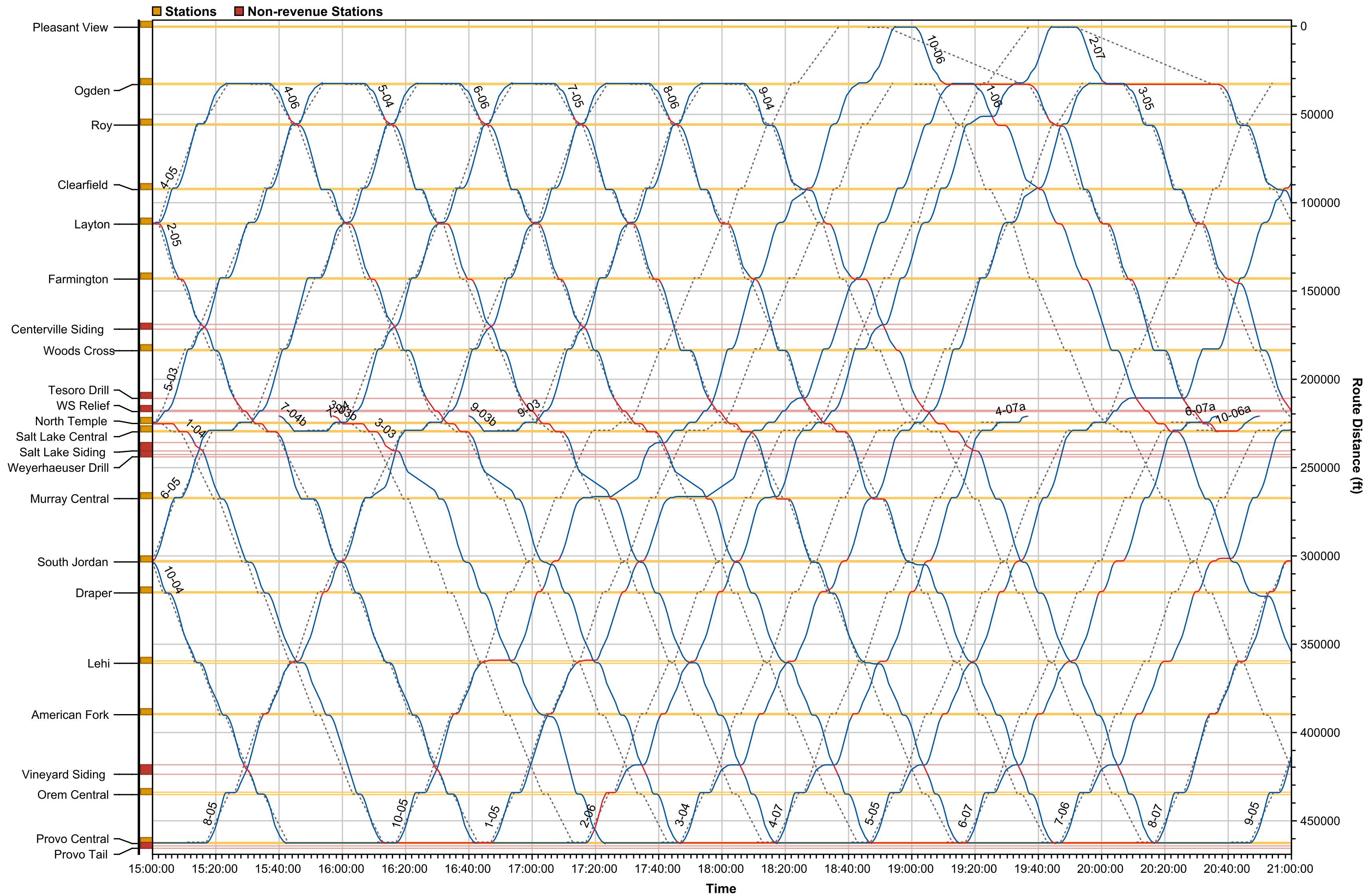


Figure 19-23: Time-Distance ("String") Chart – 3 PM – 9 PM – Future with PTC Day 2 Simulation Results with Perturbations

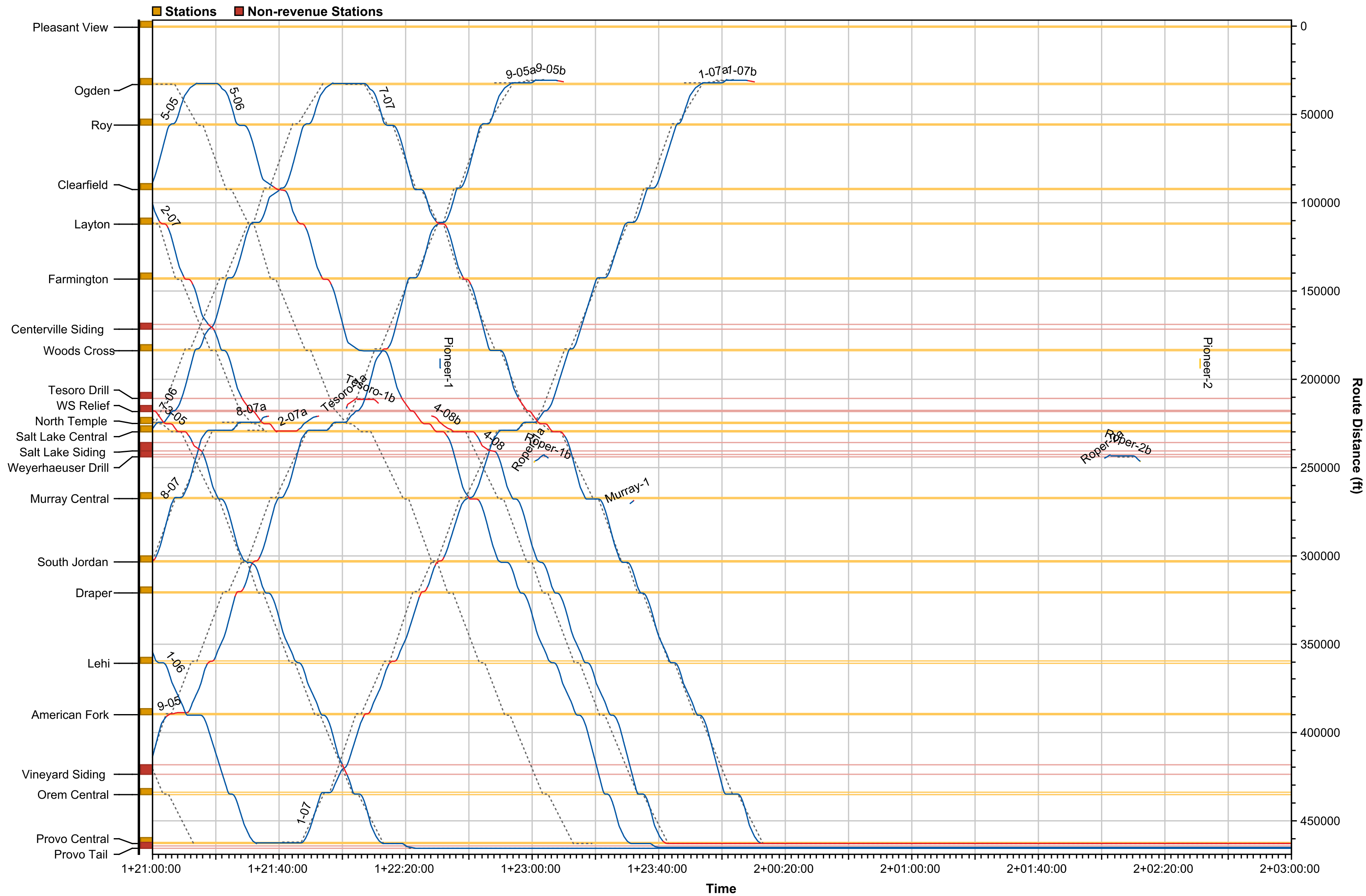


Figure 19-24: Time-Distance ("String") Chart – 9 PM – 3 AM – Future with PTC Day 2 Simulation Results with Perturbations

19.4 Day 3 Future Baseline with PTC Simulation Results with Perturbations

The FrontRunner - Day 3 operating plan includes a locomotive failure on train 10-02 between Layton station and Clearfield station causing the train to stop for 10-minutes while the locomotive is reset. Day 3 also includes a door failure for train 4-03 at Woods Cross Station. This causes an assumed 7-minute extended dwell while the door is cut out and removed from service. Station occupancy charts and string charts are included in the following sections.

19.4.1 Station Occupancy Charts – Salt Lake Central

Figure 19-25 shows train 8-01 and train 1-02 arriving and leaving late on the northbound track. On the southbound track, only train 1-01 arrives on time and only three of the eight trains depart on time.

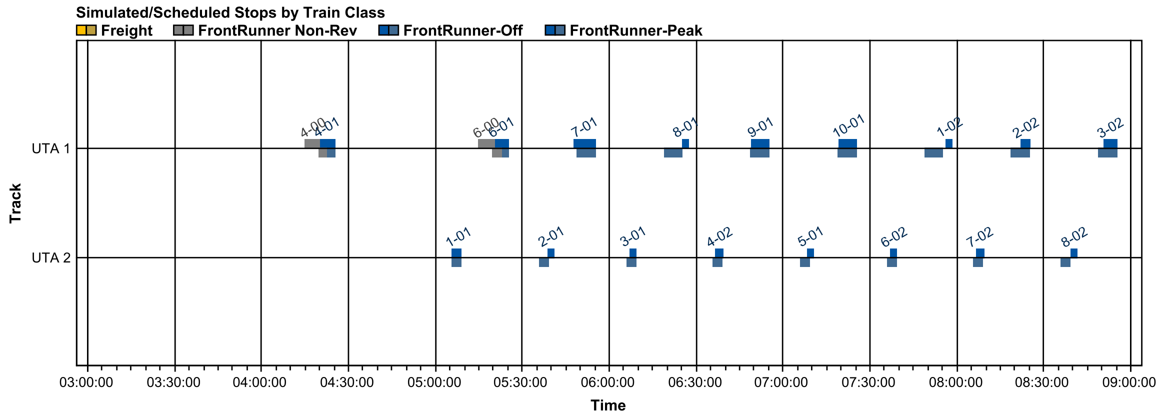


Figure 19-25: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Future with PTC Day 3 Simulation Results with Perturbations

Figure 19-26 shows train 10-02's late arrival due to the locomotive failure that occurred earlier just south of Clearfield station.

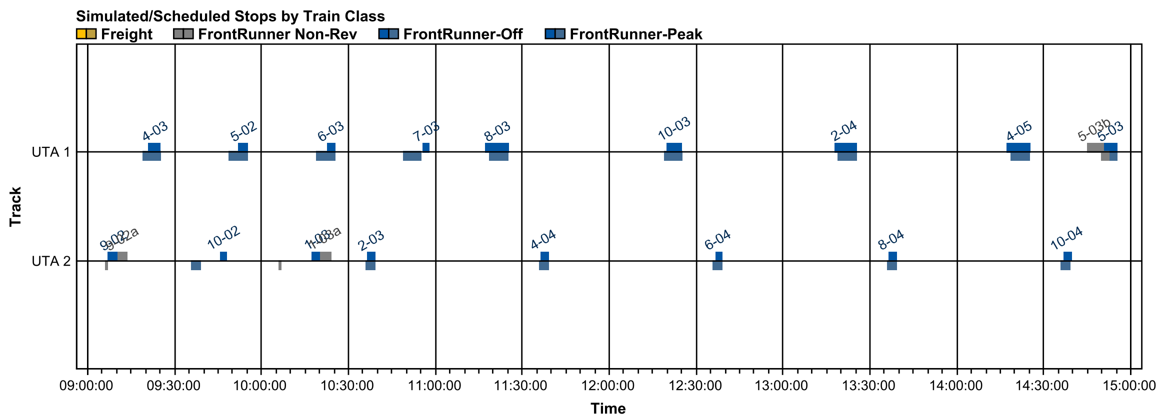


Figure 19-26: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Future with PTC Day 3 Simulation Results with Perturbations

Figure 19-27 shows all northbound trains leaving Salt Lake Central on time, with half of them arriving on time as well. The southbound trains have one train arriving on time and four that leave on time.

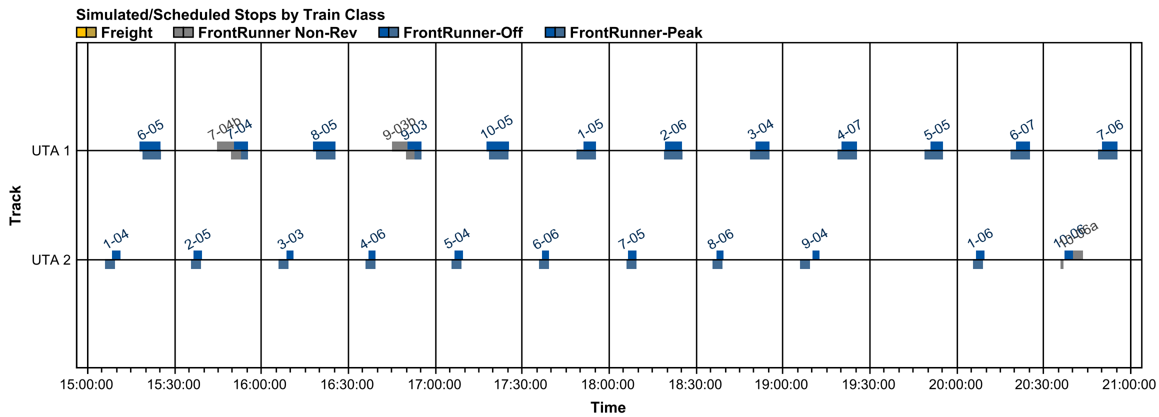


Figure 19-27: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Future with PTC Day 3 Simulation Results with Perturbations

Figure 19-28 shows all trains departing Salt Lake Central station on time with the exception of train 2-07 which turns into train 2-07a (a non-revenue train).

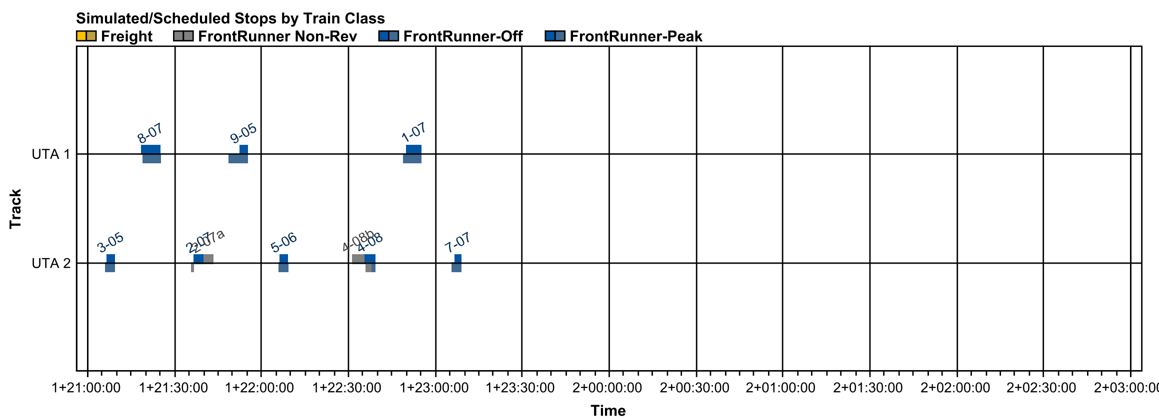


Figure 19-28: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Future with PTC Day 3 Simulation Results with Perturbations

19.4.2 String Charts

In Figure 19-29, train 1-01 at Draper station has randomly been assigned a significantly long dwell. Due to the prolonged dwell, train 8-01 becomes delayed as it waits for train 1-01 while still at Lehi station. The resulting cascading delays on the South End do not resolve until 1 PM, which can be seen in Figure 19-30.

The Day 3 perturbation of train 10-02 experiencing a 10-minute stop in between Clearfield station and Layton station is shown in Figure 19-29 and Figure 19-30. Train 2-02 is delayed at Layton station waiting for train 10-02 to pass. Train 2-02 arrives late enough to Ogden station that the return trip (train 10-03) departs late. The 7-minute extended dwell for train 4-03 at Woods Cross station is also shown in Figure 19-30. There is enough time built into the schedule that the delay is resolved at Ogden station.

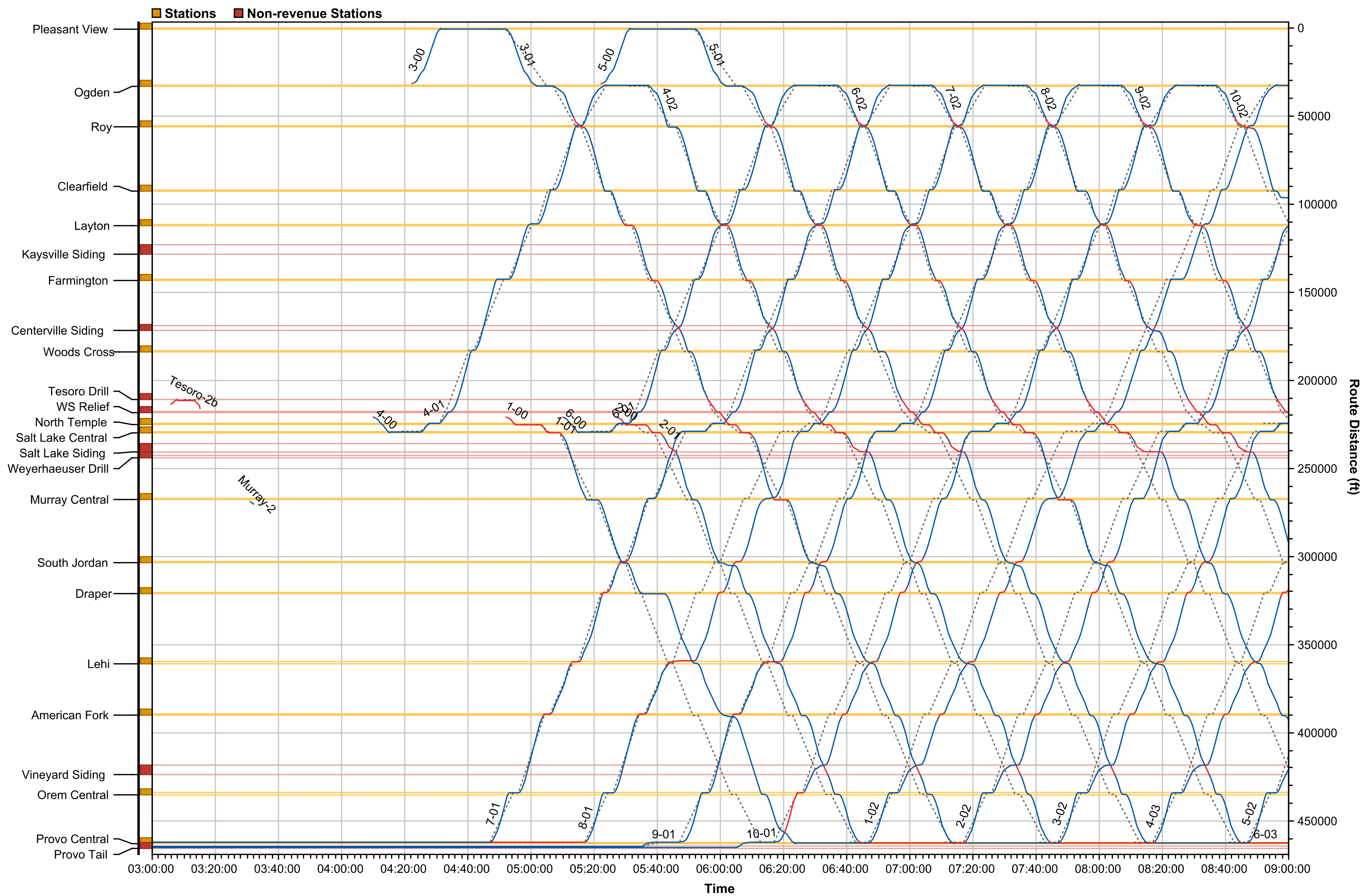


Figure 19-29: Time-Distance ("String") Chart – 3 AM – 9 AM – Future with PTC Day 3 Simulation Results with Perturbations

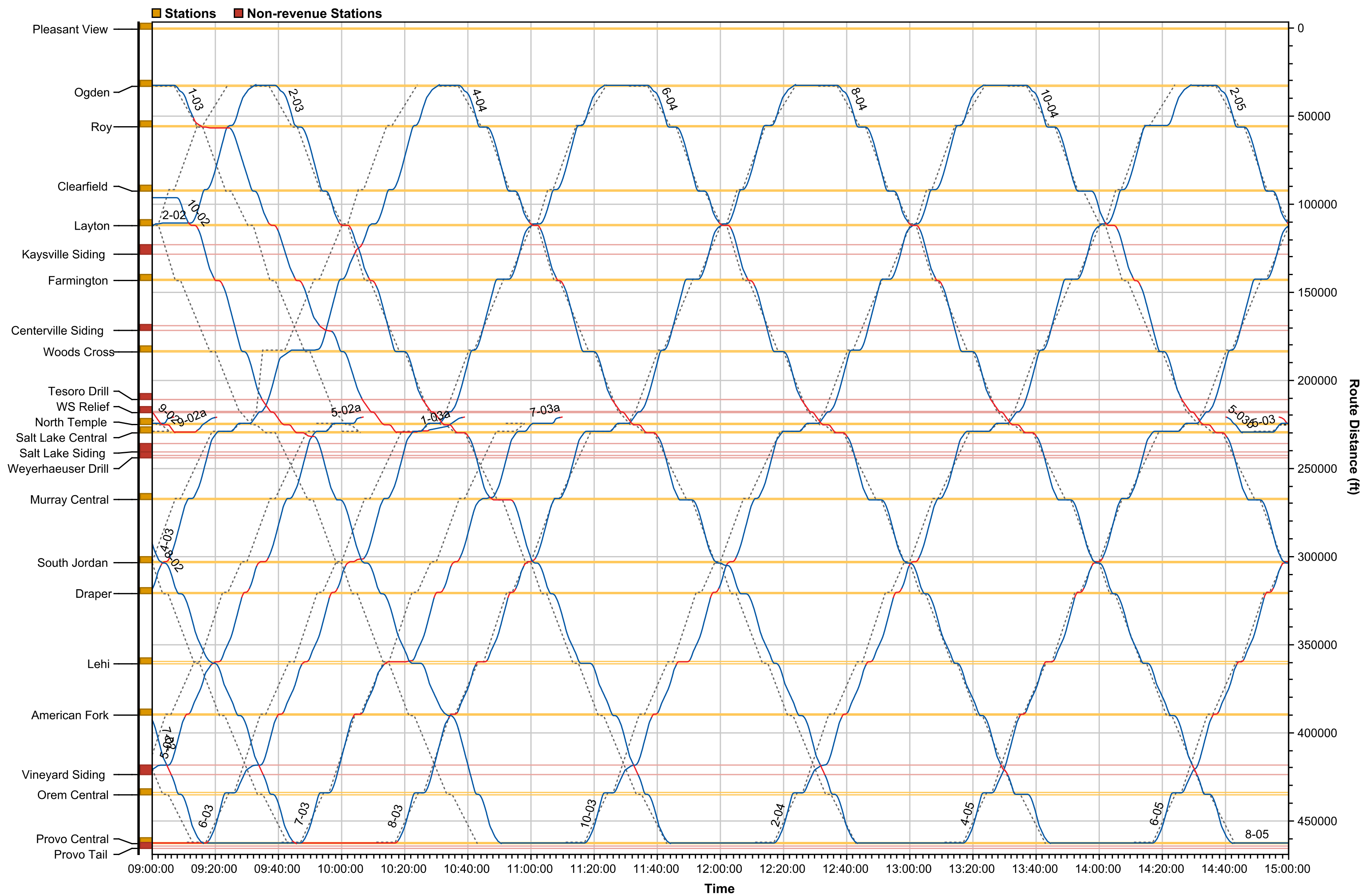


Figure 19-30: Time-Distance ("String") Chart – 9 AM – 3 PM – Future with PTC Day 3 Simulation Results with Perturbations

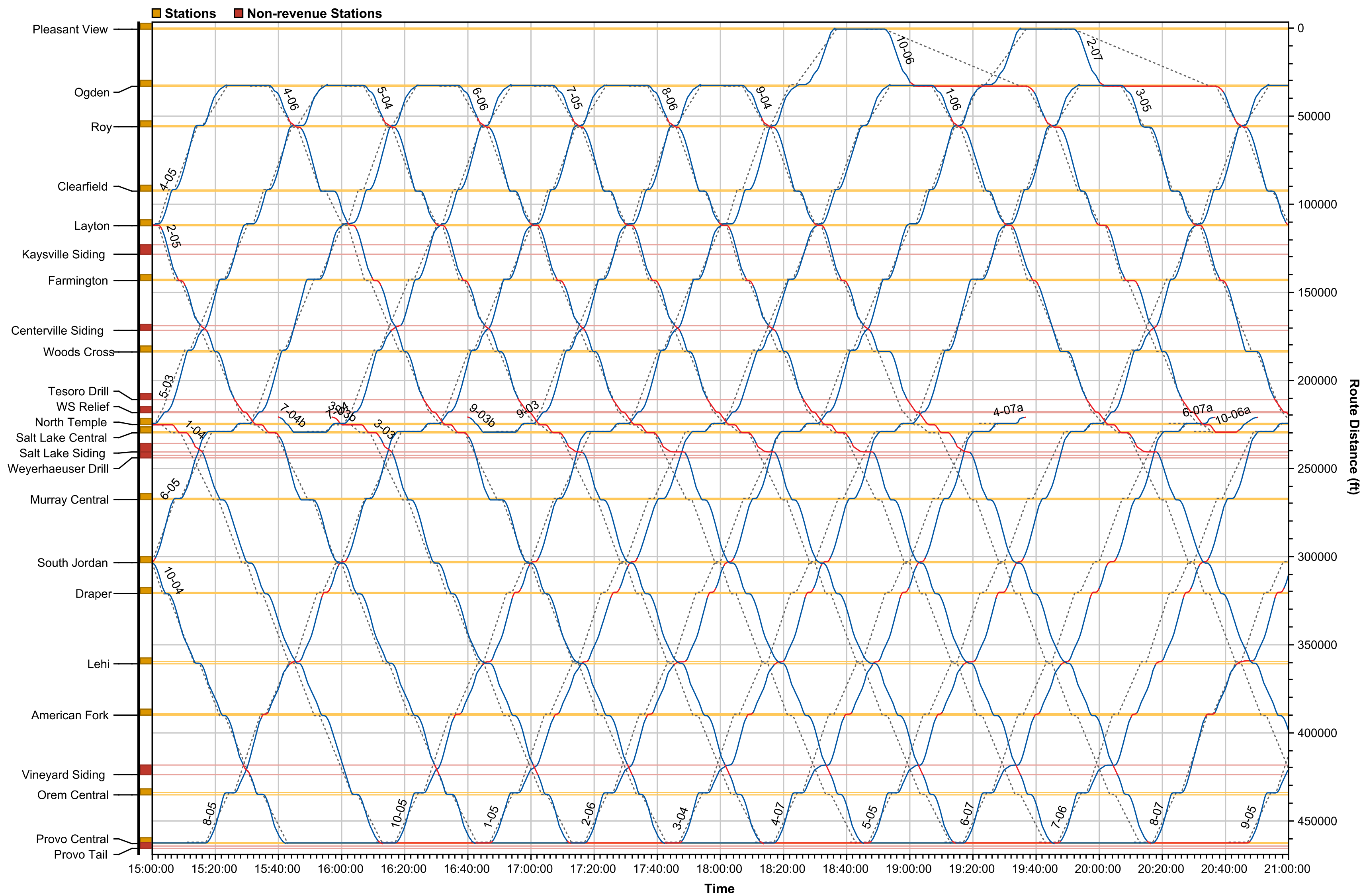


Figure 19-31: Time-Distance ("String") Chart – 3 PM – 9 PM – Future with PTC Day 3 Simulation Results with Perturbations

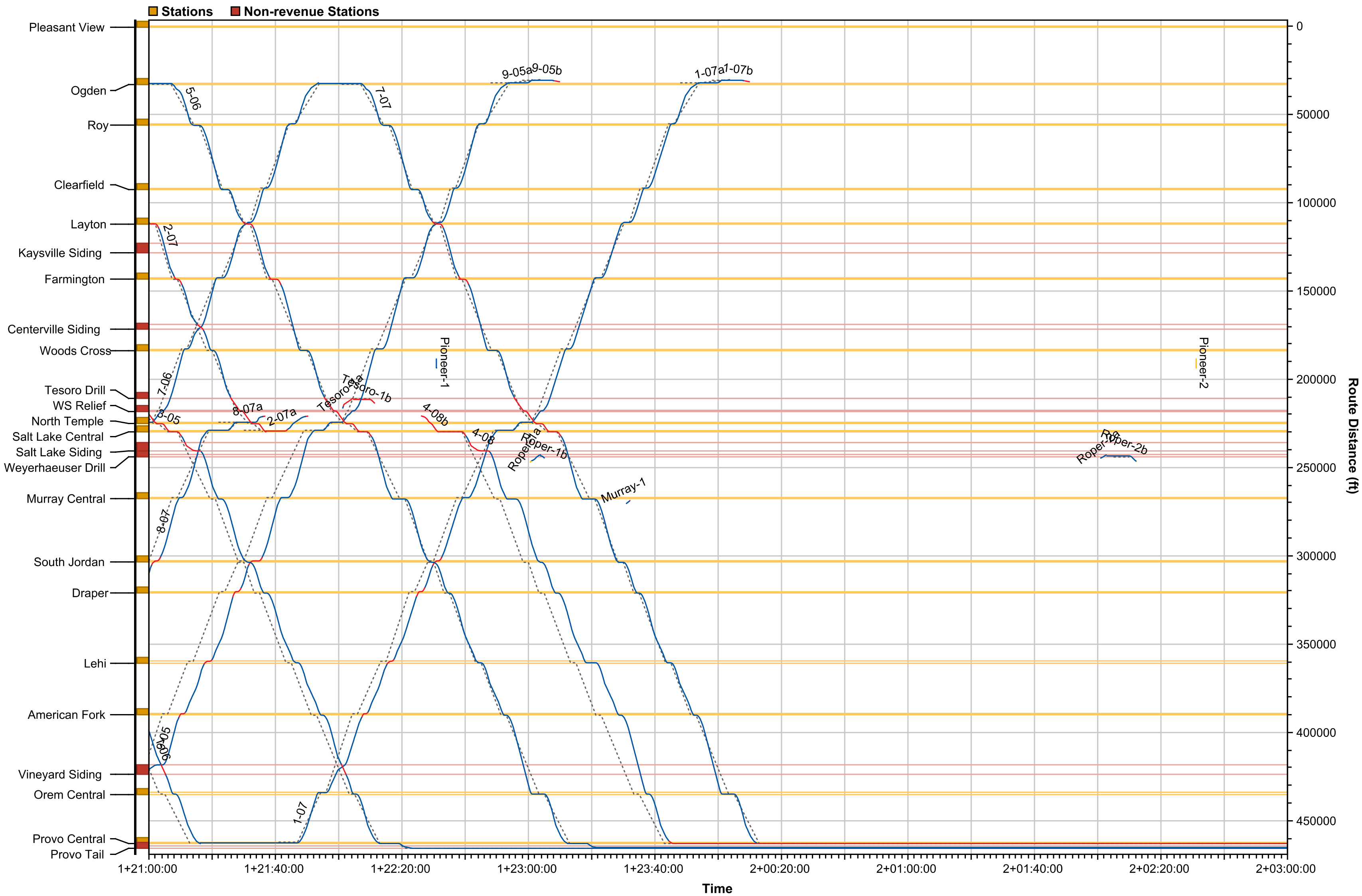


Figure 19-32: Time-Distance ("String") Chart – 9 PM – 3 AM – Future with PTC Day 3 Simulation Results with Perturbations

19.5 Day 4 Future Baseline with PTC Simulation Results with Perturbations

The FrontRunner - Day 4 operating plan includes a door failure for train 6-03 at Orem Station. This causes an assumed 7-minute extended dwell while the door failure is resolved. Day 4 also includes a 15 MPH speed restriction through 9400 South Grade Crossing (North of South Jordan) from 6:30 AM through 8:30 AM due to a crossing failure/broken gate. Salt Lake Central station occupancy charts and full network string charts are included in the following sections.

19.5.1 Station Occupancy Charts – Salt Lake Central

Figure 19-33 shows how the Grade Crossing Failure is affecting the northbound trains starting with train 9-01. Train 8-02 is the first southbound train that suffers the effects from the northbound trains' delay.

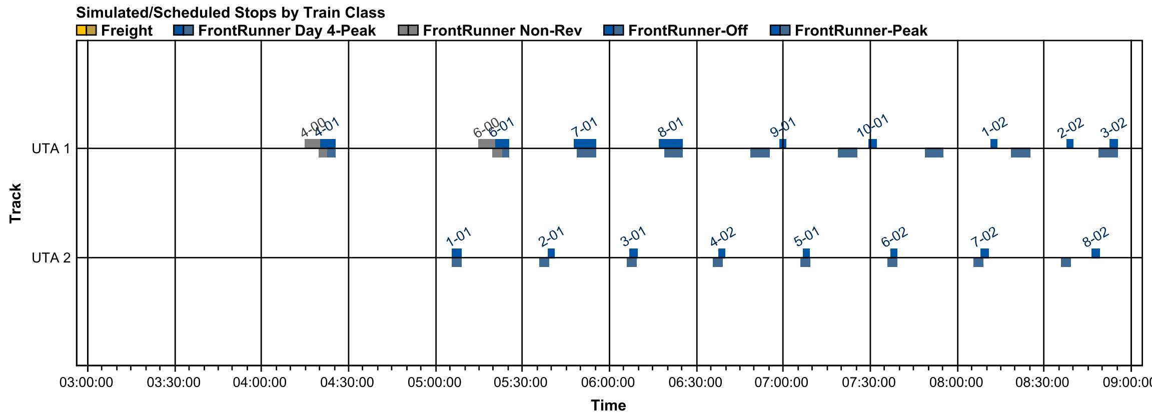


Figure 19-33: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Future with PTC Day 4 Simulation Results with Perturbations

Figure 19-34 shows the southbound trains continuing to suffer delays from the earlier grade crossing failure until 11:30 AM.

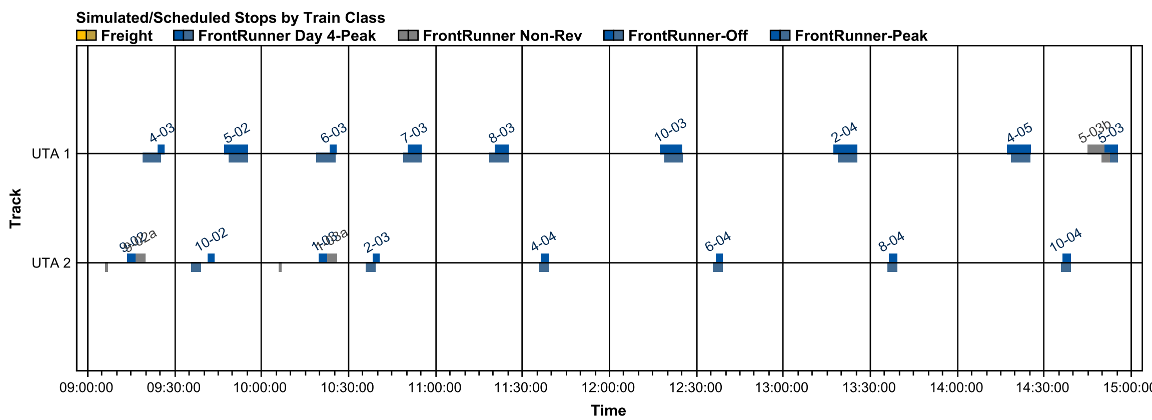


Figure 19-34: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Future with PTC Day 4 Simulation Results with Perturbations

Figure 19-35 shows one northbound train arriving and departing the station late. Approximately half of the southbound trains arrive and depart late.

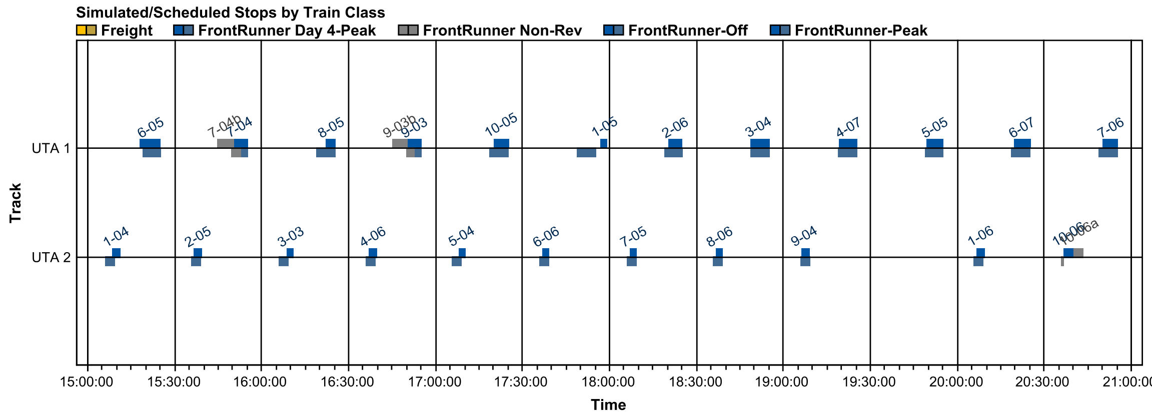


Figure 19-35: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Future with PTC Day 4 Simulation Results with Perturbations

Figure 19-36 shows all revenue trains departing on time.

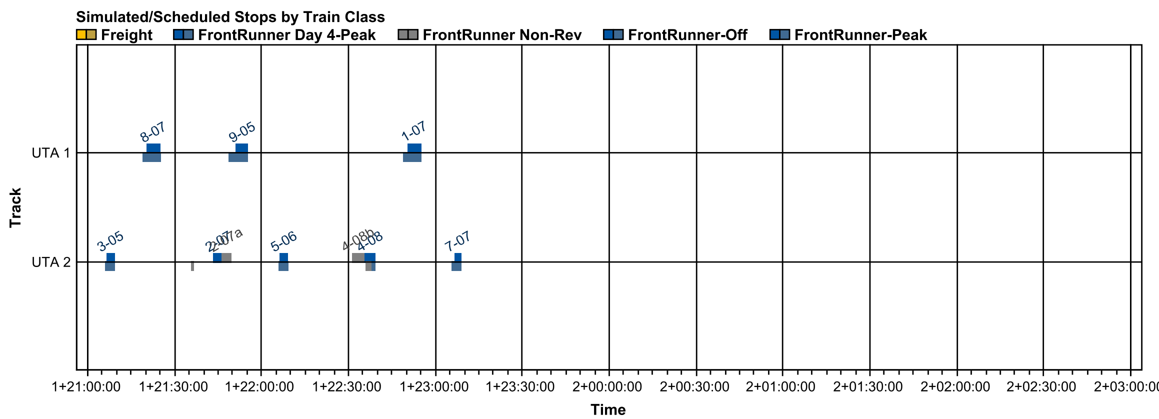


Figure 19-36: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Future with PTC Day 4 Simulation Results with Perturbations

19.5.2 String Charts

The Day 4 perturbation of a 15 MPH speed restriction through a grade crossing just north of South Jordan is shown in Figure 19-37. This causes cascading delays to the trains throughout the morning peak period.

When modeling the Grade Crossing failure in the current 2016 Baseline simulation for a train heading south, both the civil and cab speeds remain at the max track speed of 79 mph before reaching 9400 South grade crossing. The train starts braking 2,906 feet before the grade crossing in order to be down to the 15 mph restriction when it reaches the crossing. The train then starts accelerating 415 feet after the grade crossing.

In the Future with PTC simulation, the speed step-down starts much earlier. When heading south, the cab speed drops to a 60 mph max speed 16,430 feet before the grade crossing failure. The cab speed then drops to a 15 mph max speed 11,230 feet before the grade crossing. The train starts accelerating 458 feet after the grade crossing.

In the northbound direction, for the Existing Baseline simulation the train starts braking 1292 feet before the grade crossing and begins accelerating 428 feet after the grade crossing. In the Future with PTC simulation, the train starts braking 4,200 feet before the grade crossing and does not begin to accelerate until 5,845 feet after the grade crossing. This is caused by the 15 MPH speed restriction which is valid for the entire length of the signal block within which the grade crossing exists instead of just the length of the crossing (as is required in the Baseline simulation).

Figure 19-38 shows the door failure for train 6-03 at Orem Station. This assumed 7-minute extended dwell while the door is disabled causes train 6-03 to run late until it can recover at Salt Lake Central station.

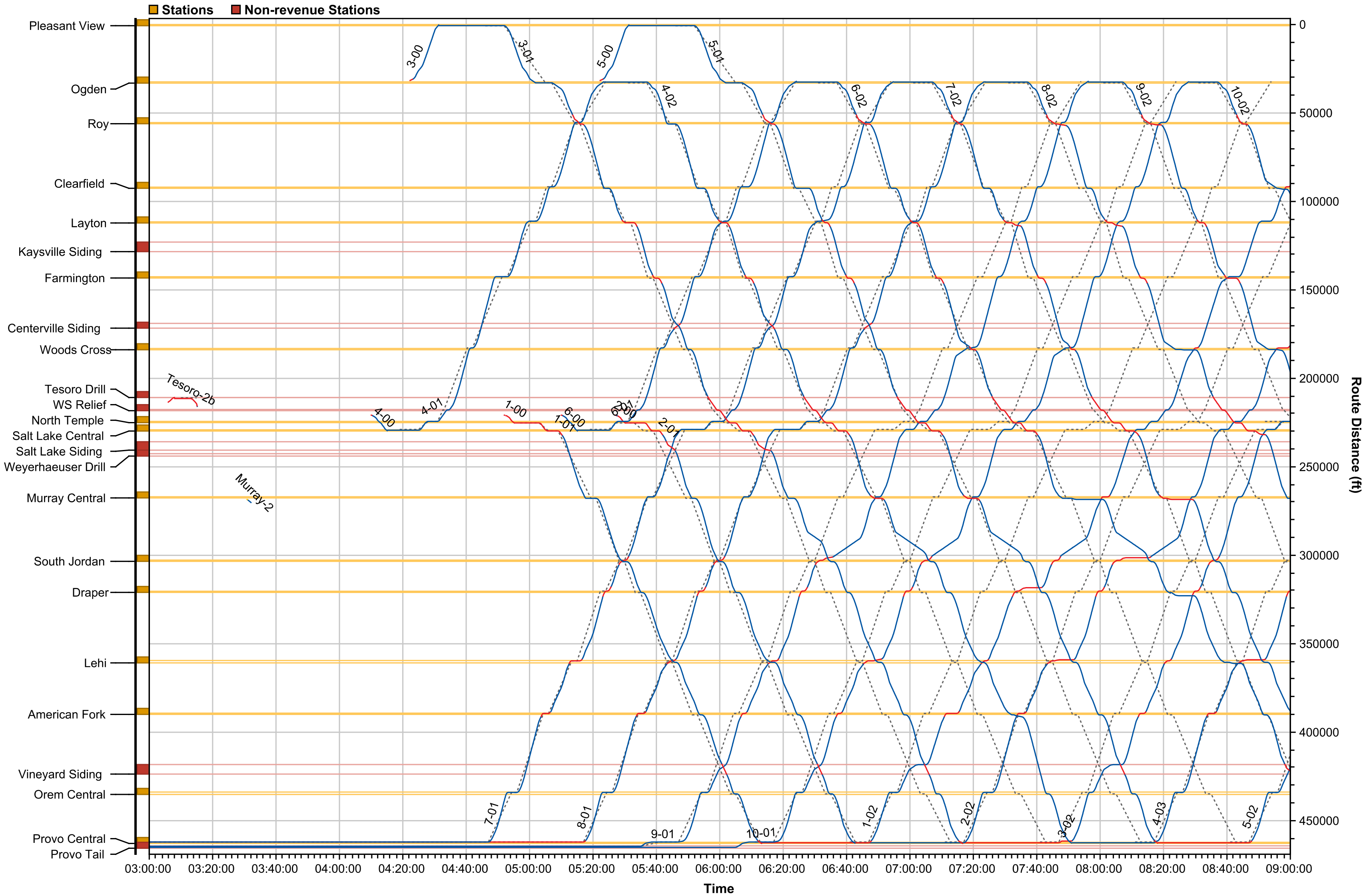


Figure 19-37: Time-Distance ("String") Chart – 3 AM – 9 AM – Future with PTC Day 4 Simulation Results with Perturbations

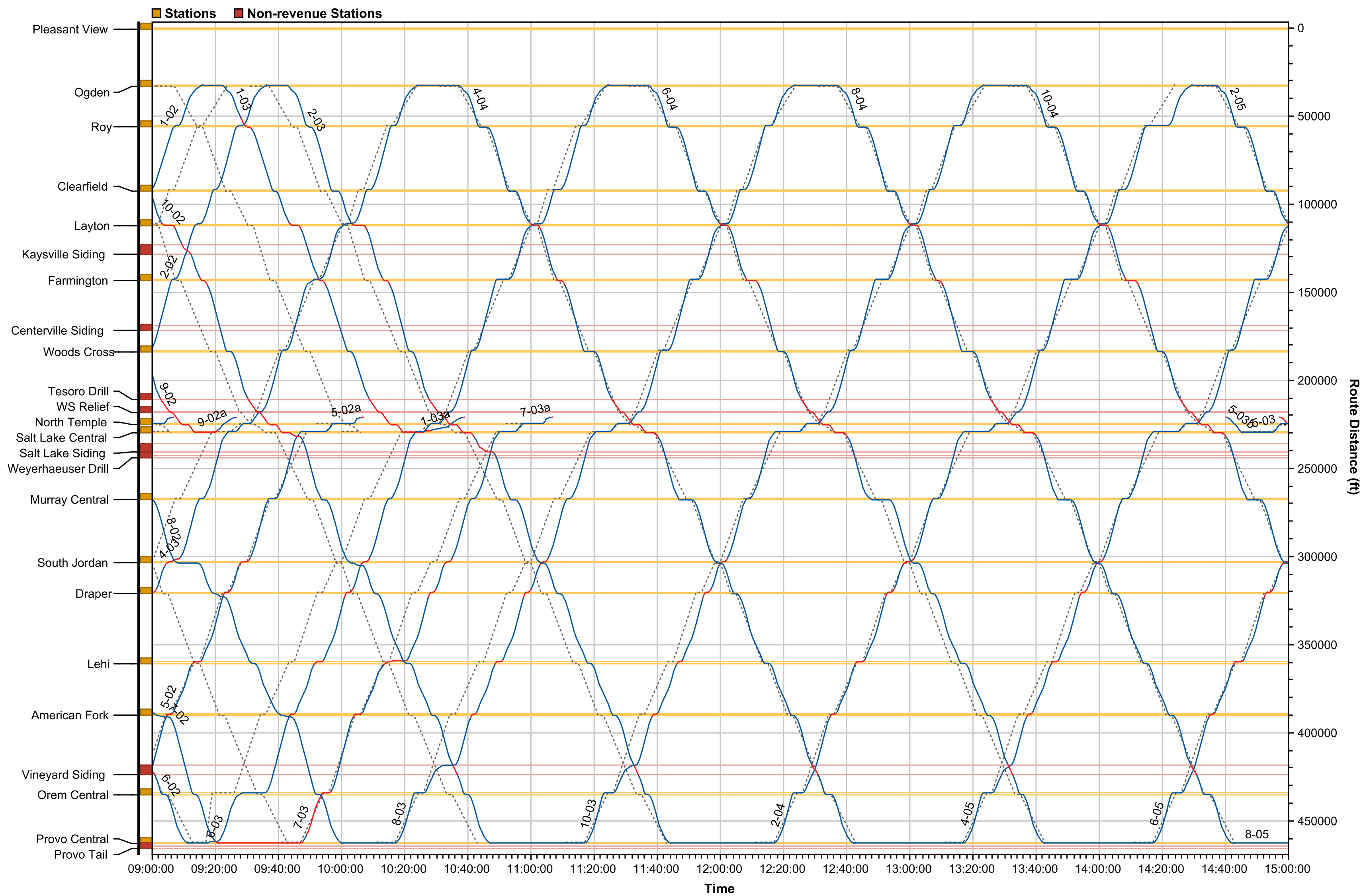


Figure 19-38: Time-Distance ("String") Chart – 9 AM – 3 PM – Future with PTC Day 4 Simulation Results with Perturbations

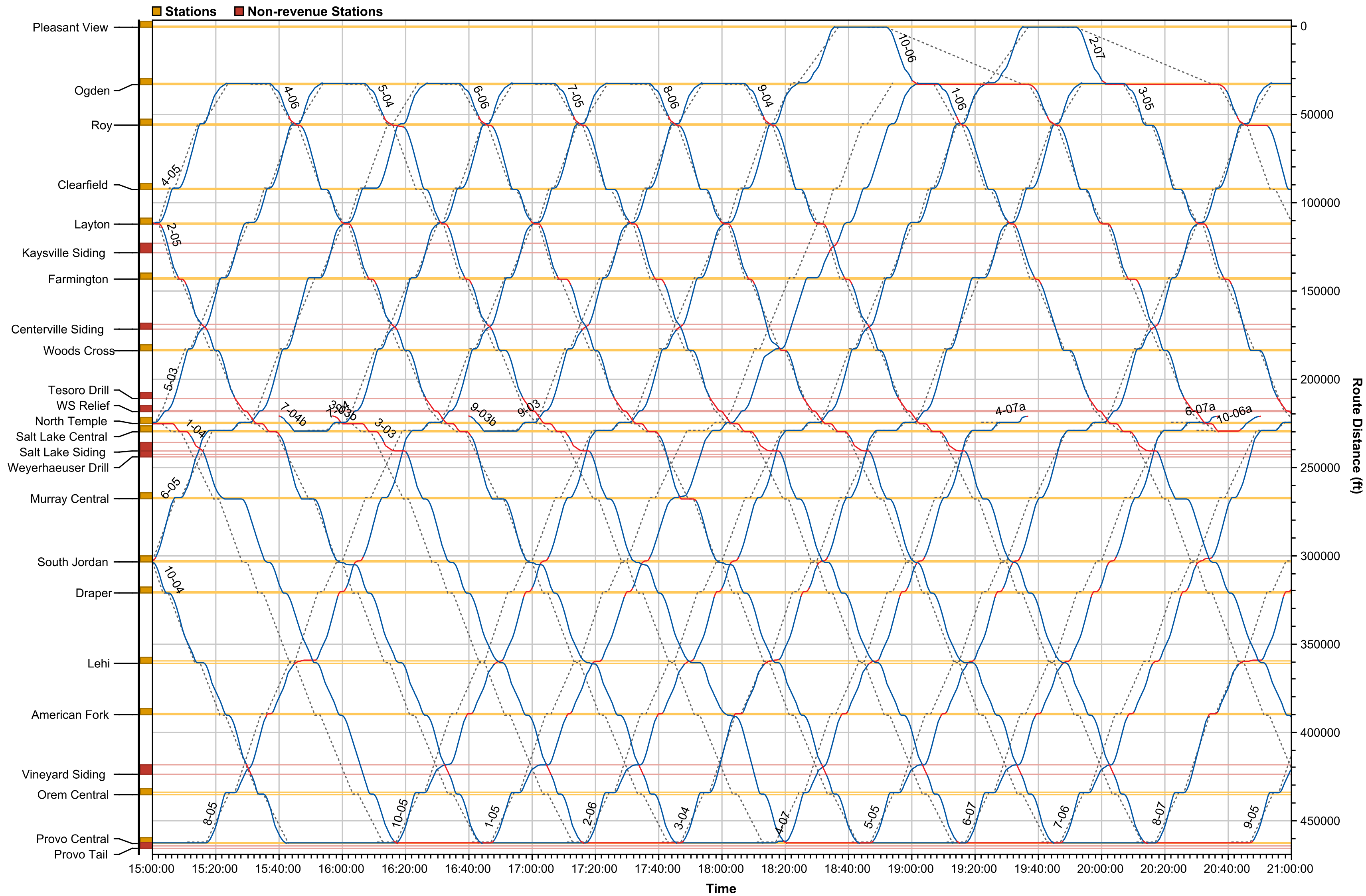


Figure 19-39: Time-Distance ("String") Chart – 3 PM – 9 PM – Future with PTC Day 4 Simulation Results with Perturbations

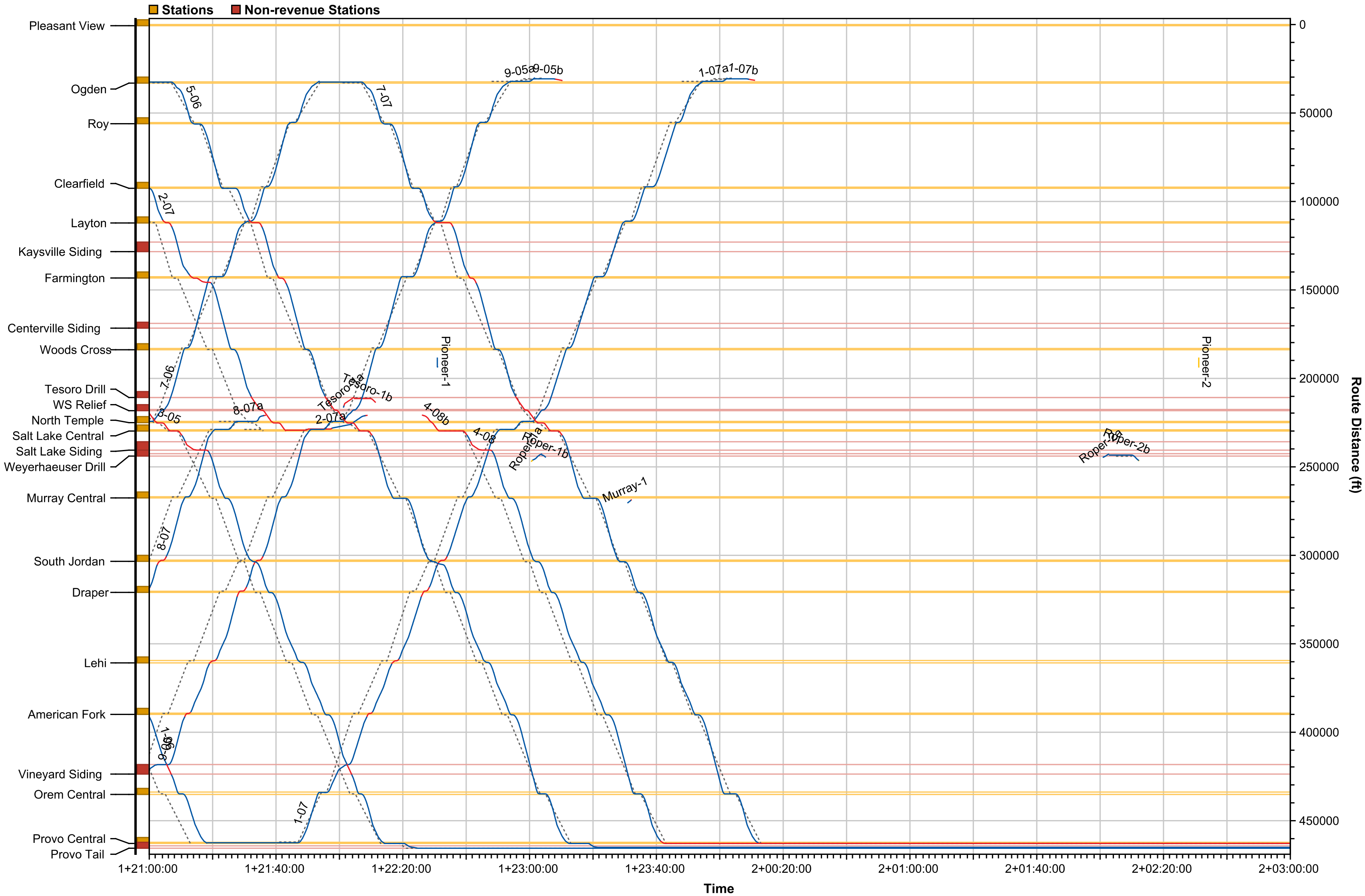


Figure 19-40: Time-Distance ("String") Chart – 9 PM – 3 AM – Future with PTC Day 4 Simulation Results with Perturbations

19.6 Day 5 Future Baseline with PTC Simulation Results with Perturbations

The FrontRunner - Day 5 operating plan includes a 5-minute delay for train 10-01 at North Temple due to assumed need to hold for a late connecting TRAX train. Day 5 also includes a locomotive failure on train 3-04 between Lehi station and American Fork station causing the train to stop for 10-minutes while the locomotive is reset. Station occupancy charts and string charts are included in the following sections.

19.6.1 Station Occupancy Charts – Salt Lake Central

Figure 19-41 shows all northbound trains leaving Salt Lake Central Station on time except for train 1-02. Six of the eight southbound trains departed the station late.

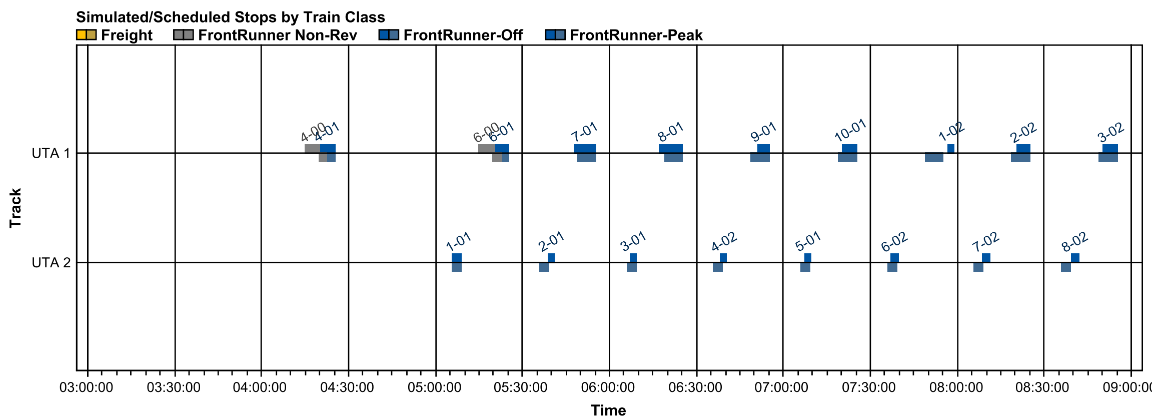


Figure 19-41: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Future with PTC Day 5 Simulation Results with Perturbations

Figure 19-42 shows all revenue through trains in both directions departing the station on time except train 6-04.

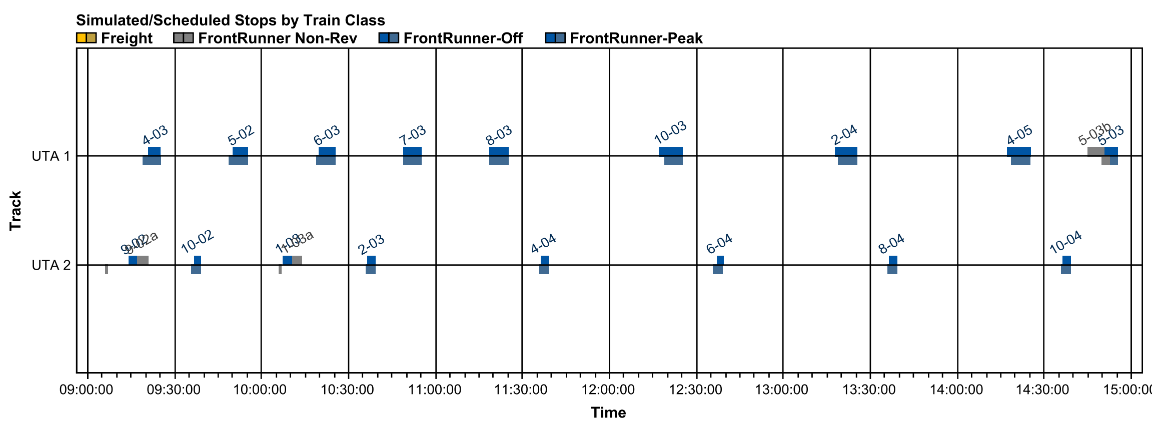


Figure 19-42: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Future with PTC Day 5 Simulation Results with Perturbations

Figure 19-43 shows the impact to train 3-04 of the locomotive failure and resulting 10-minute delay.

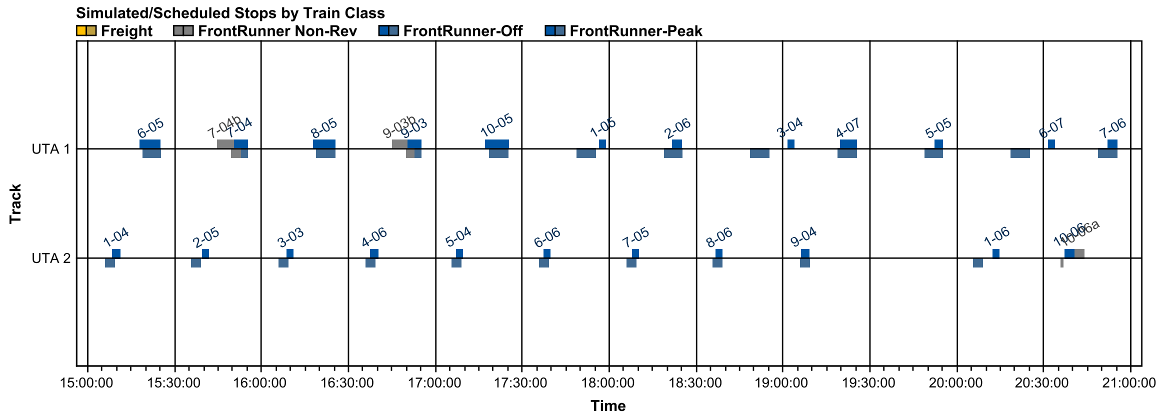


Figure 19-43: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Future with PTC Day 5 Simulation Results with Perturbations

Figure 19-44 shows a majority of the trains arriving to the station late.

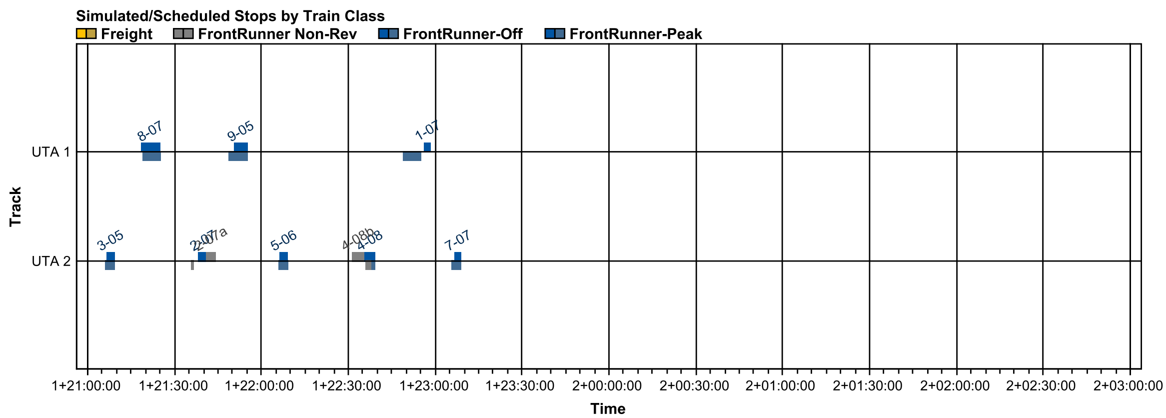


Figure 19-44: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Future with PTC Day 5 Simulation Results with Perturbations

19.6.2 String Charts

Figure 19-45 shows that train 10-01 has been randomly assigned the 5-minute delay perturbation at North Temple station. Train 9-02 is significantly delayed at Roy station waiting for the meet with train 10-01. Train 8-01 is randomly assigned a significantly long dwell at Lehi station. This causes delays for train 9-01 while it waits at Vineyard Siding and then to train 2-01 as it waits for train 9-01 at Lehi station.

Under the Day 5 perturbations, train 3-04 is randomly assigned a locomotive failure and stops for 10-minutes between Lehi station and American Fork station as shown in Figure 19-47. Train 4-06 is randomly assigned a significantly long dwell at South Jordan station. This causes train 1-05 to wait at Lehi station for train 4-06 to pass. Train 1-05 continues to run behind schedule for the rest of its trip and leaves Ogden station late as train 1-06.

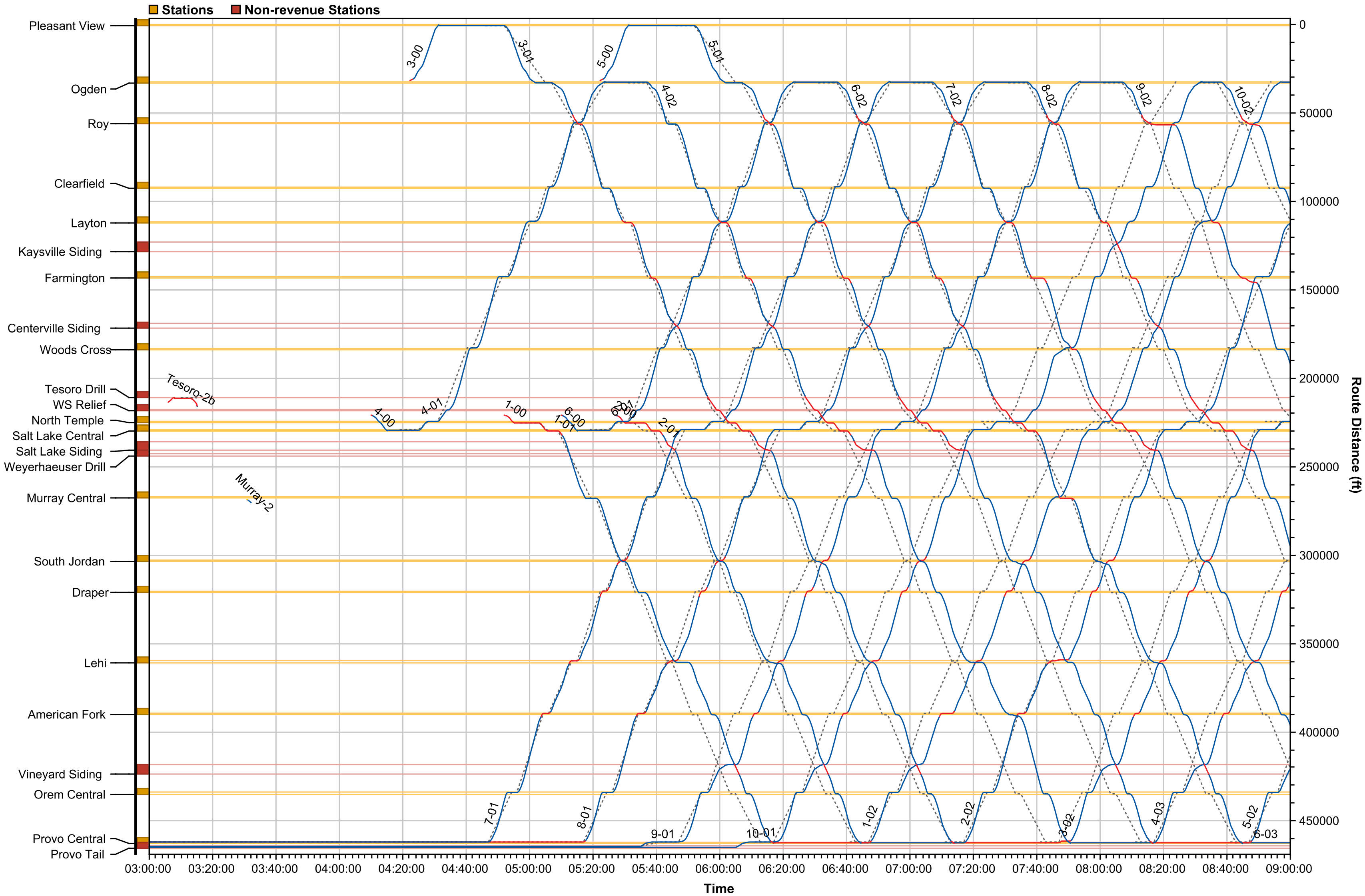


Figure 19-45: Time-Distance ("String") Chart – 3 AM – 9 AM – Future with PTC Day 5 Simulation Results with Perturbations ()

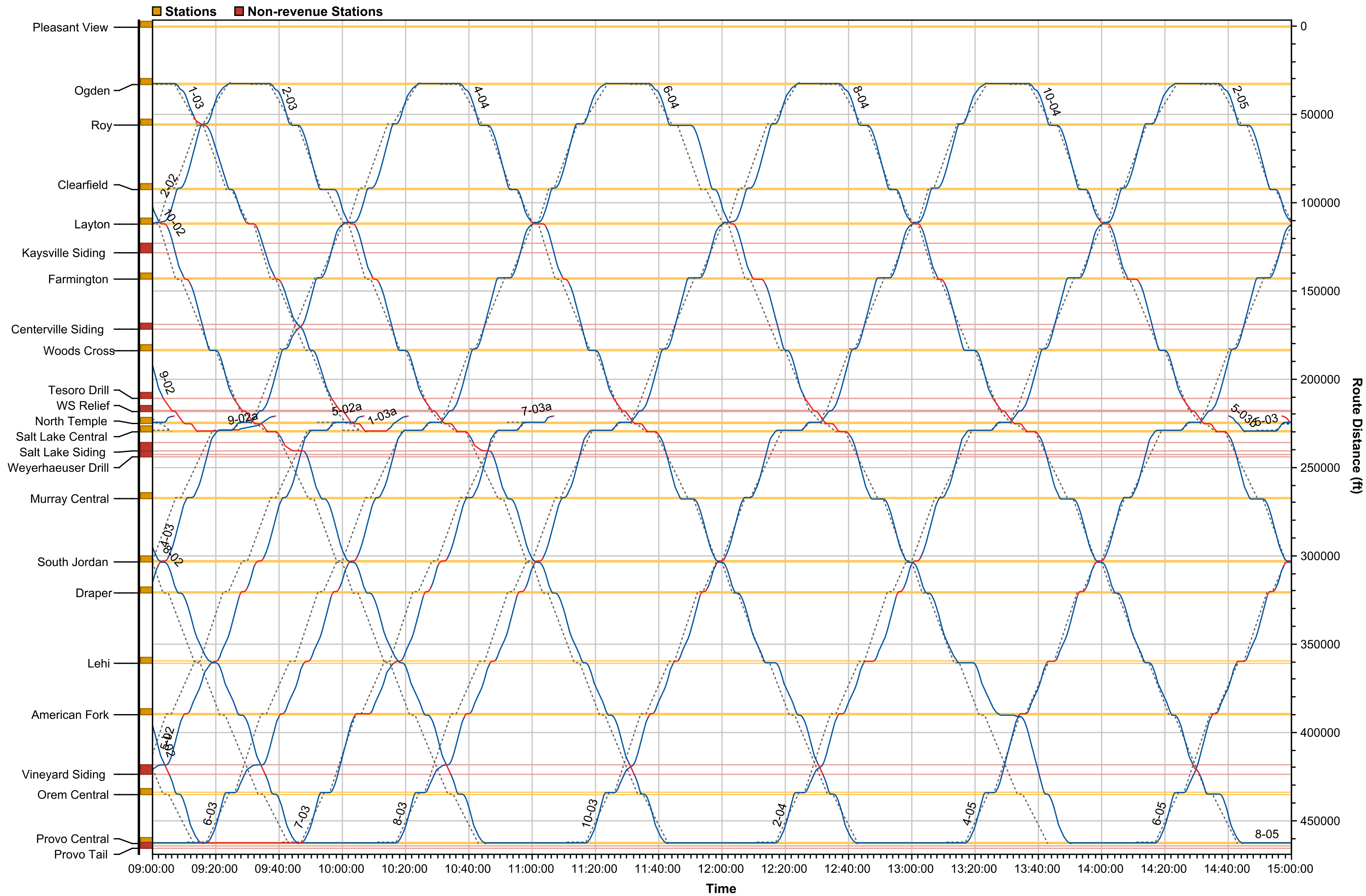


Figure 19-46: Time-Distance ("String") Chart – 9 AM – 3 PM – Future with PTC Day 5 Simulation Results with Perturbations

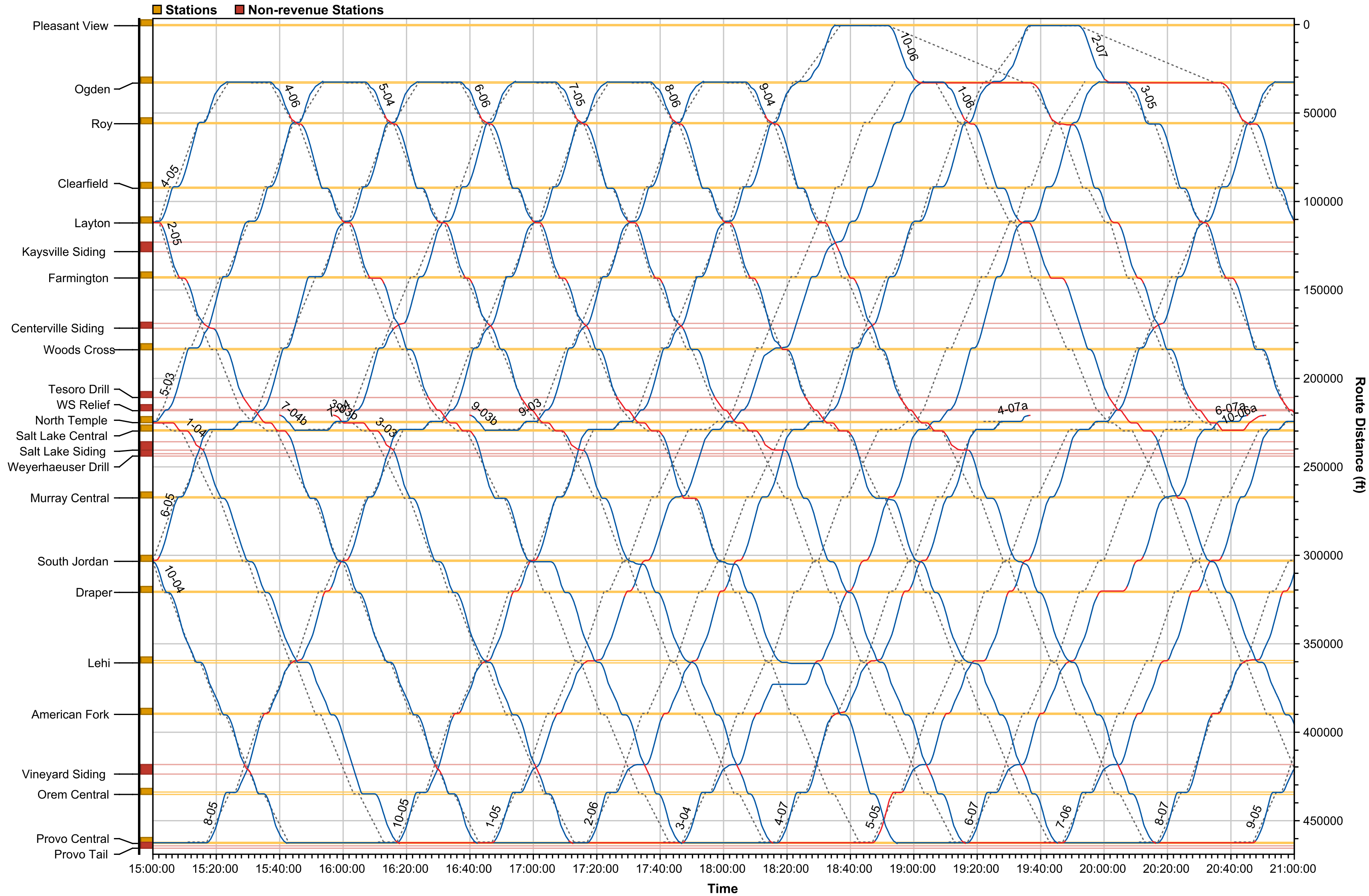


Figure 19-47: Time-Distance ("String") Chart – 3 PM – 9 PM – Future with PTC Day 5 Simulation Results with Perturbations

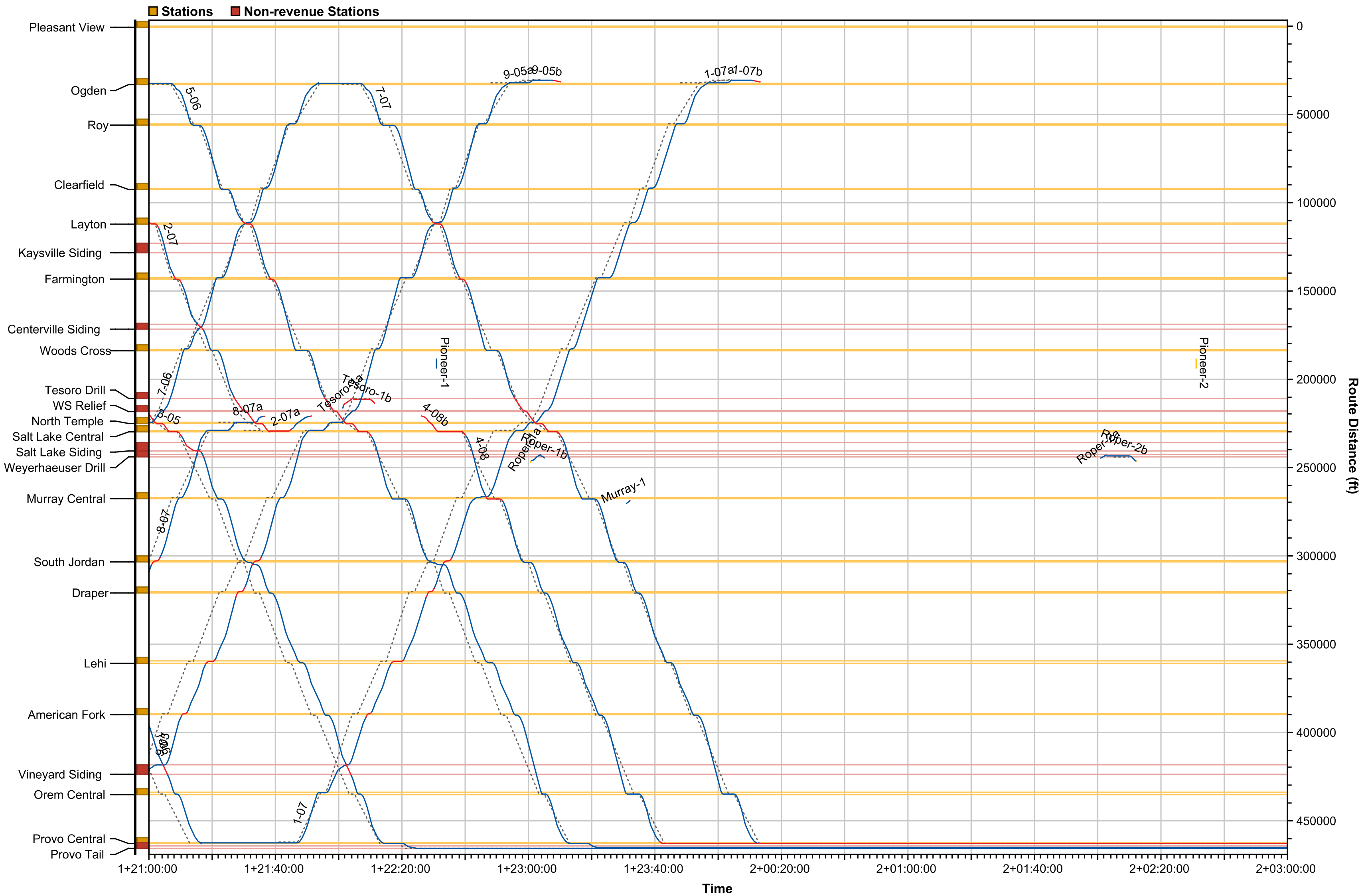
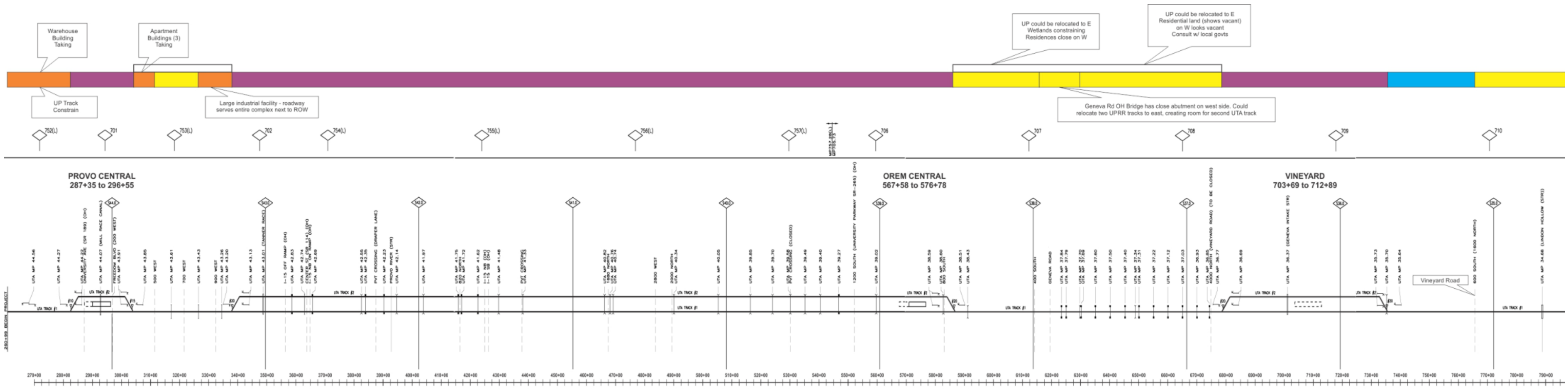
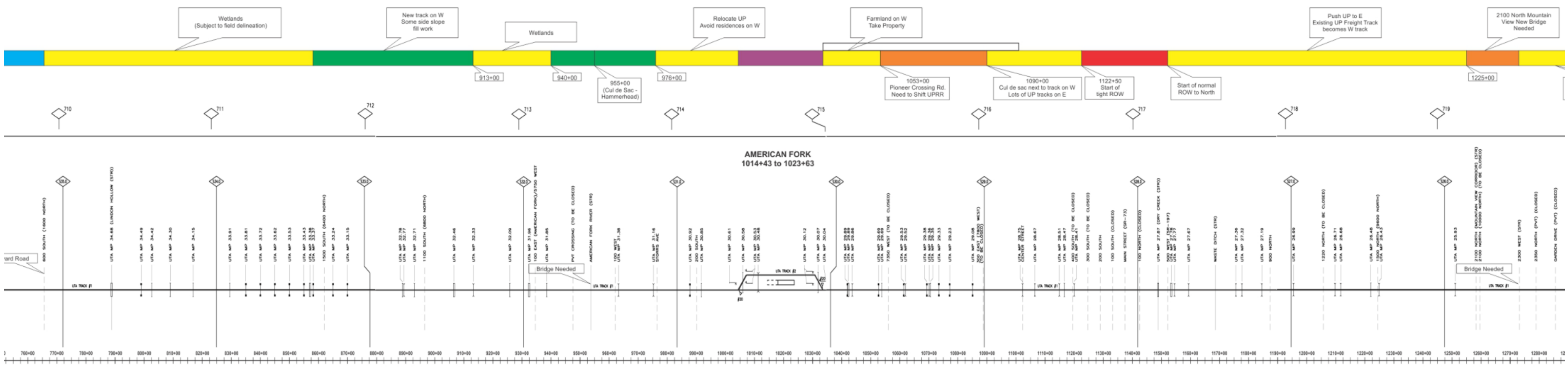
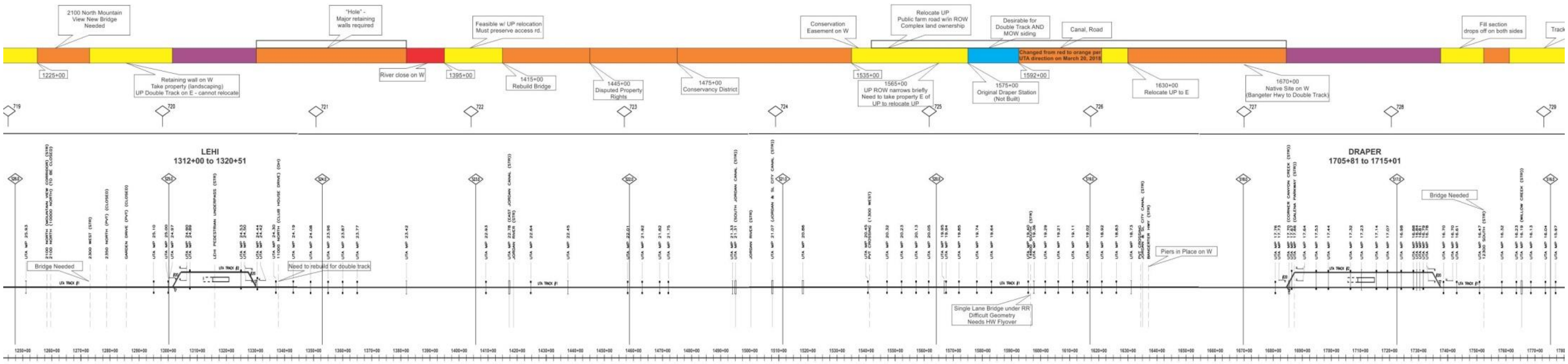


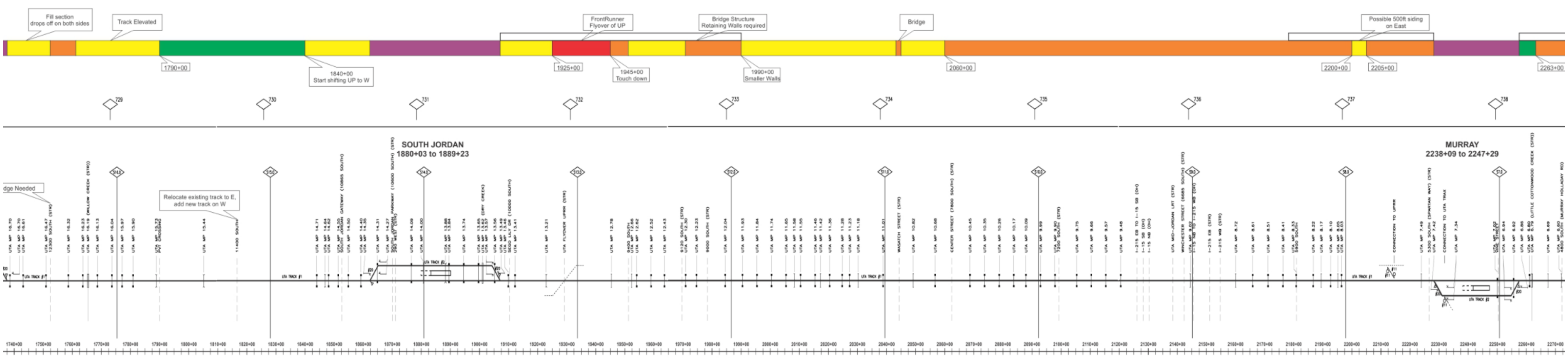
Figure 19-48: Time-Distance ("String") Chart – 9 PM – 3 AM – Future with PTC Day 5 Simulation Results with Perturbations

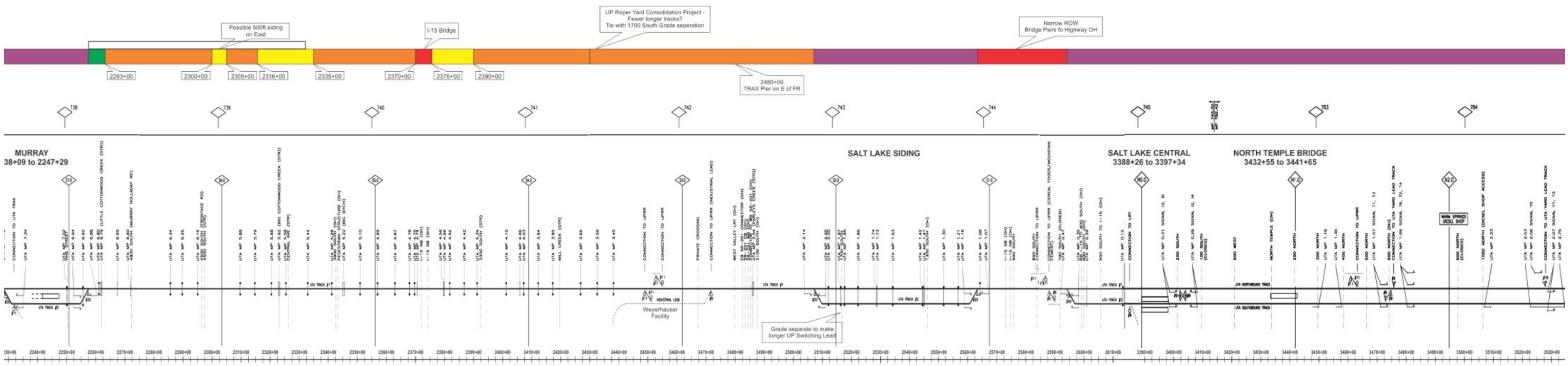
20 Appendix E Double Track Feasibility Workshop Results

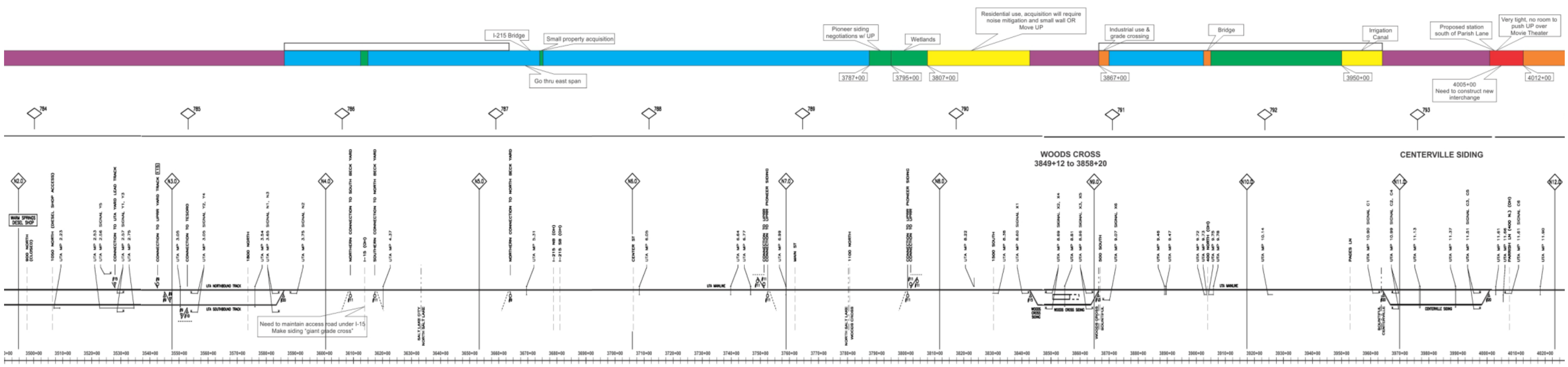

Warehouse Building Taking
Apartment Buildings (3) Taking
UP could be relocated to E Wetlands constraining Residences close on W
UP could be relocated to E Residential land (shows vacant) on W looks vacant Consult w/ local govts
UP Track Constrain
Large industrial facility - roadway serves entire complex next to ROW
Geneva Rd OH Bridge has close abutment on west side. Could relocate two UPRR tracks to east, creating room for second UTA track
PROVO CENTRAL 287+35 to 296+55
OREM CENTRAL 567+58 to 576+78
VINEYARD 703+69 to 712+89
Vineyard Road

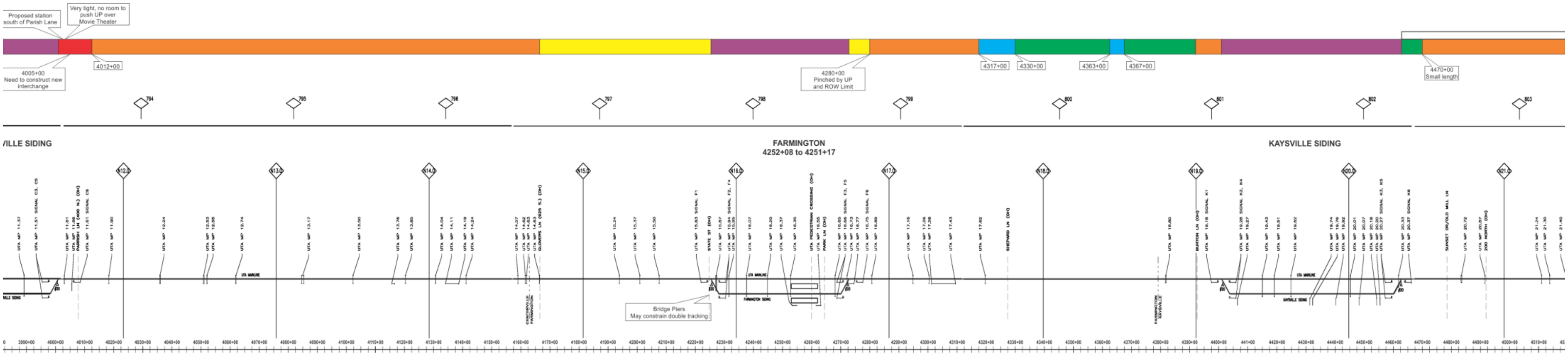

Wetlands (Subject to field delineation)
New track on W Some side slope fill work
Wetlands
Relocate UP Avoid residences on W
Farmland on W Take Property
Push UP to E Existing UP Freight Track becomes W track
2100 North Mountain View New Bridge Needed
913+00
940+00
955+00 (Cul de Sac - Hammerhead)
976+00
1053+00 Pioneer Crossing Rd. Need to Shift UPRR
1090+00 Cul de sac next to track on W Lots of UP tracks on E
1122+50 Start of tight ROW
Start of normal ROW to North
1225+00
AMERICAN FORK 1014+43 to 1023+63
Bridge Needed
Bridge Needed

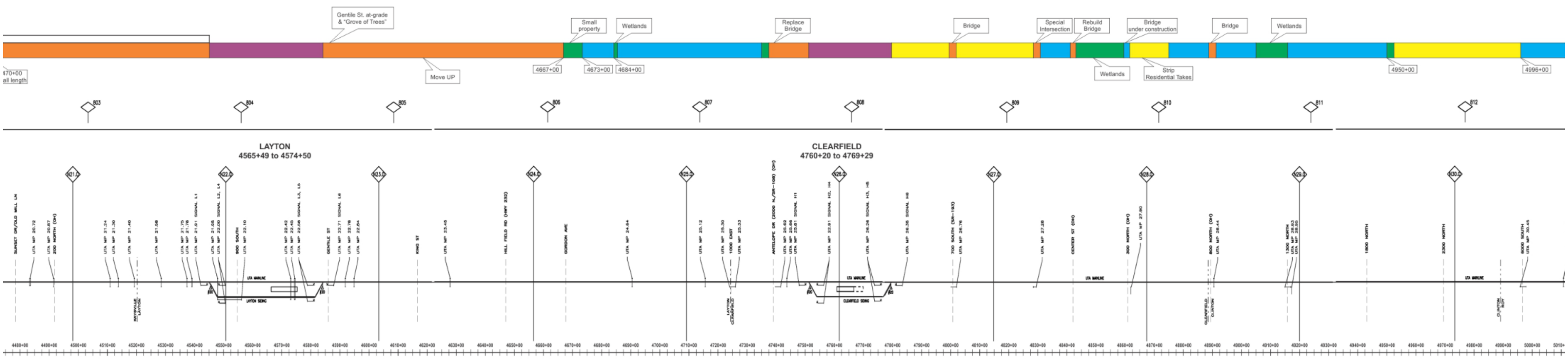

2100 North Mountain View New Bridge Needed
"Hole" - Major retaining walls required
Feasible w/ UP relocation Must preserve access rd.
Conservation Easement on W
Relocate UP Public farm road w/in ROW Complex land ownership
Desirable for Double Track AND MOW siding
Canal, Road
Fill section drops off on both sides
1225+00
Retaining wall on W Take property (landscaping) UP Double Track on E - cannot relocate
River close on W
1395+00
1415+00 Rebuild Bridge
1445+00 Disputed Property Rights
1475+00 Conservancy District
1535+00
1565+00 UP ROW narrows briefly Need to take property E of UP to relocate UP
1575+00 Original Draper Station (Not Built)
1592+00
Changed from red to orange per UTA direction on March 28, 2018
1630+00 Relocate UP to E
1670+00 Native Site on W (Bangeter Hwy to Double Track)
LEHI
1312+00 to 1320+51
DRAPER
1705+81 to 1715+01
Bridge Needed
Need to rebuild for double track
Piers in Place on W
Single Lane Bridge under RR Difficult Geometry Needs HW Flyover

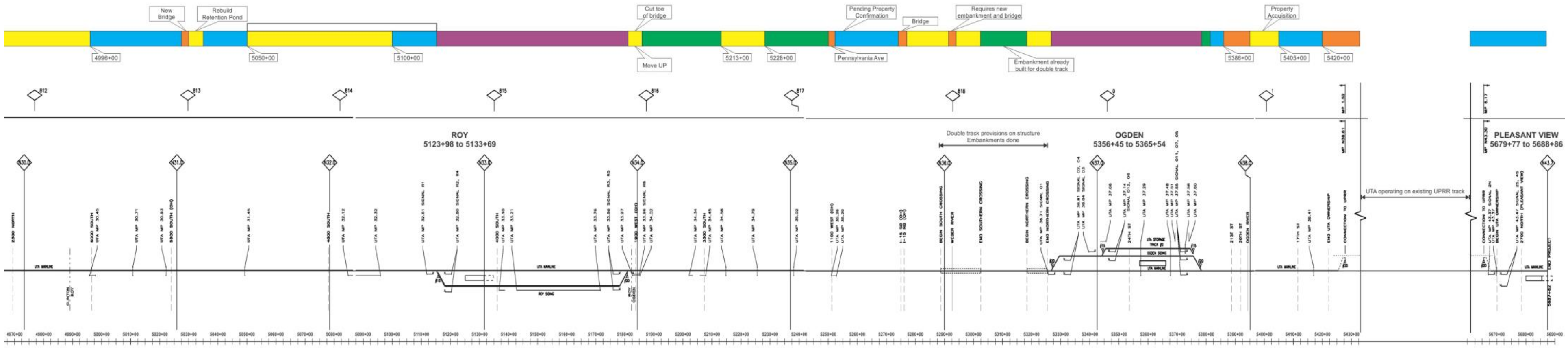

Fill section drops off on both sides
Track Elevated
FrontRunner Flyover of UP
Bridge Structure Retaining Walls required
Bridge
Possible 500ft siding on East
1790+00
1840+00 Start shifting UP to W
1925+00
1945+00 Touch down
1990+00 Smaller Walls
2060+00
2200+00
2205+00
2263+00
SOUTH JORDAN
1880+03 to 1889+23
MURRAY
2238+09 to 2247+29
Relocate existing track to E, add new track on W


Possible 500ft siding on East
I-15 Bridge
UP Roper Yard Consolidation Project - Fewer longer tracks? Tie with 1700 South Grade seperation
Narrow ROW Bridge Piers fo Highway OH
2263+00
2300+00
2305+00
2316+00
2335+00
2370+00
2376+00
2390+00
2480+00 TRAX Pier on E of FR
MURRAY
SALT LAKE SIDING
SALT LAKE CENTRAL 3388+26 to 3397+34
NORTH TEMPLE BRIDGE 3432+55 to 3441+65
Weyerhauser Facility
Grade separate to make longer UP Switching Lead


I-215 Bridge
Small property acquisition
Go thru east span
Pioneer siding negotiations w/ UP
Wetlands
Residential use, acquisition will require noise mitigation and small wall OR Move UP
Industrial use & grade crossing
Bridge
Irrigation Canal
Proposed station south of Parish Lane
Very tight, no room to push UP over Movie Theater
3787+00
3795+00
3807+00
3867+00
3950+00
4005+00 Need to construct new interchange
4012+00
WOODS CROSS 3849+12 to 3858+20
CENTERVILLE SIDING
Need to maintain access road under I-15 Make siding "giant grade cross"


Proposed station south of Parish Lane
Very tight, no room to push UP over Movie Theater
4012+00
4005+00 Need to construct new interchange
4280+00 Pinched by UP and ROW Limit
4317+00
4330+00
4363+00
4367+00
4470+00 Small length
FARMINGTON 4252+08 to 4251+17
KAYSVILLE SIDING
Bridge Piers May constrain double tracking


Gentile St. at-grade & "Grove of Trees"
Small property
Wetlands
Replace Bridge
Bridge
Special Intersection
Rebuild Bridge
Bridge under construction
Bridge
Wetlands
Move UP
4667+00
4673+00
4684+00
Wetlands
Strip Residential Takes
4950+00
4998+00
LAYTON 4565+49 to 4574+50
CLEARFIELD 4760+20 to 4769+29



Double Track already in place

Double Track can be obtained with minimal difficulty (no ROW acquisition, simple grading, no obvious utility relocations, no UP relocation, no wetlands mitigation, no new structures other than culverts)

Double Track can be obtained with moderate difficulty (no ROW acquisition except for possible UP ROW acquisition with no associated track relocation, simple to moderate grading, possible utility relocations, no UP relocation, possible minor to moderate wetlands mitigation, no new structures other than culverts and simple short bridge spans)

Double Track can be obtained with difficulty (possible ROW acquisition except for major taking of active industrial facilities or multiple residences, possible UP ROW acquisition with associated track relocation, possible major grading including new minor to major retaining walls, possible utility relocations, possible minor to major wetlands mitigation, possible new bridge structures including multiple span structures but excluding major new rail viaducts/flyovers or complete reconstruction of major (interstate or other major arterial) overgrade structures)

Double Track can be obtained with major difficulty (possible ROW acquisition including taking of active industrial facilities or multiple residences, possible UP ROW acquisition with associated track relocation including major relocation of multiple main or yard tracks, possible major grading including new minor to major retaining walls, possible utility relocations, possible minor to major wetlands mitigation, possible new bridge structures including multiple span structures but excluding major new rail viaducts/flyovers or complete reconstruction of major (interstate or other major arterial) overgrade structures, possible major reconstruction of stations include new ADA-compliant elevator towers for cross-track access)

Double Track can be obtained with extreme difficultly and expense or is physically impossible (possible ROW acquisition including taking of active industrial facilities or multiple residences, possible UP ROW acquisition with associated track relocation including relocation of multiple main or yard tracks, possible major grading including new minor to major retaining walls, possible utility relocations, possible minor to major wetlands mitigation, possible environmental impact to publicly-owned lands, including public parks, adjacent to ROW, possible destruction or alteration of significant cultural resources adjacent to ROW, possible required relocation of waterbodies such as rivers and canals, possible new bridge structures including multiple span structures and possibly including major new rail viaducts/flyovers or complete reconstruction of major (interstate or other major arterial) overgrade structures, possible major reconstruction of stations include new ADA-compliant elevator towers for cross-track access

Double Track additions proposed for all scenarios in August 2014 UTA Double Tracking Feasibility Analysis

21 Appendix F Low Investment Scenario Time-Distance ("String") Charts and Station Occupancy Charts

21.1 Low Investment Scenario Simulation Results without Perturbations (Ideal Day)

21.1.1 Station Occupancy Charts – Salt Lake Central

Northbound trains are shown on UTA1 with southbound trains on UTA2. Most northbound trains are arriving early. The southbound trains have just a three-minute dwell scheduled that in this simulation results in almost half of the through trains arriving and departing late.

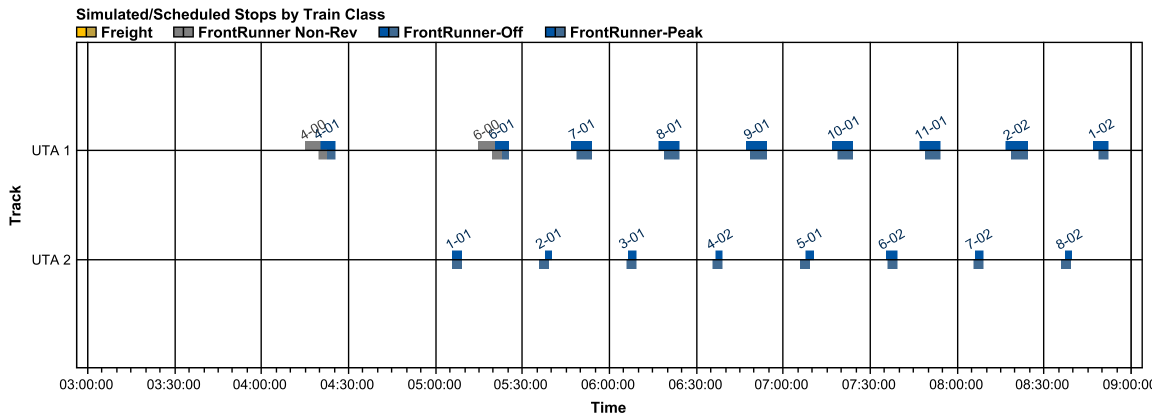


Figure 21-1: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Low Investment Scenario No Added Perturbations

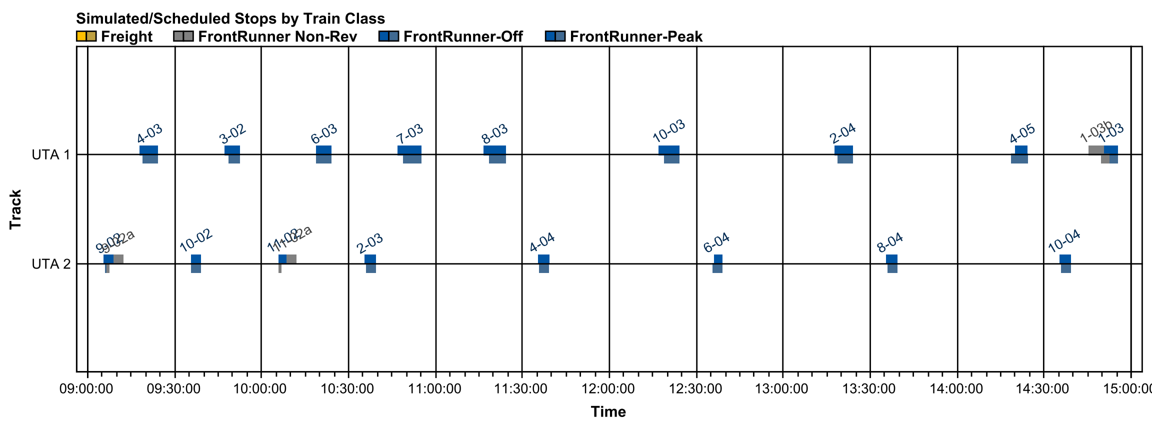


Figure 21-2: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Low Investment Scenario No Added Perturbations

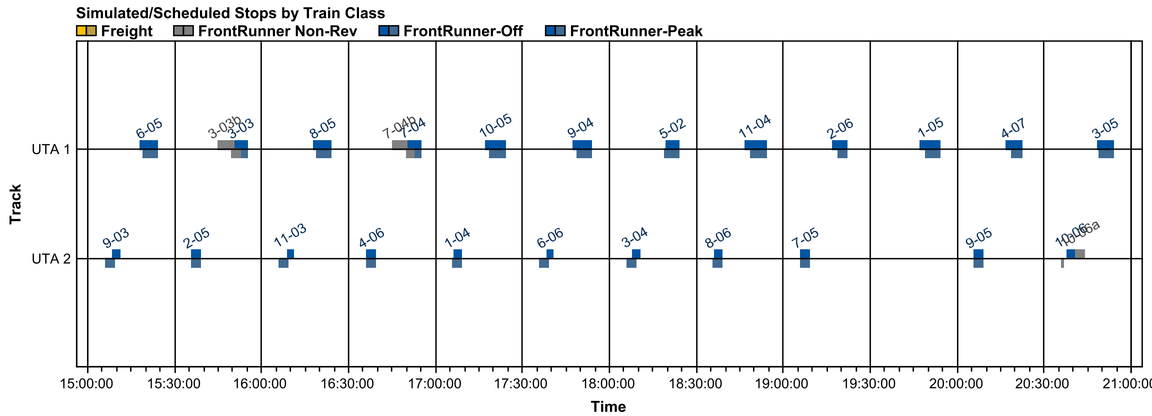


Figure 21-3: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Low Investment Scenario No Added Perturbations

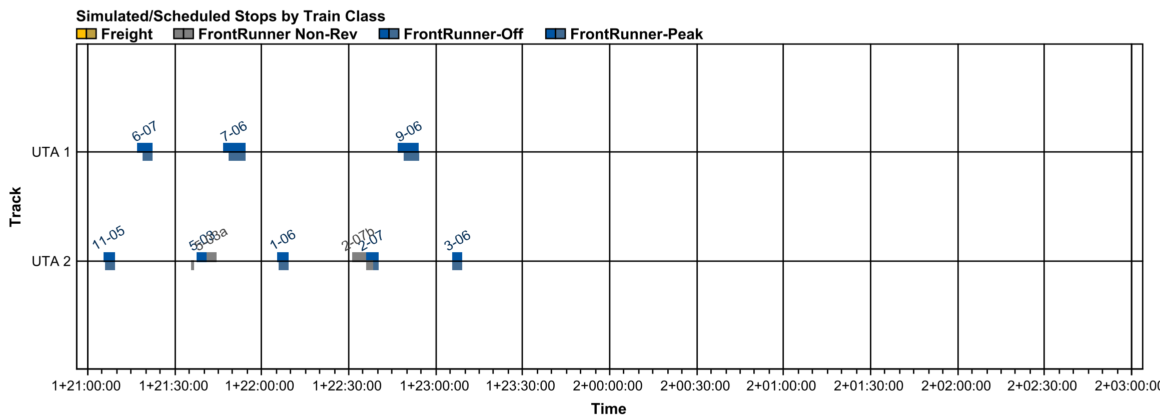


Figure 21-4: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Low Investment Scenario No Added Perturbations

21.1.2 String Charts

Delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones. The trains run very close to on-time in the No Added Perturbations run. With the extended double track sections, there are no cascading delays, unlike the Future with PTC scenario.

Figure 21-8 shows that train 6-03 and train 8-03 are randomly assigned long dwells at Clearfield and train 6-04 has a long dwell at Roy. Additionally, Train 4-05 receives a long dwell at Lehi. The northbound trains recover to schedule by the time they arrive Ogden and the southbound trains recover to schedule by the time they leave North Temple.

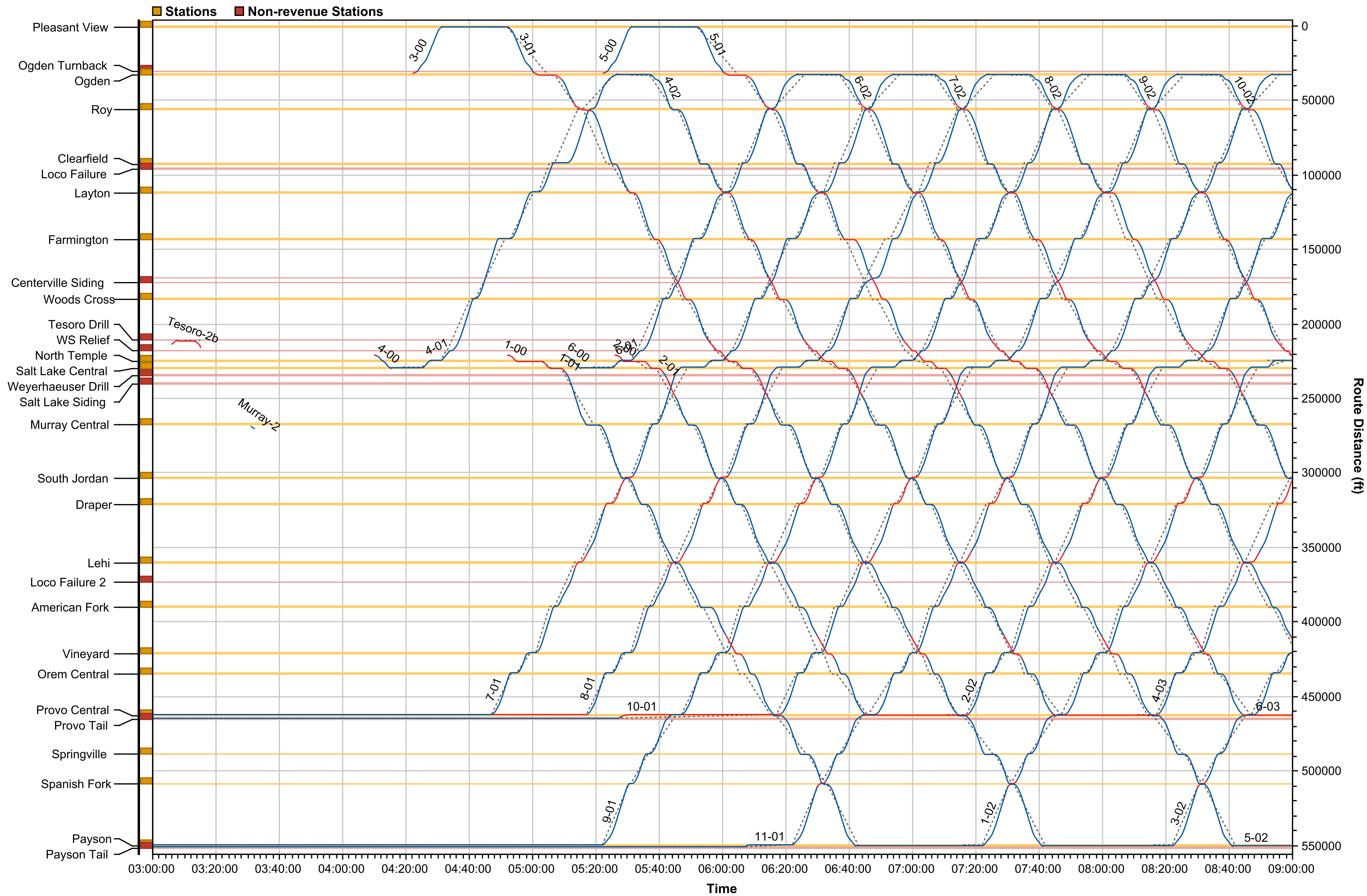


Figure 21-5: Time-Distance ("String") Chart – 3 AM – 9 AM – Low Investment Scenario No Added Perturbations

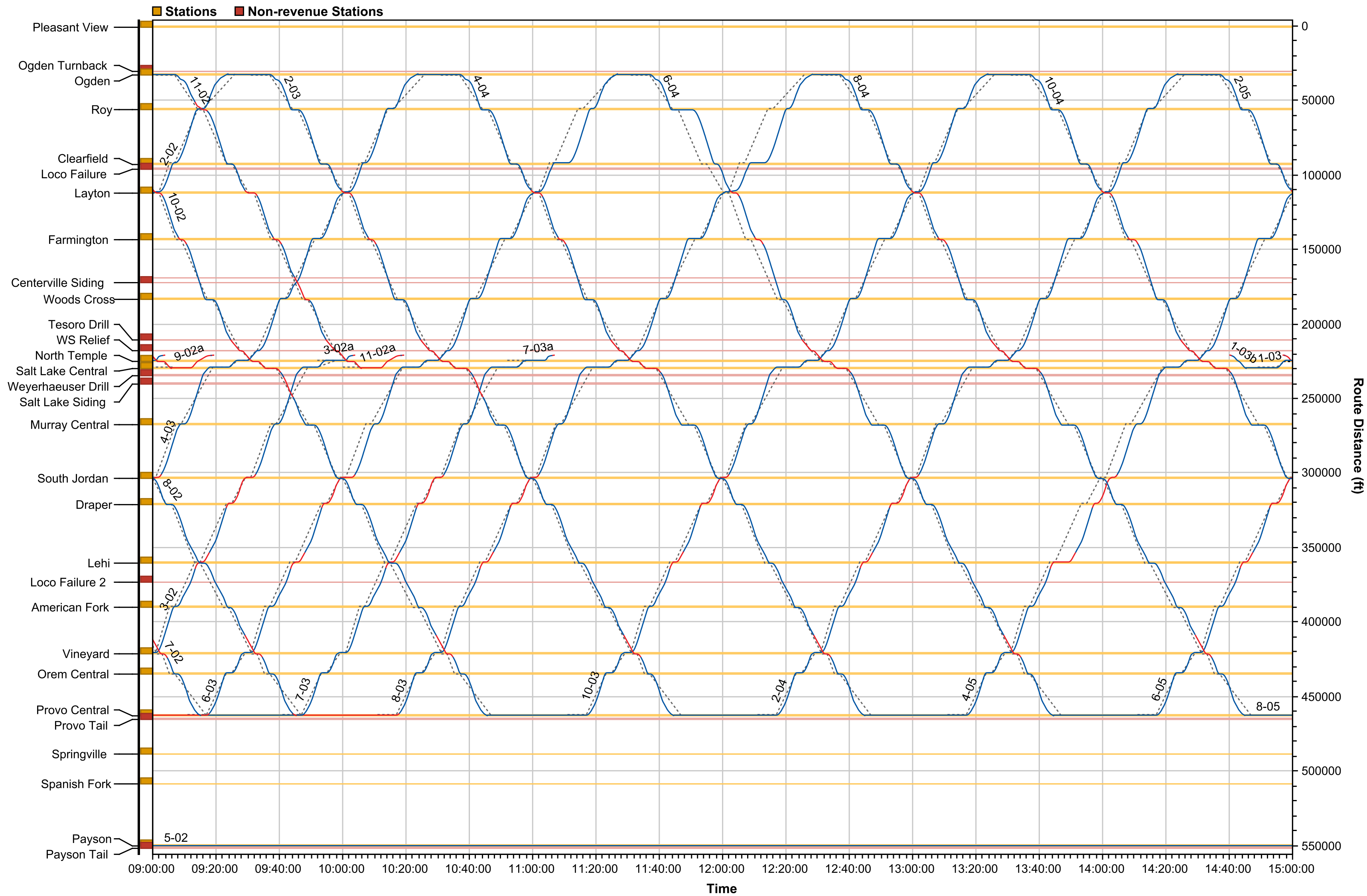


Figure 21-6: Time-Distance ("String") Chart – 9 AM – 3 PM – Low Investment Scenario No Added Perturbations

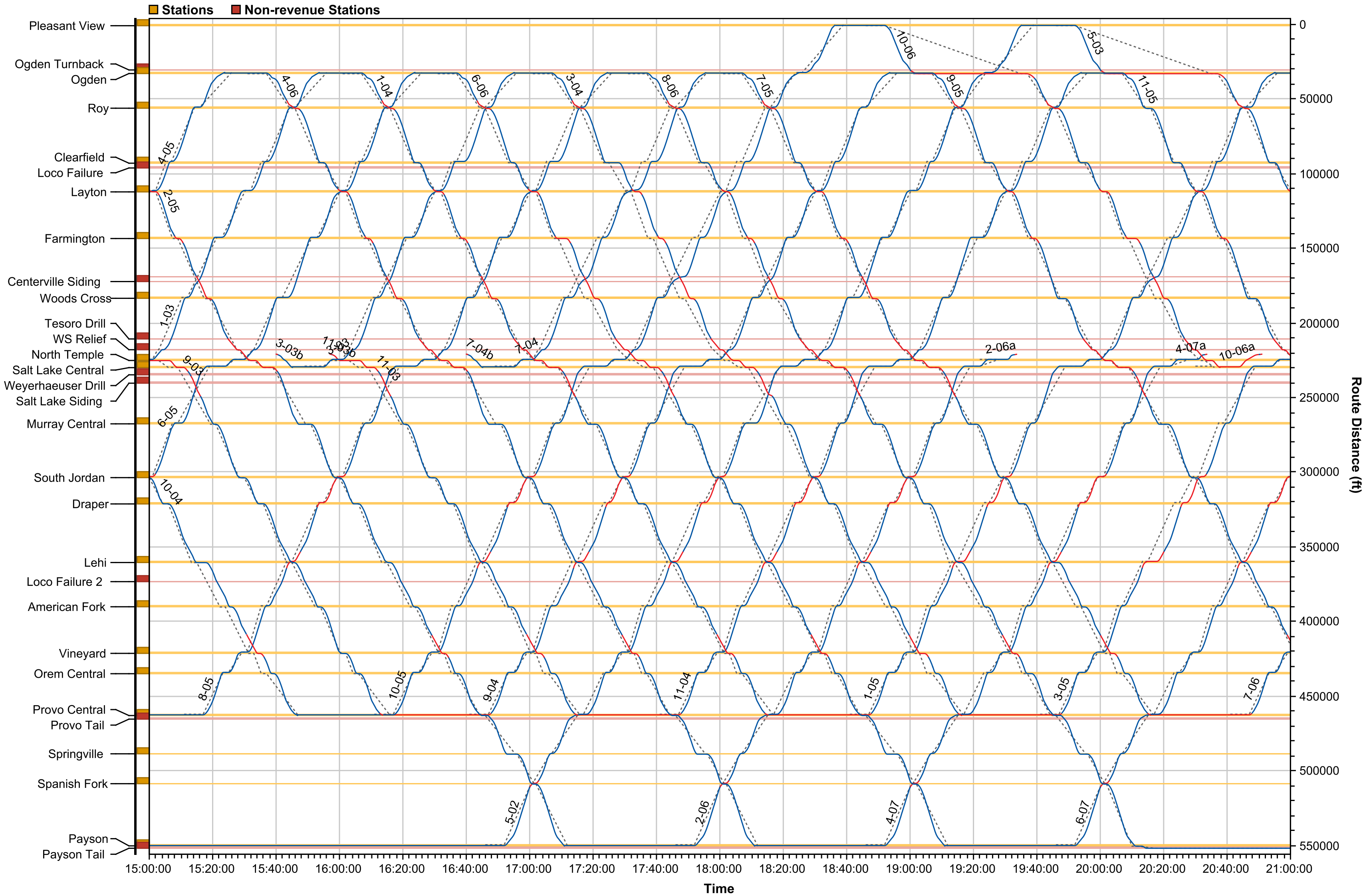


Figure 21-7: Time-Distance ("String") Chart – 3 PM – 9 PM – Low Investment Scenario No Added Perturbations

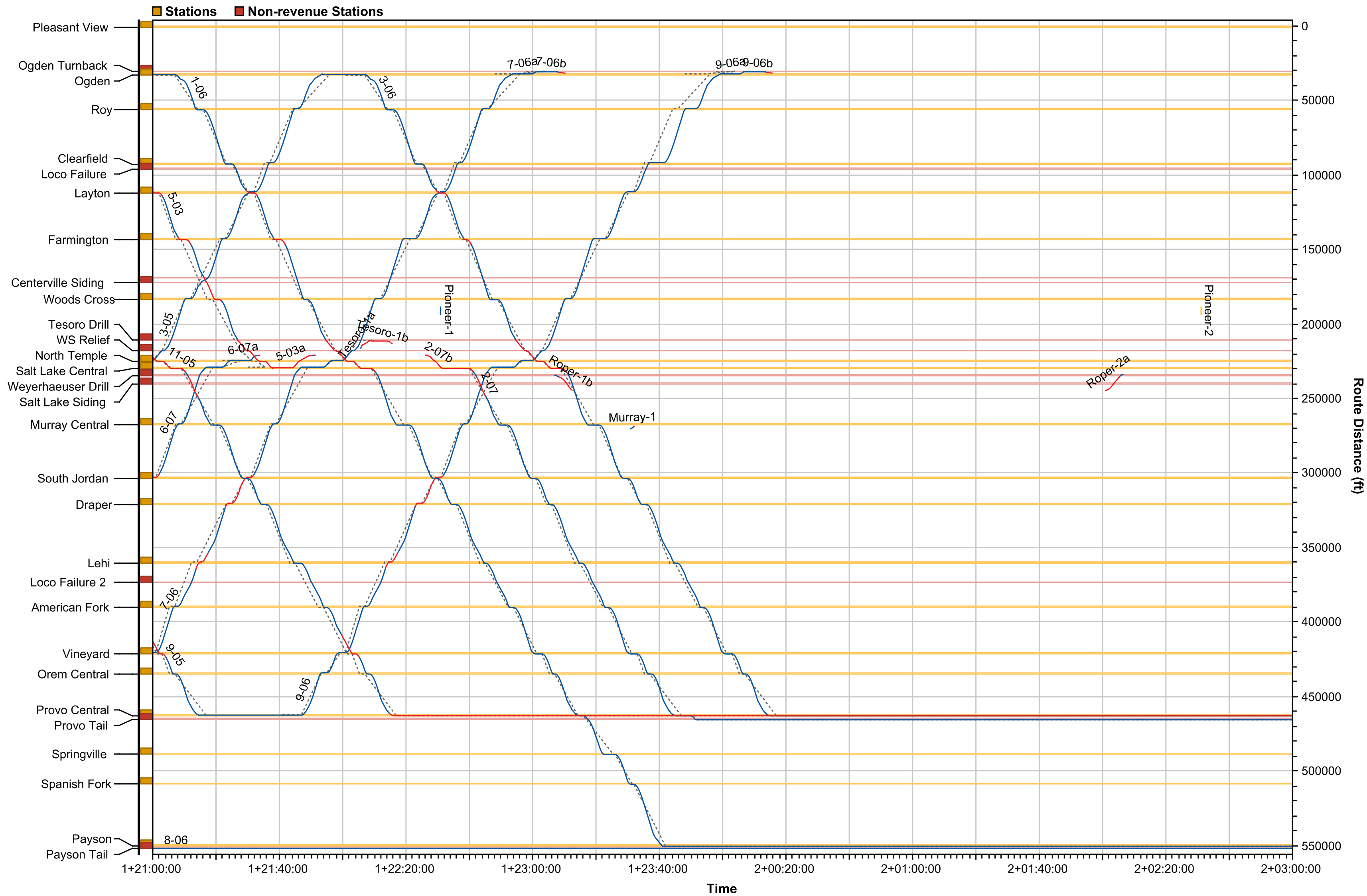


Figure 21-8: Time-Distance ("String") Chart – 9 PM – 3 AM – Low Investment Scenario No Added Perturbations

21.2 Day 1 Low Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 1 operating plan includes a randomly-assigned door failure for train 8-06 at South Jordan station. This causes a 7-minute extended dwell. Day 1 also includes a 5-minute delay for train 10-01 at North Temple due to the randomly-assigned need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

21.2.1 Station Occupancy Charts – Salt Lake Central

Figure 21-9 shows all northbound trains on UTA 1 leaving Salt Lake City on time. About half of the southbound trains arrive and depart the station late.

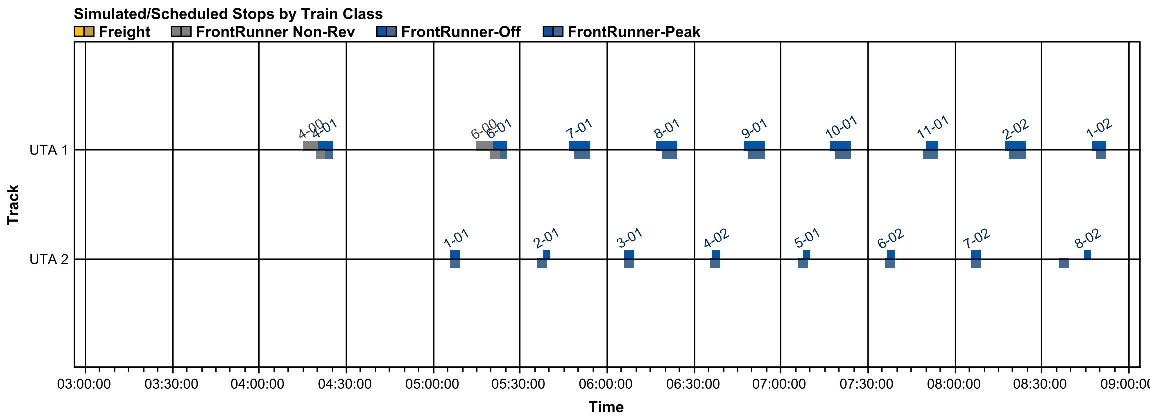


Figure 21-9: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Low Investment Scenario Day 1 Simulation Results with Perturbations

Figure 21-10 shows trains 7-03 and 2-04 arriving and departing late on the northbound track. The southbound track has most trains arriving and departing on time.

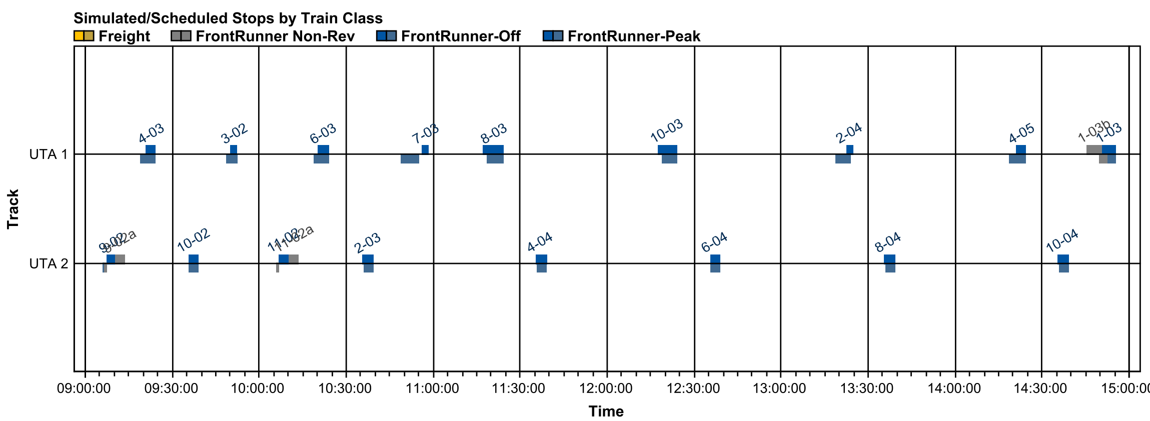


Figure 21-10: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Low Investment Scenario Day 1 Simulation Results with Perturbations

Figure 21-11 shows train 5-02, train 11-04, and train 1-05, arriving late on the northbound track but still leaving the station on time. Train 4-07 arrives on the northbound track late and departs late as well. About half of the trains on the southbound track arrive and depart late.

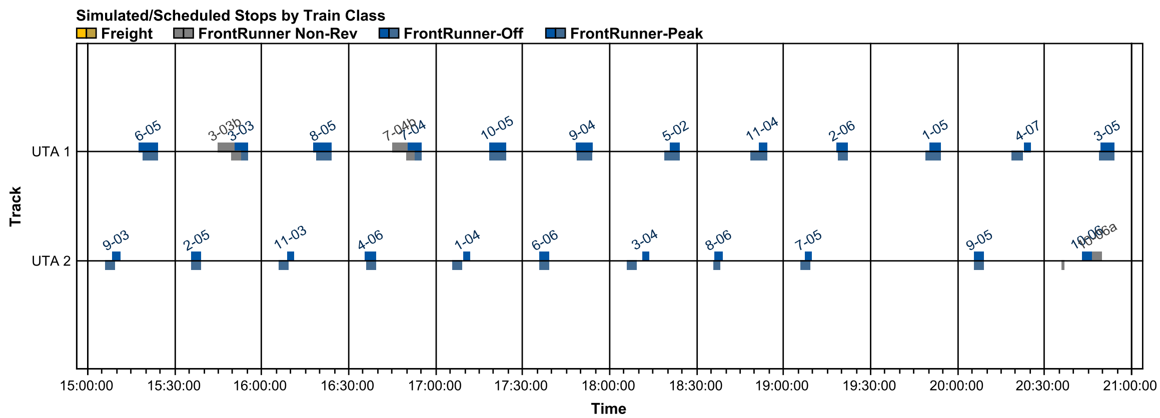


Figure 21-11: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Low Investment Scenario Day 1 Simulation Results with Perturbations

Figure 21-12 shows most trains departing on time, except for northbound train 6-07, which arrives and departs late.

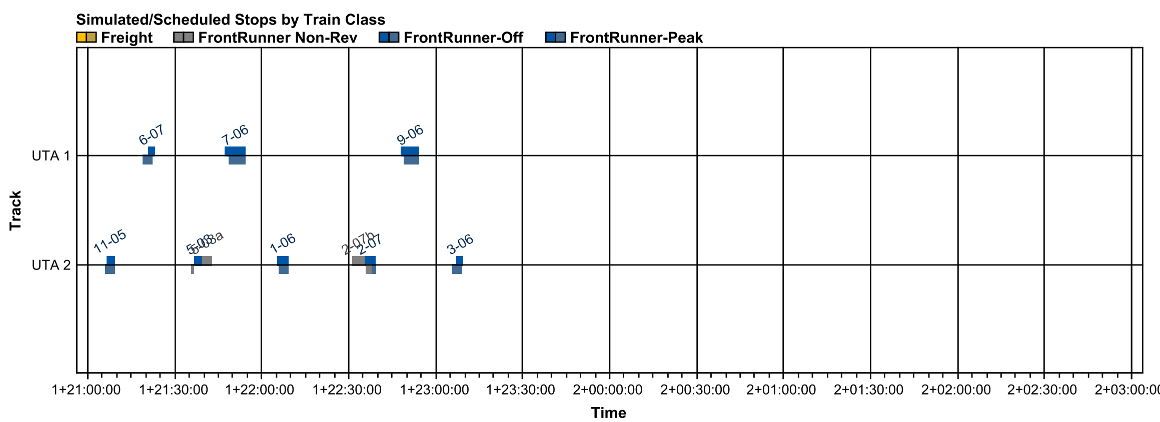


Figure 21-12: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Low Investment Scenario Day 1 Simulation Results with Perturbations

21.2.2 String Charts

Figure 21-13 shows the randomly-assigned 5-minute delay for train 10-01 at North Temple due to the need to hold for a late TRAX connection. Due to this prolonged delay, train 10-01 meets train 7-02 at the lengthened Woods Cross-Centerville Siding, train 8-02 at Layton and a prolonged wait for train 9-02 to wait for train 10-01 to pass at Roy. With the help of the extended sidings, train 10-01 is able to arrive Ogden nearly on time and 10-02 departs Ogden on time. However, the lateness caused to train 8-02 causes some issues to northbound trains at the end of the AM peak period.

Figure 21-15 shows the 7-minute extended dwell perturbation to train 8-06. This causes a delay to train 1-05 as it waits at Lehi station for the meet with train 8-06, although the extended siding helps lessen the delay. The delay to train 1-05 does not cause a delay to southbound train 7-05 because of the extended siding between South Jordan and Draper. Train 4-07 is delayed at Vineyard, although the extended siding helps with this meet so that the train is nearly on time at Salt Lake Central.

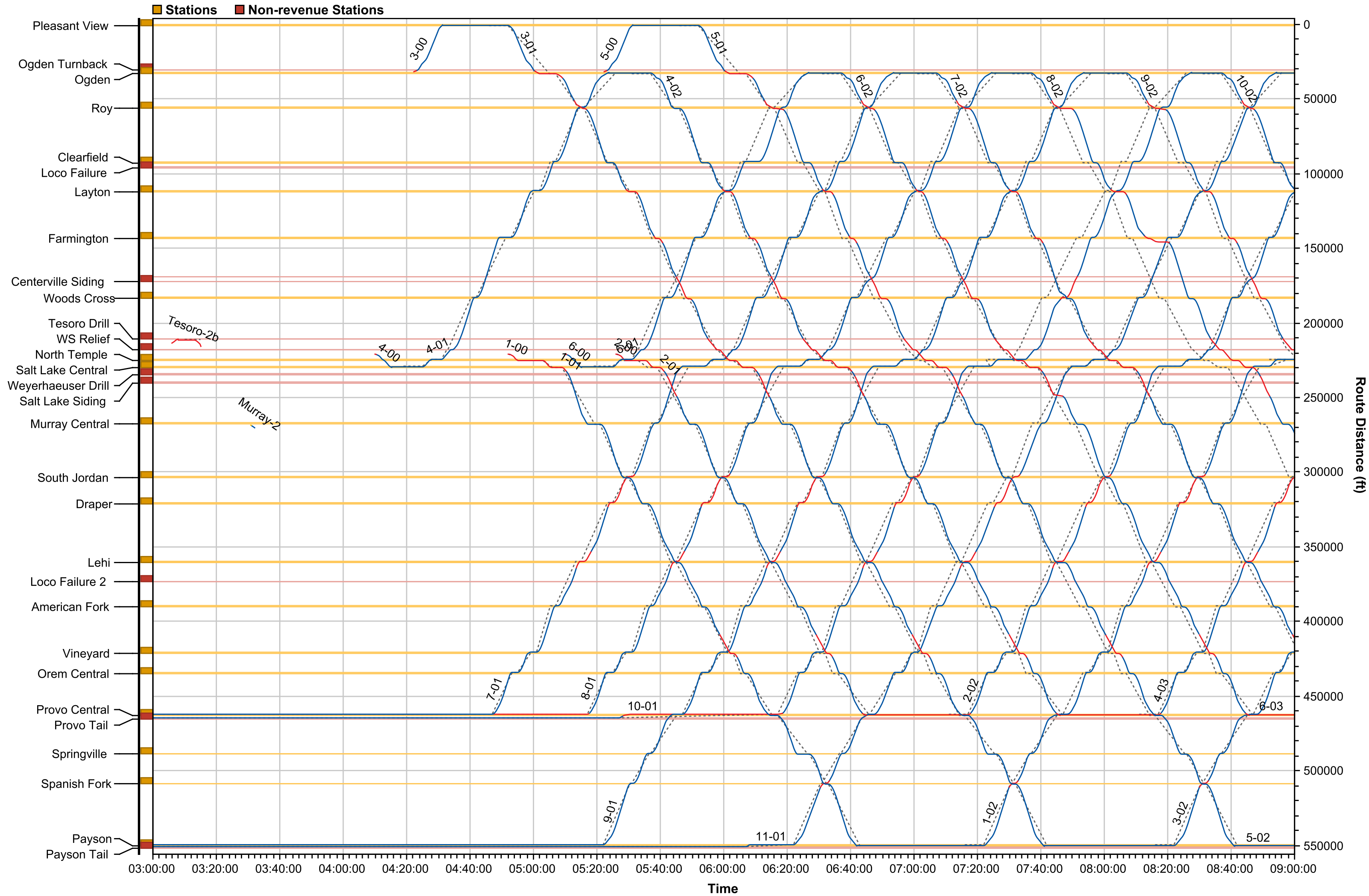


Figure 21-13: Time-Distance (“String”) Chart – 3 AM – 9 AM – Low Investment Scenario Day 1 Simulation Results with Perturbations

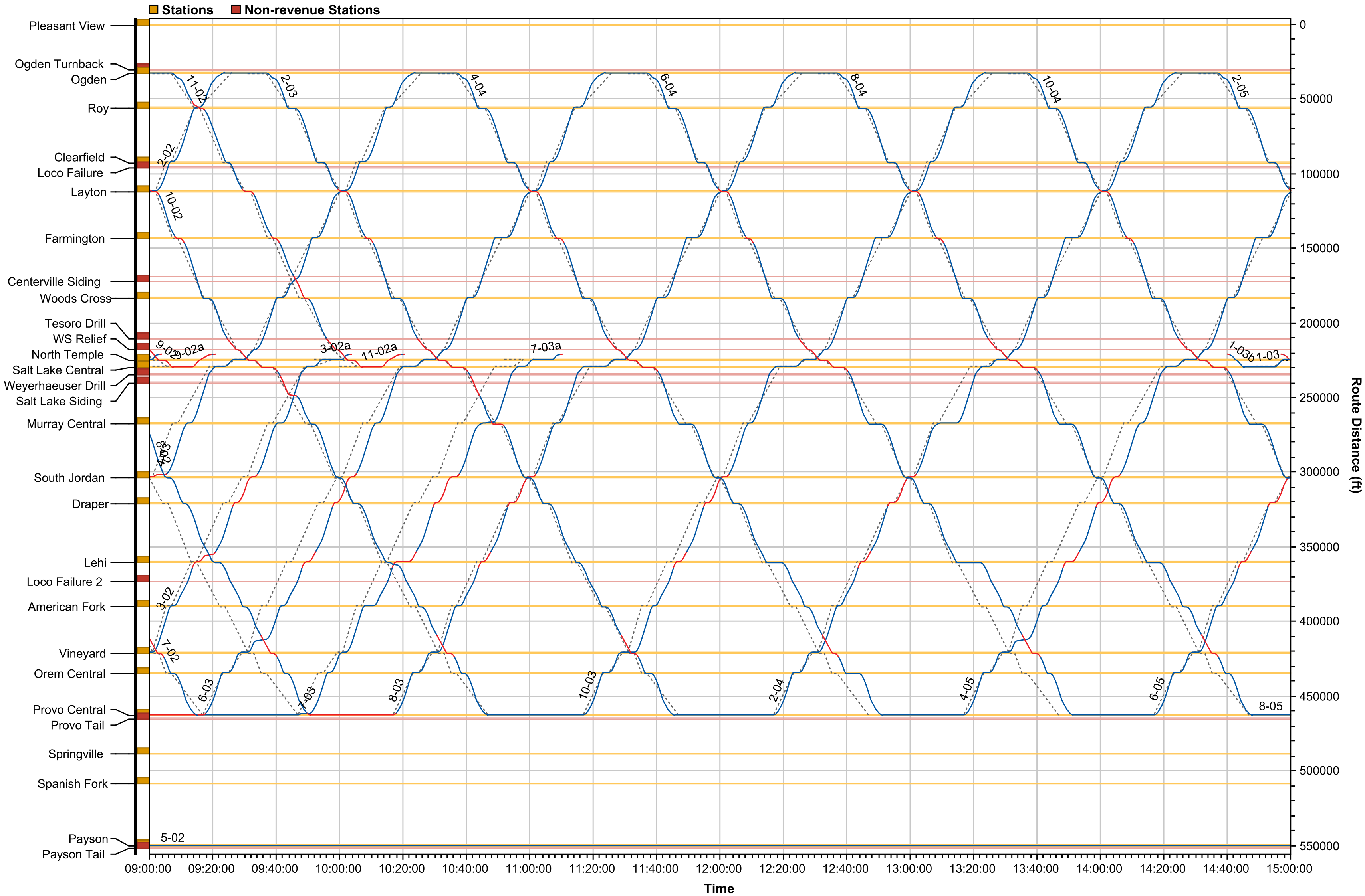


Figure 21-14: Time-Distance ("String") Chart – 9 AM – 3 PM – Low Investment Scenario Day 1 Simulation Results with Perturbations

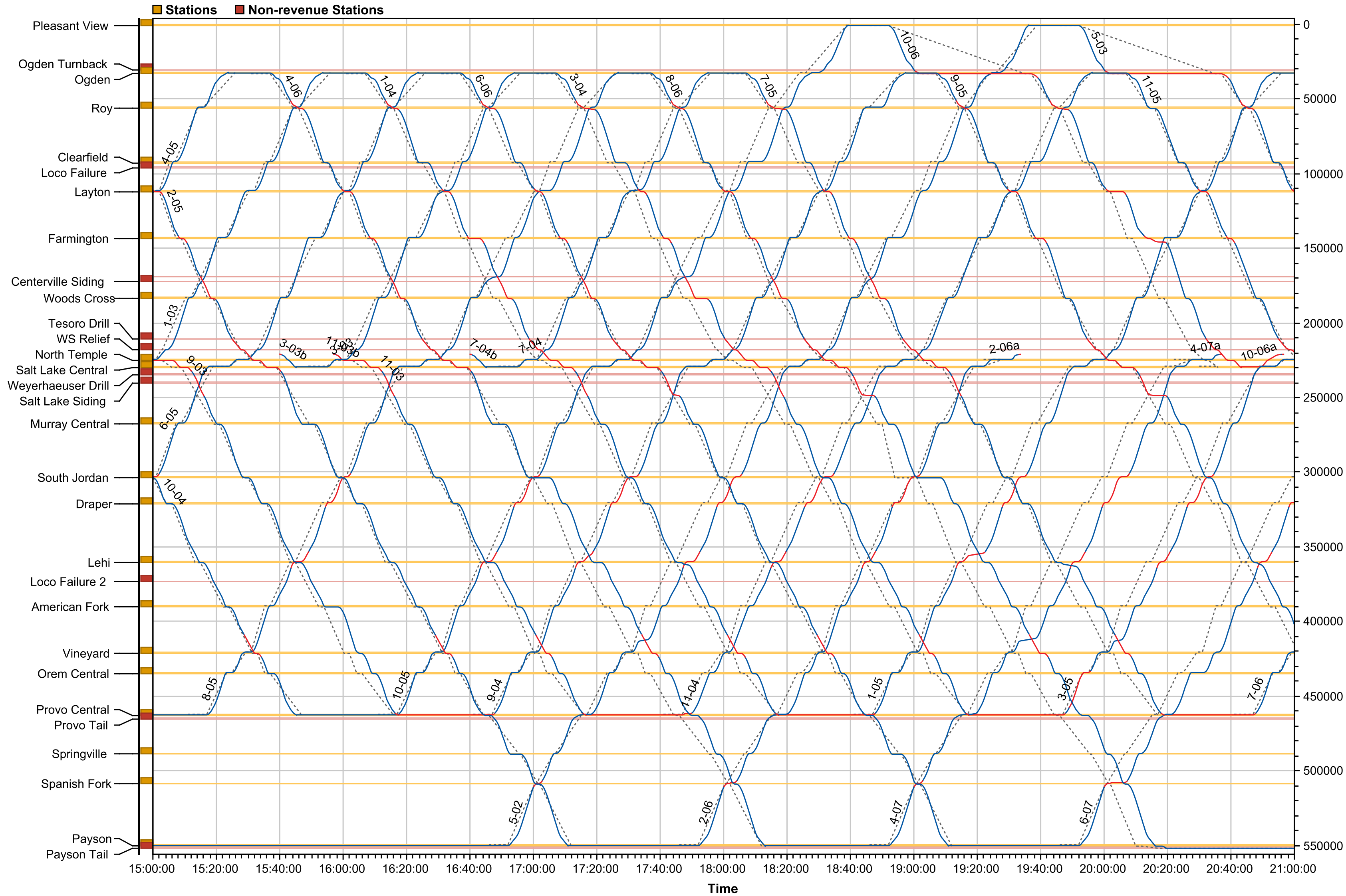


Figure 21-15: Time-Distance ("String") Chart – 3 PM – 9 PM – Low Investment Scenario Day 1 Simulation Results with Perturbations

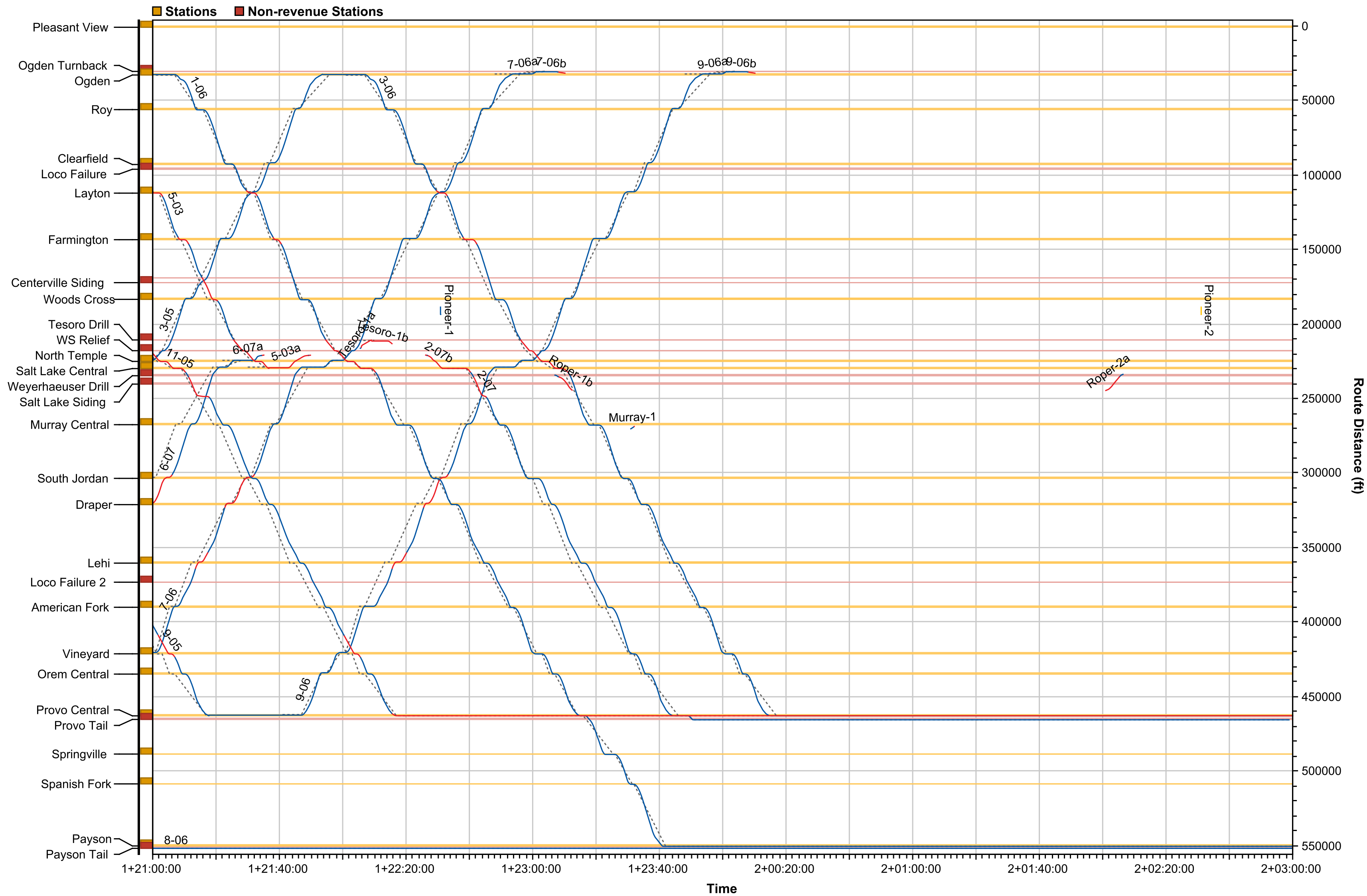


Figure 21-16: Time-Distance ("String") Chart – 9 PM – 3 AM – Low Investment Scenario Day 1 Simulation Results with Perturbations

21.3 Day 2 Low Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 2 operating plan perturbations include a 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM due to a crossing failure/broken gate. Day 2 also includes a 5-minute delay for train 2-02 at North Temple due to the need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

21.3.1 Station Occupancy Charts – Salt Lake Central

Of the 17 trains shown in Figure 21-17, all but five depart on time. Most northbound trains arrive early and depart on time, except for train 11-01, which arrives and departs late. About half of the southbound trains arrive and depart late due to having less dwell time than the northbound trains.

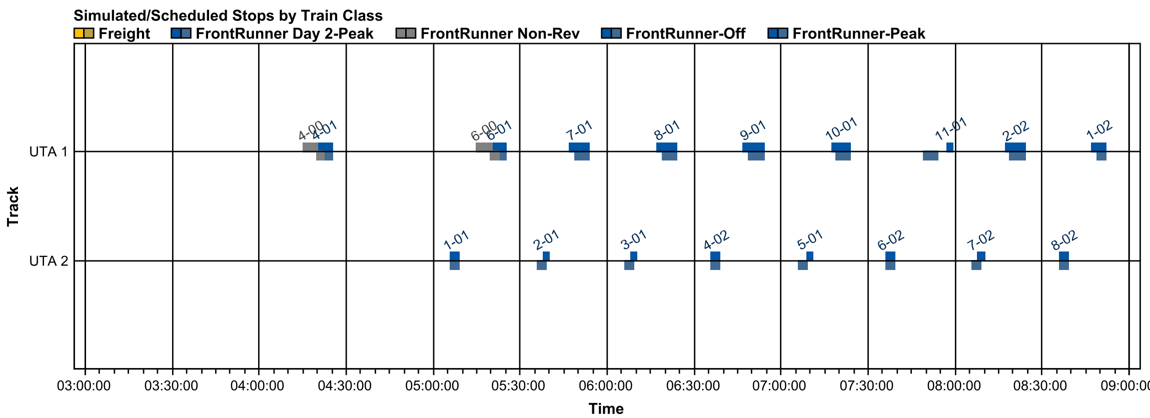


Figure 21-17: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Low Investment Scenario Day 2 Simulation Results with Perturbations

Figure 21-18 shows all trains arriving and departing on time.

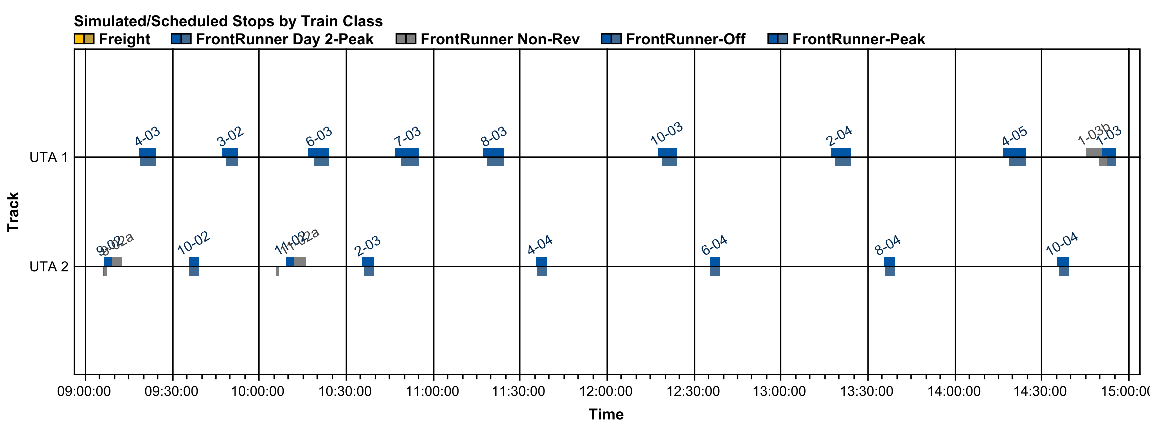


Figure 21-18: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Low Investment Scenario Day 2 Simulation Results with Perturbations

Figure 21-19 shows the impact of the grade crossing failure (south of Salt Lake Central) starting just after 5 PM on the northbound track and just after 7 PM on the southbound track.

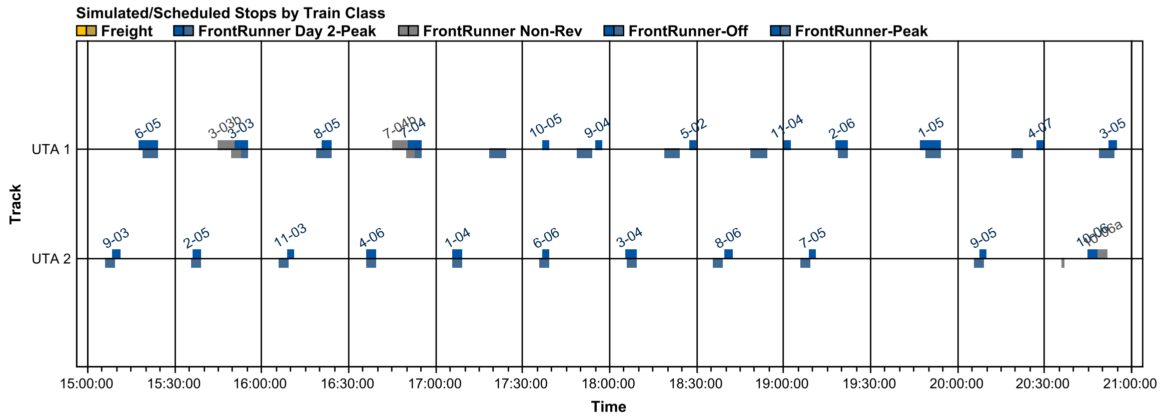


Figure 21-19: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Low Investment Scenario Day 2 Simulation Results with Perturbations

Figure 21-20 shows the northbound and southbound trains recovering from the grade crossing failure as they are all able to depart Salt Lake Central on time.

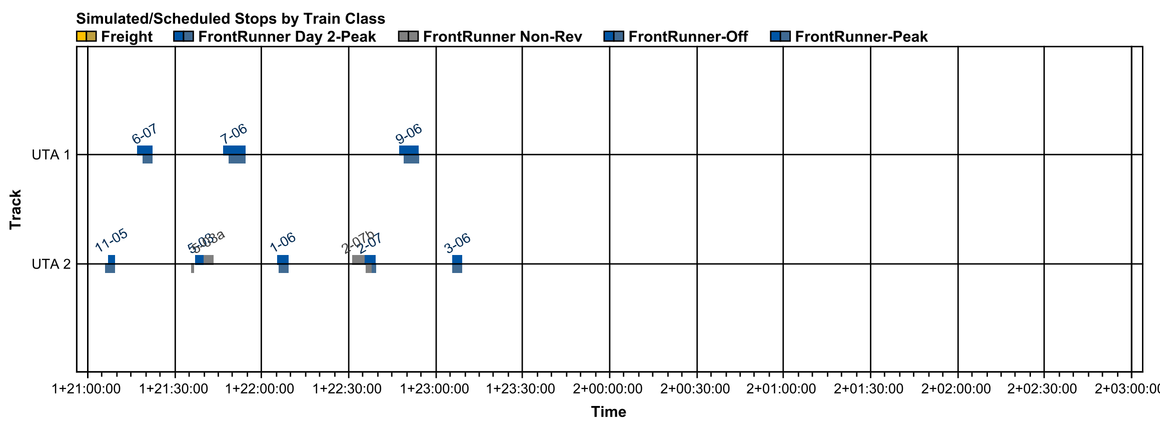


Figure 21-20: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Low Investment Scenario Day 2 Simulation Results with Perturbations

21.3.2 String Charts

Figure 21-21 shows the randomly-assigned 5-minute delay for train 2-02 at North Temple due to the need to hold for a late TRAX connection. There are very few consequences from this delay and the train would arrive Ogden on time if not for the random extended dwell at Clearfield and Roy.

Figure 21-23 shows the 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM. The lower speed is evident in the more horizontal slopes of the string lines through this period. Train 11-03, which is also the train with the cautious engineer, is the first train to get this speed restriction. Train 10-05 initially gets delayed at Lehi station while it waits for train 11-03 to pass. As it continues northward, train 10-05 waits at Murray Central station waiting for train 1-04 to get through the grade crossing with the 15 MPH speed restriction. Once train 10-05 gets through the grade crossing, it does not encounter any further delays but still arrives late enough at its final station that it is late leaving Pleasant View station as train 10-06.

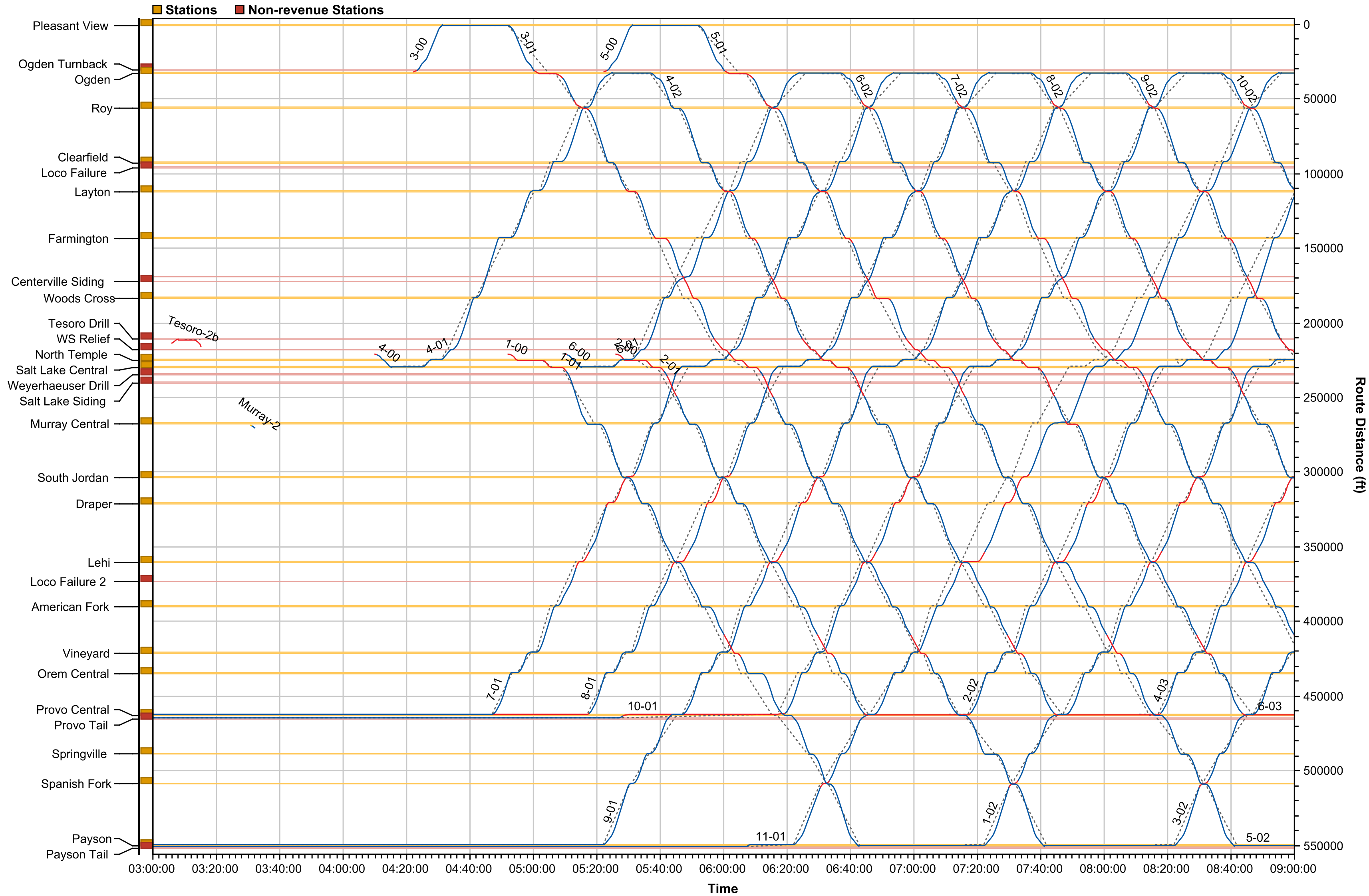


Figure 21-21: Time-Distance ("String") Chart – 3 AM – 9 AM – Low Investment Scenario Day 2 Simulation Results with Perturbations

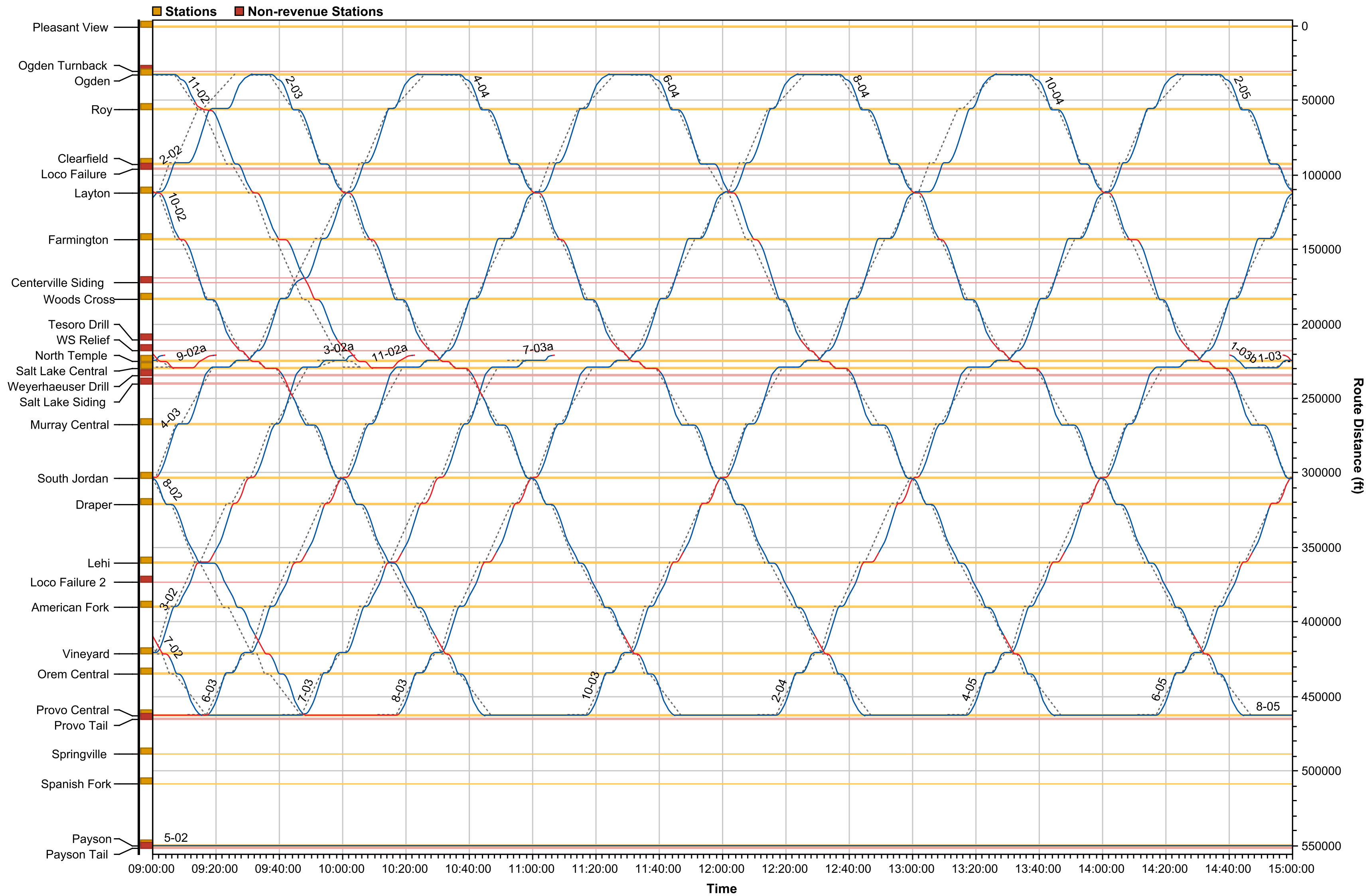


Figure 21-22: Time-Distance ("String") Chart – 9 AM – 3 PM – Low Investment Scenario Day 2 Simulation Results with Perturbations

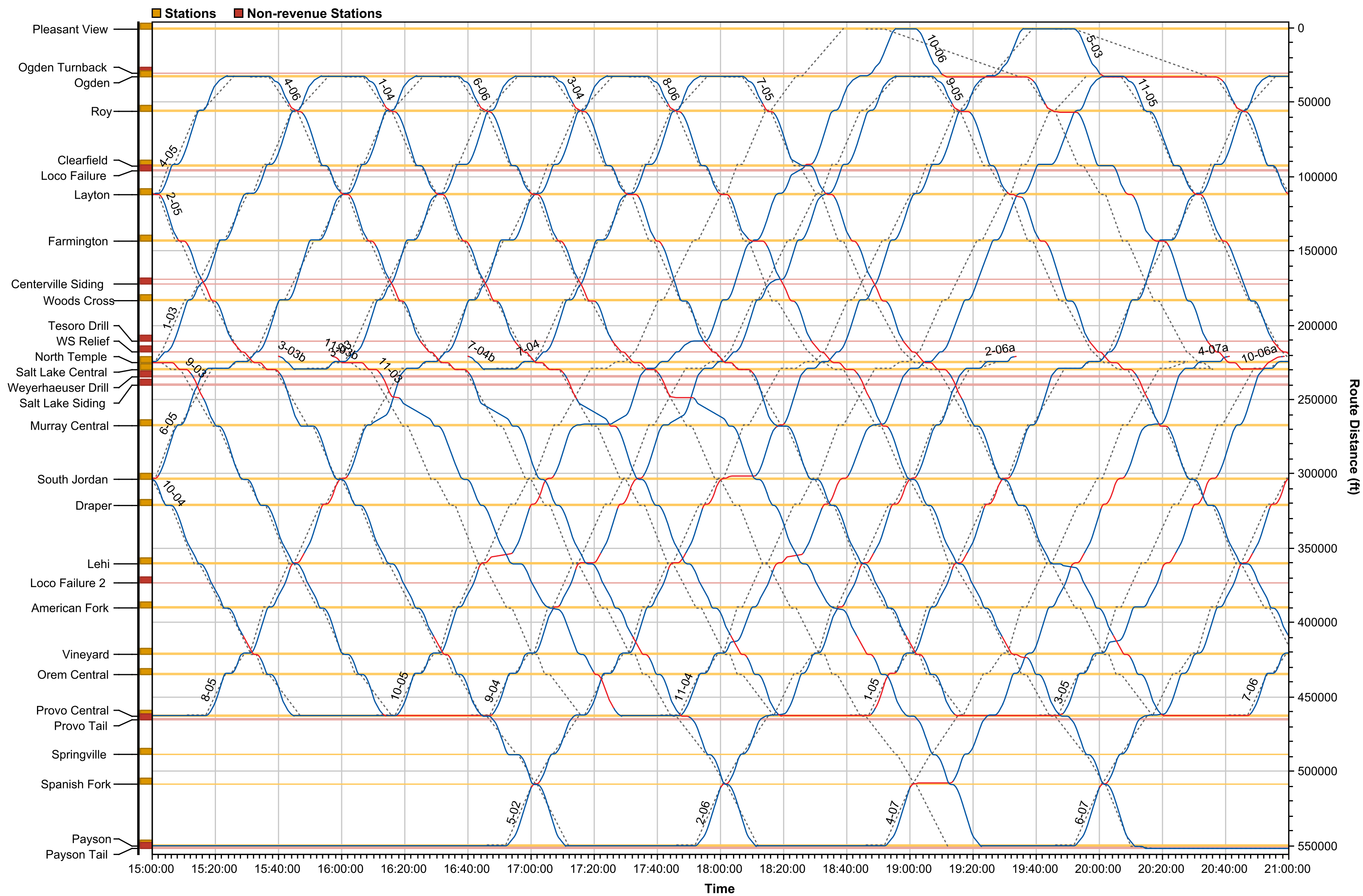


Figure 21-23: Time-Distance ("String") Chart – 3 PM – 9 PM – Low Investment Scenario Day 2 Simulation Results with Perturbations

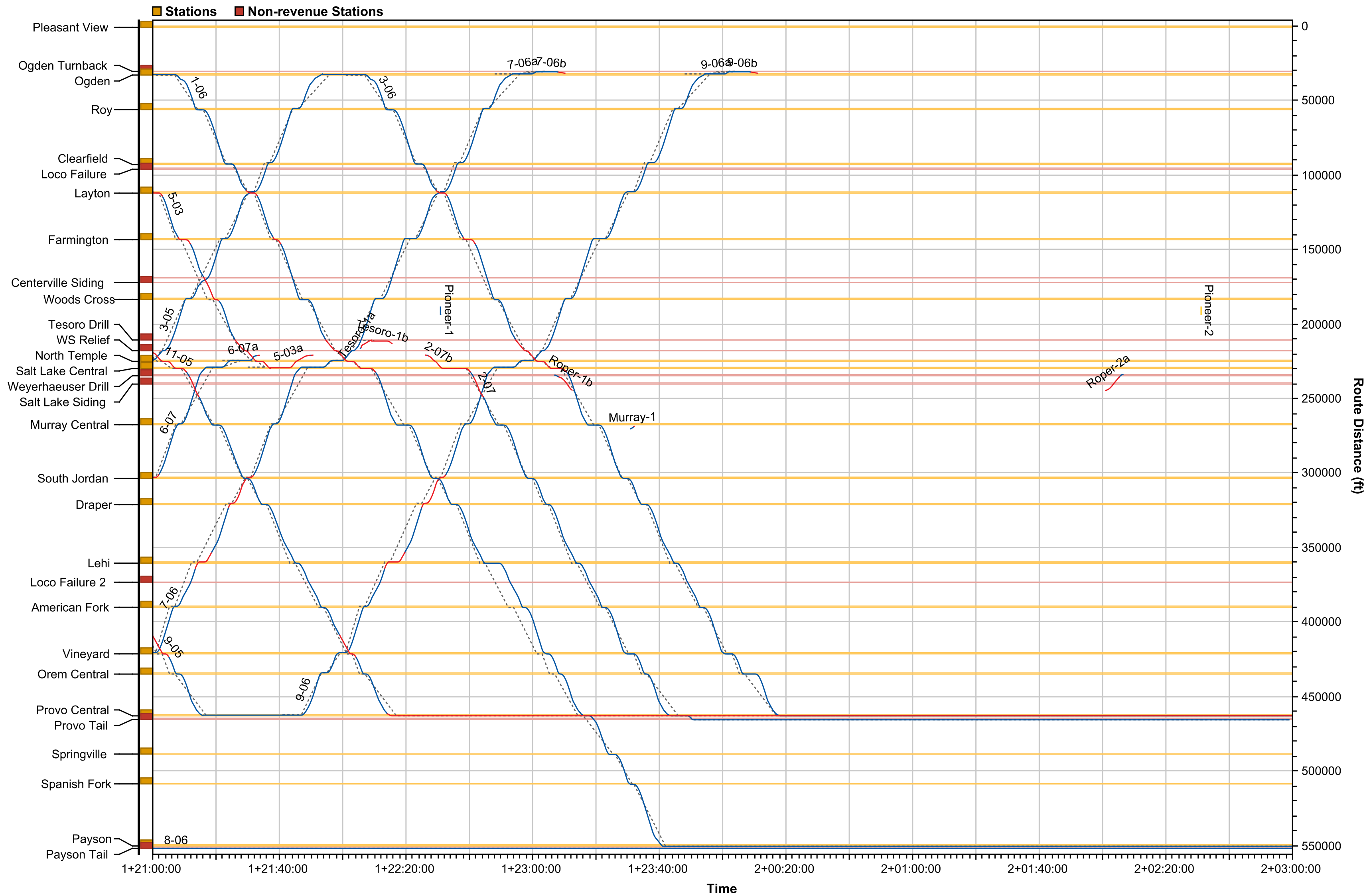


Figure 21-24: Time-Distance ("String") Chart – 9 PM – 3 AM Low Investment Scenario Day 2 Simulation Results with Perturbations

21.4 Day 3 Low Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 3 operating plan includes a locomotive failure on train 10-02 between Layton station and Clearfield station causing the train to stop for 10-minutes while the locomotive is reset. Day 3 also includes a door failure for train 4-03 at Woods Cross Station. This causes an assumed 7-minute extended dwell while the door is cut out and removed from service. Station occupancy charts and string charts are included in the following sections.

21.4.1 Station Occupancy Charts – Salt Lake Central

Figure 21-25 shows all trains leaving on time on the northbound track with most arriving early. On the southbound track, trains 2-01 and 4-02 depart late while the others are on time.

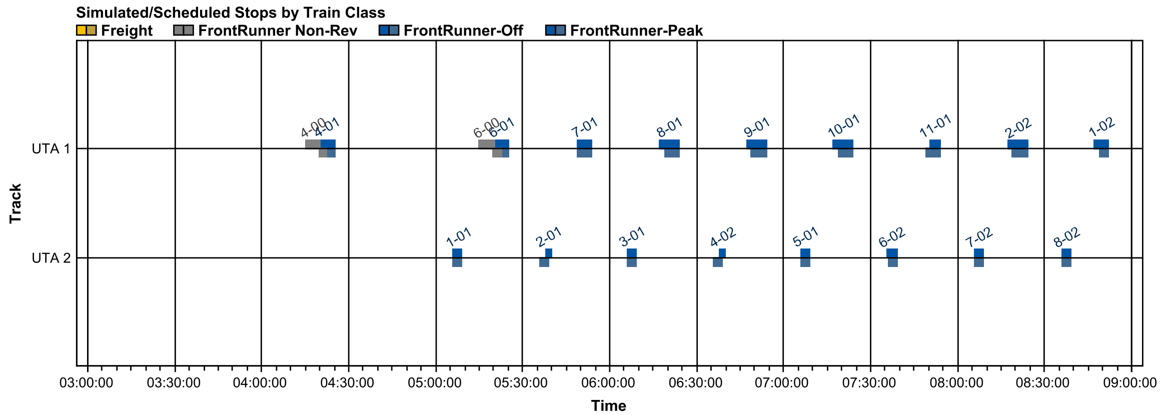


Figure 21-25: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Low Investment Scenario Day 3 Simulation Results with Perturbations

Figure 21-26 shows train 10-02's late arrival due to the locomotive failure that occurred earlier just south of Clearfield station.

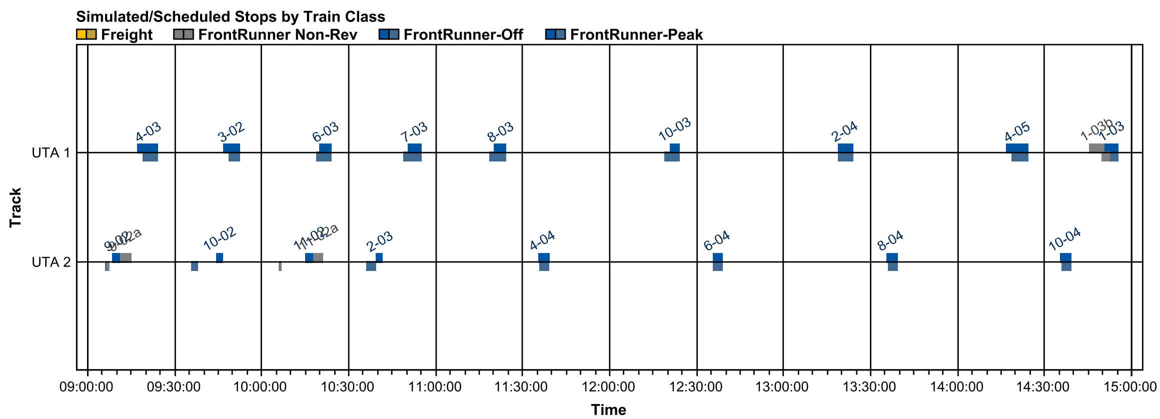


Figure 21-26: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Low Investment Scenario Day 3 Simulation Results with Perturbations

Figure 21-27 shows all northbound trains leaving Salt Lake Central on time, with most of them arriving early as well. The southbound trains have four trains arriving on time and five that leave on time.

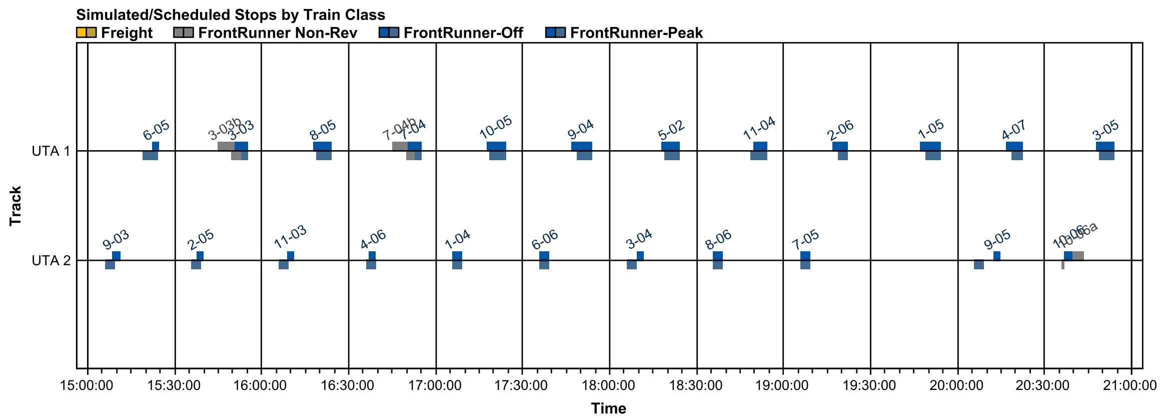


Figure 21-27: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Low Investment Scenario Day 3 Simulation Results with Perturbations

Figure 21-28 shows all trains departing Salt Lake Central station on time with the exception of train 3-06.

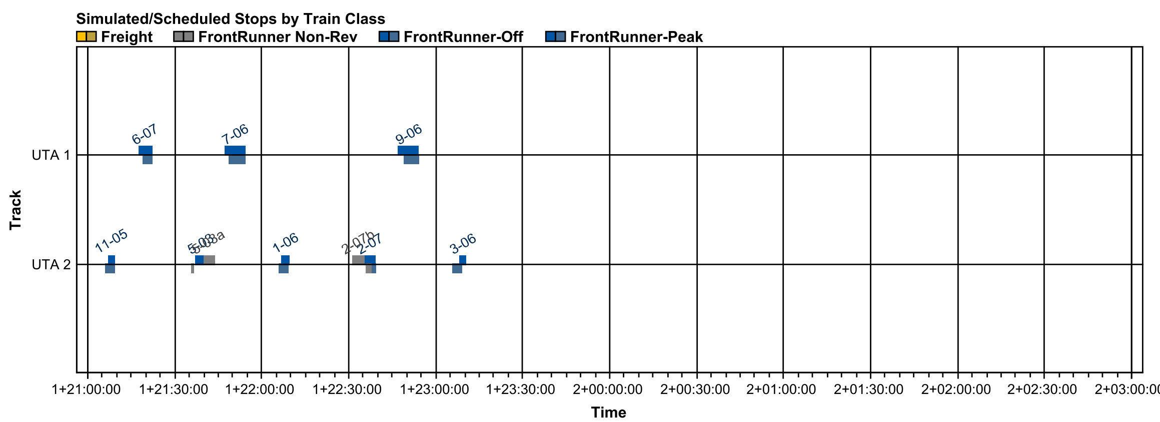


Figure 21-28: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Low Investment Scenario Day 3 Simulation Results with Perturbations

21.4.2 String Charts

The Day 3 perturbation of train 10-02 experiencing a 10-minute delay in between Clearfield station and Layton station is shown in Figure 21-29 and Figure 21-30. Train 2-02 is delayed at Layton station waiting for train 10-02 to pass. Train 2-02 arrives late enough to Ogden station that the return trip (train 10-03) departs late, although it makes up some time southbound until the random extended dwell at Lehi. The 7-minute extended dwell for train 4-03 at Woods Cross station is also shown in Figure 21-30. There is enough time built into the schedule that the delay is resolved at Ogden station.

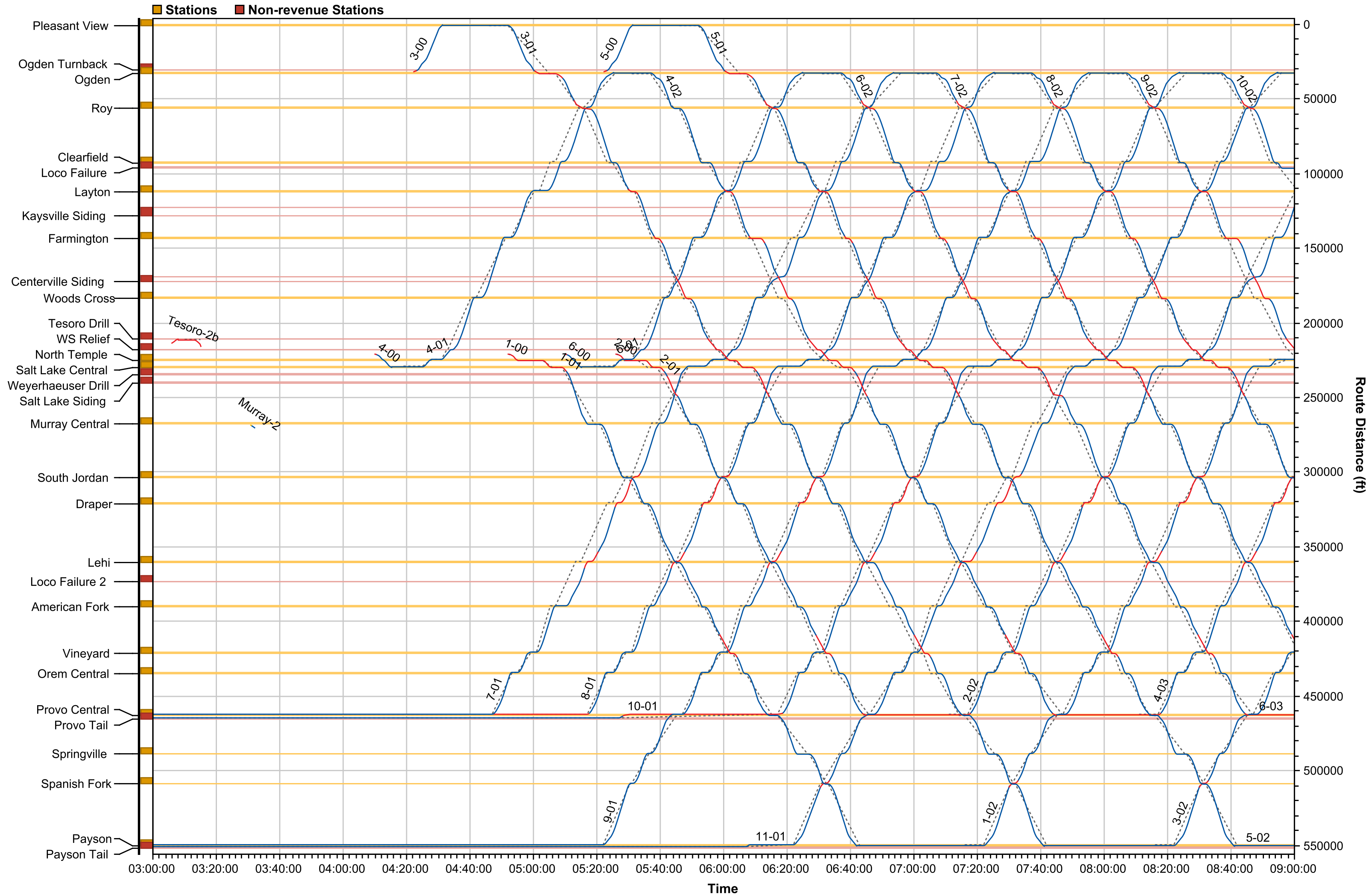


Figure 21-29: Time-Distance ("String") Chart – 3 AM – 9 AM – Low Investment Scenario Day 3 Simulation Results with Perturbations

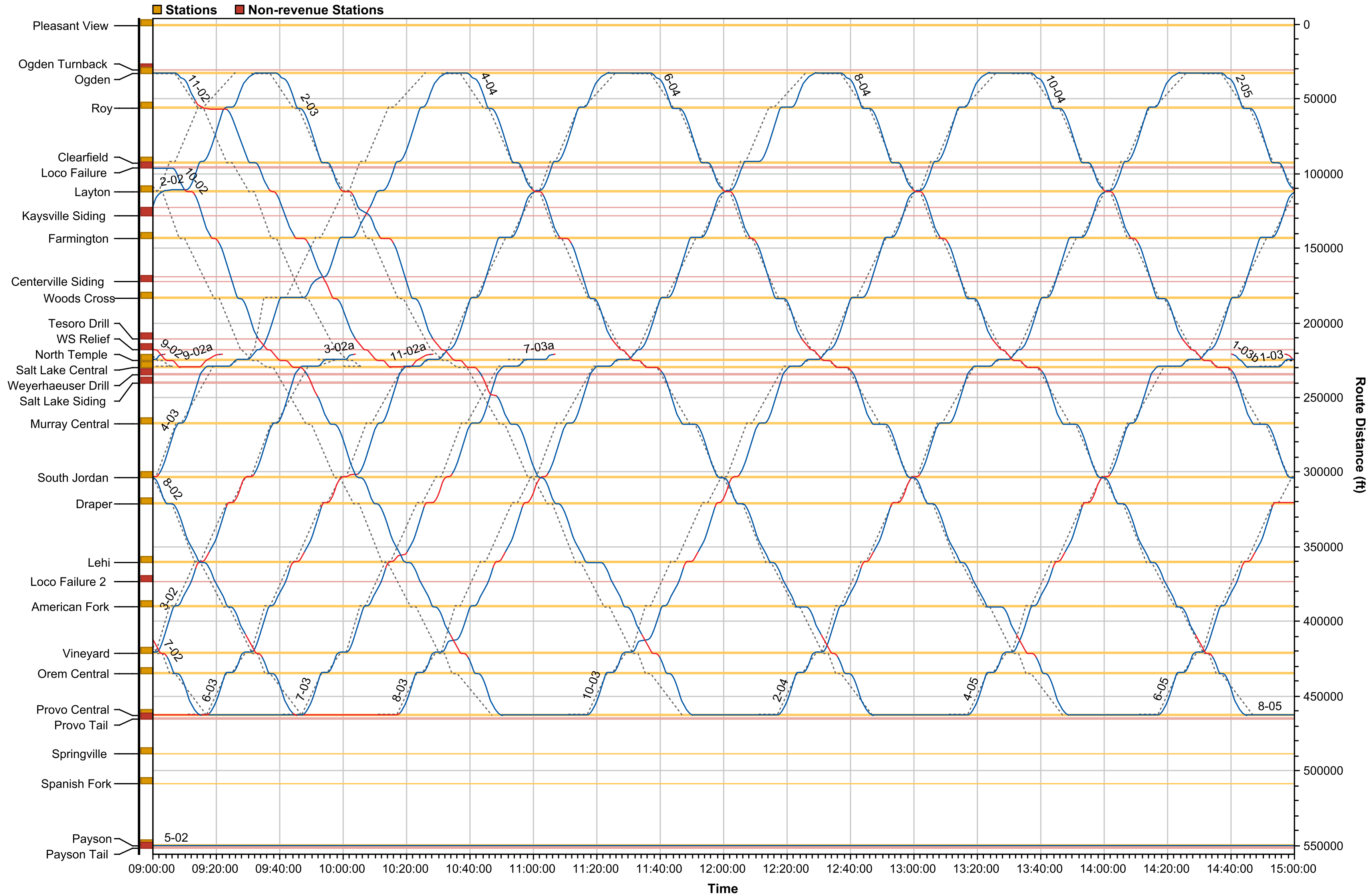


Figure 21-30: Time-Distance ("String") Chart – 9 AM – 3 PM – Low Investment Scenario Day 3 Simulation Results with Perturbations

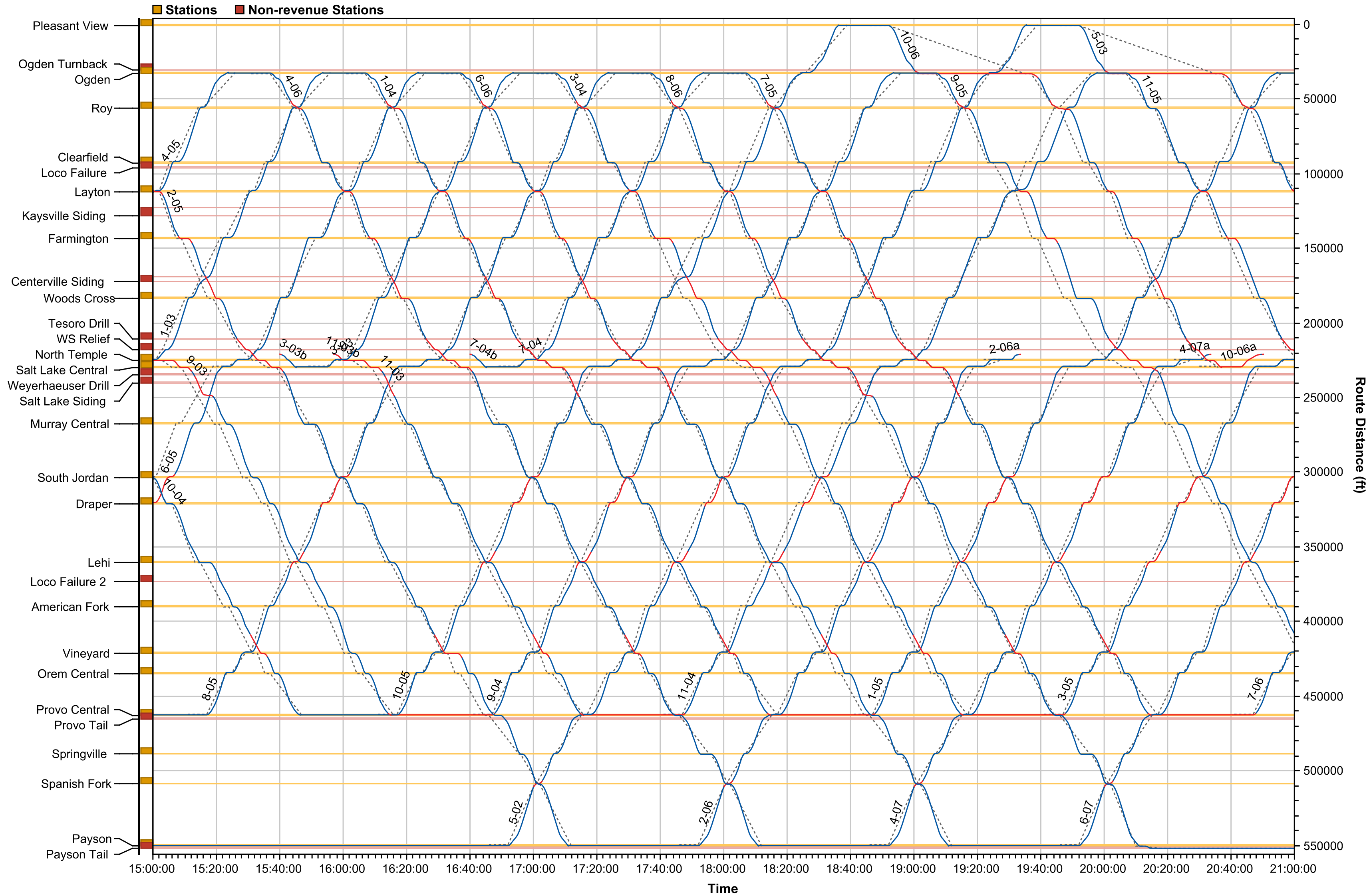


Figure 21-31: Time-Distance ("String") Chart – 3 PM – 9 PM Low Investment Scenario Day 3 Simulation Results with Perturbations

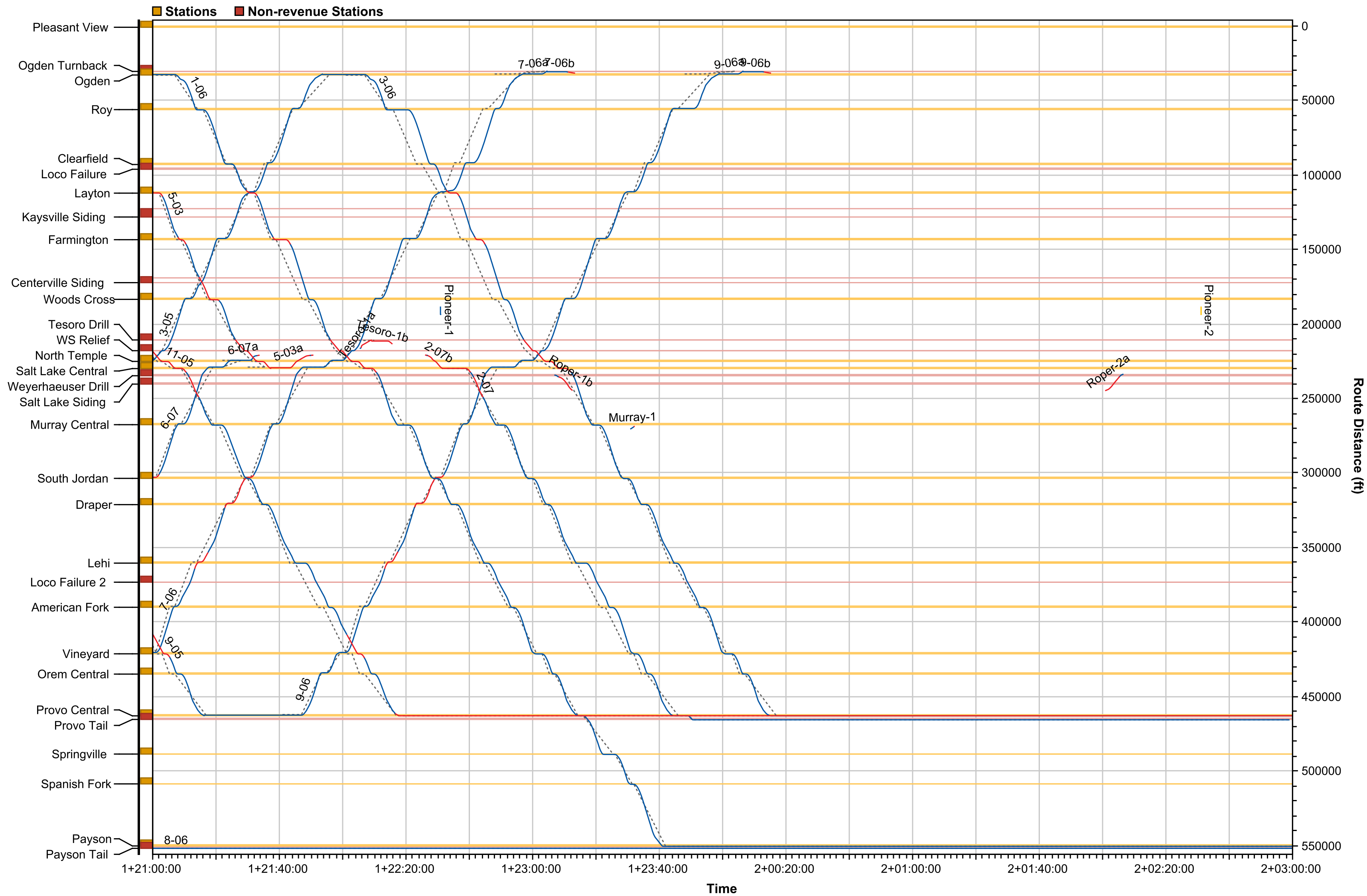


Figure 21-32: Time-Distance ("String") Chart – 9 PM – 3 AM – Low Investment Scenario Day 3 Simulation Results with Perturbations

21.5 Day 4 Low Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 4 operating plan includes a door failure for train 6-03 at Orem Station. This causes an assumed 7-minute extended dwell while the door failure is resolved. Day 4 also includes a 15 MPH speed restriction through 9400 South Grade Crossing (North of South Jordan) from 6:30 AM through 8:30 AM due to a crossing failure/broken gate. Salt Lake Central station occupancy charts and full network string charts are included in the following sections.

21.5.1 Station Occupancy Charts – Salt Lake Central

Figure 21-33 shows how the Grade Crossing Failure is affecting the northbound trains starting with train 9-01. Train 8-02 is the first southbound train that suffers the effects from the northbound trains' delay.

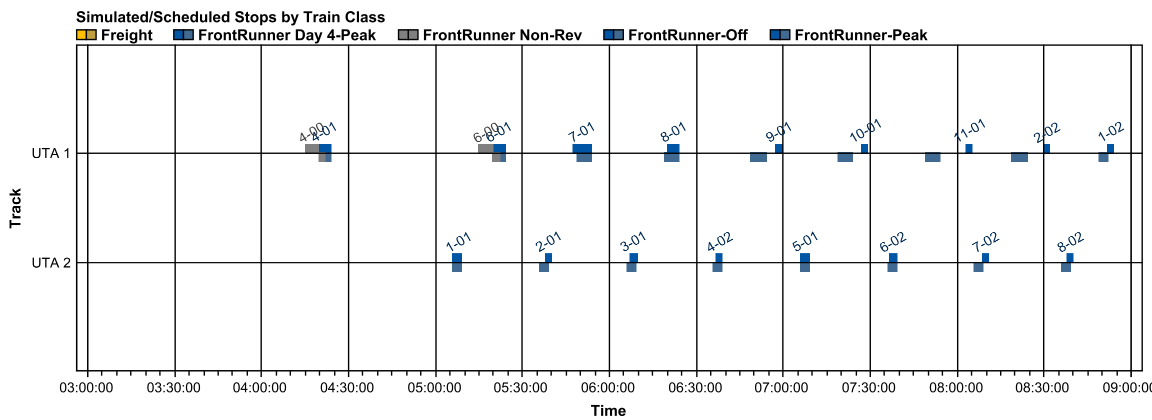


Figure 21-33: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Low Investment Scenario Day 4 Simulation Results with Perturbations

Figure 21-34 shows the southbound trains continuing to suffer delays from the earlier grade crossing failure until 10:30 AM.

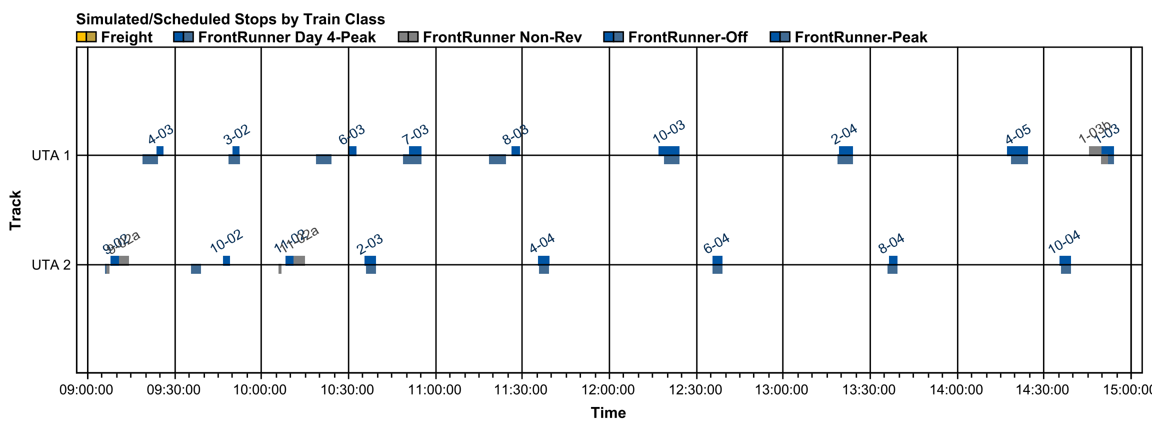


Figure 21-34: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Low Investment Scenario Day 4 Simulation Results with Perturbations

Figure 21-35 shows one northbound train arriving and departing the station late. Most of the southbound trains arrive and depart on time.

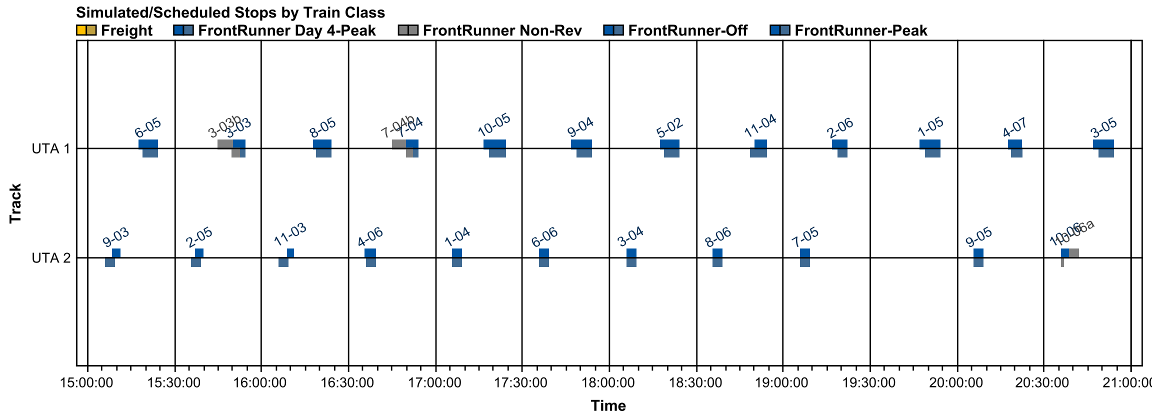


Figure 21-35: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Low Investment Scenario Day 4 Simulation Results with Perturbations

Figure 21-36 shows all revenue trains departing on time, except train 11-05.

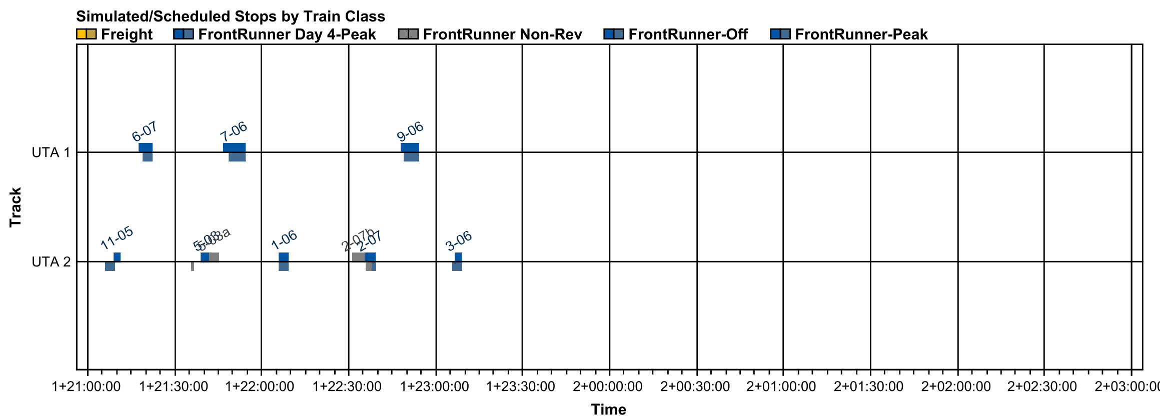


Figure 21-36: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Low Investment Scenario Day 4 Simulation Results with Perturbations

21.5.2 String Charts

The Day 4 perturbation of a 15 MPH speed restriction through a grade crossing just north of South Jordan is shown in Figure 21-37. This causes cascading delays to the trains throughout the morning peak period.

Figure 21-38 shows the door failure for train 6-03 at Orem Station. This assumed 7-minute extended dwell while the door is disabled causes train 6-03 to run late until it can recover by Layton Station, with help from the dwell time at Salt Lake Central station.

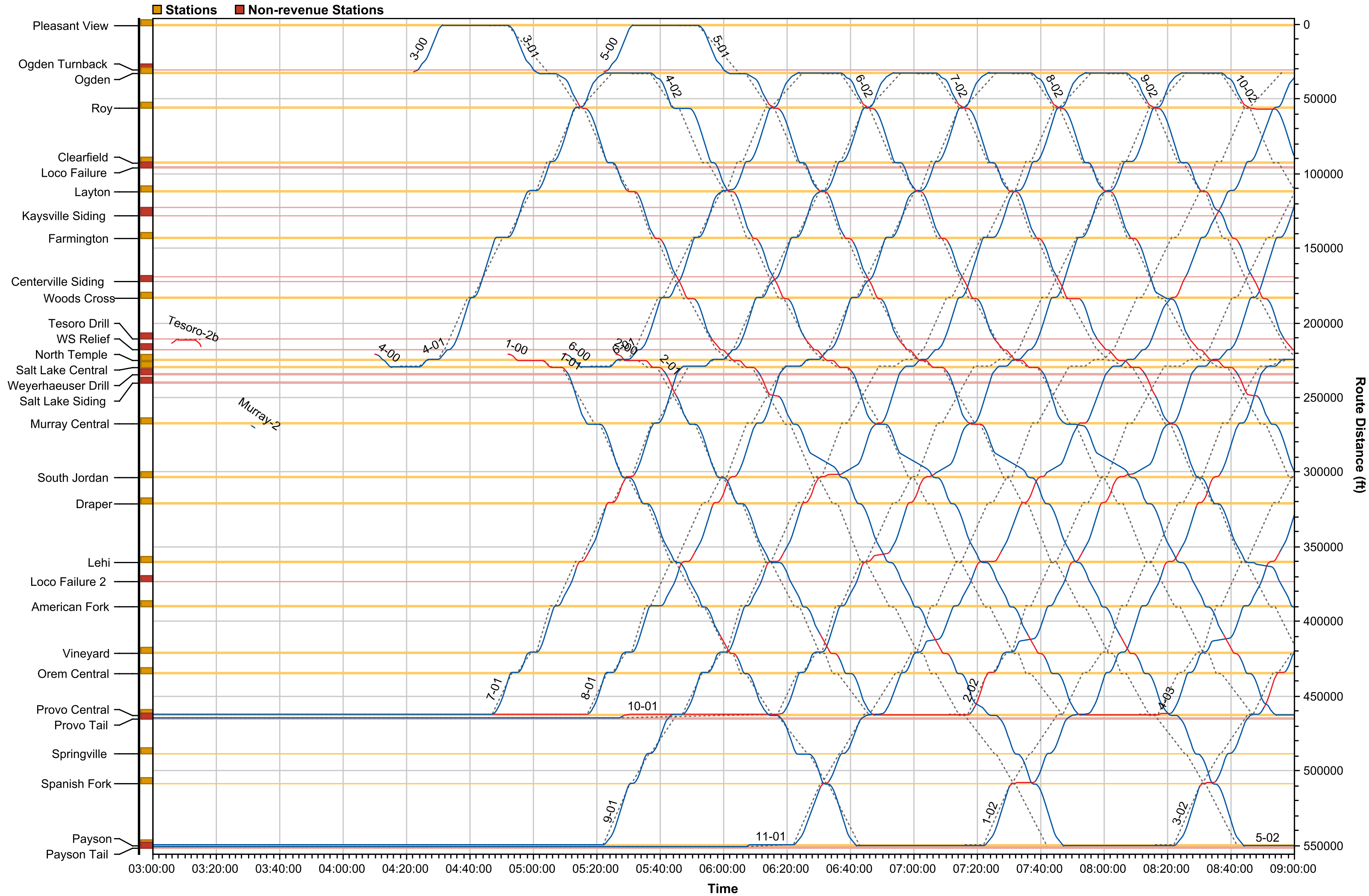


Figure 21-37: Time-Distance ("String") Chart – 3 AM – 9 AM – Low Investment Scenario Day 4 Simulation Results with Perturbations

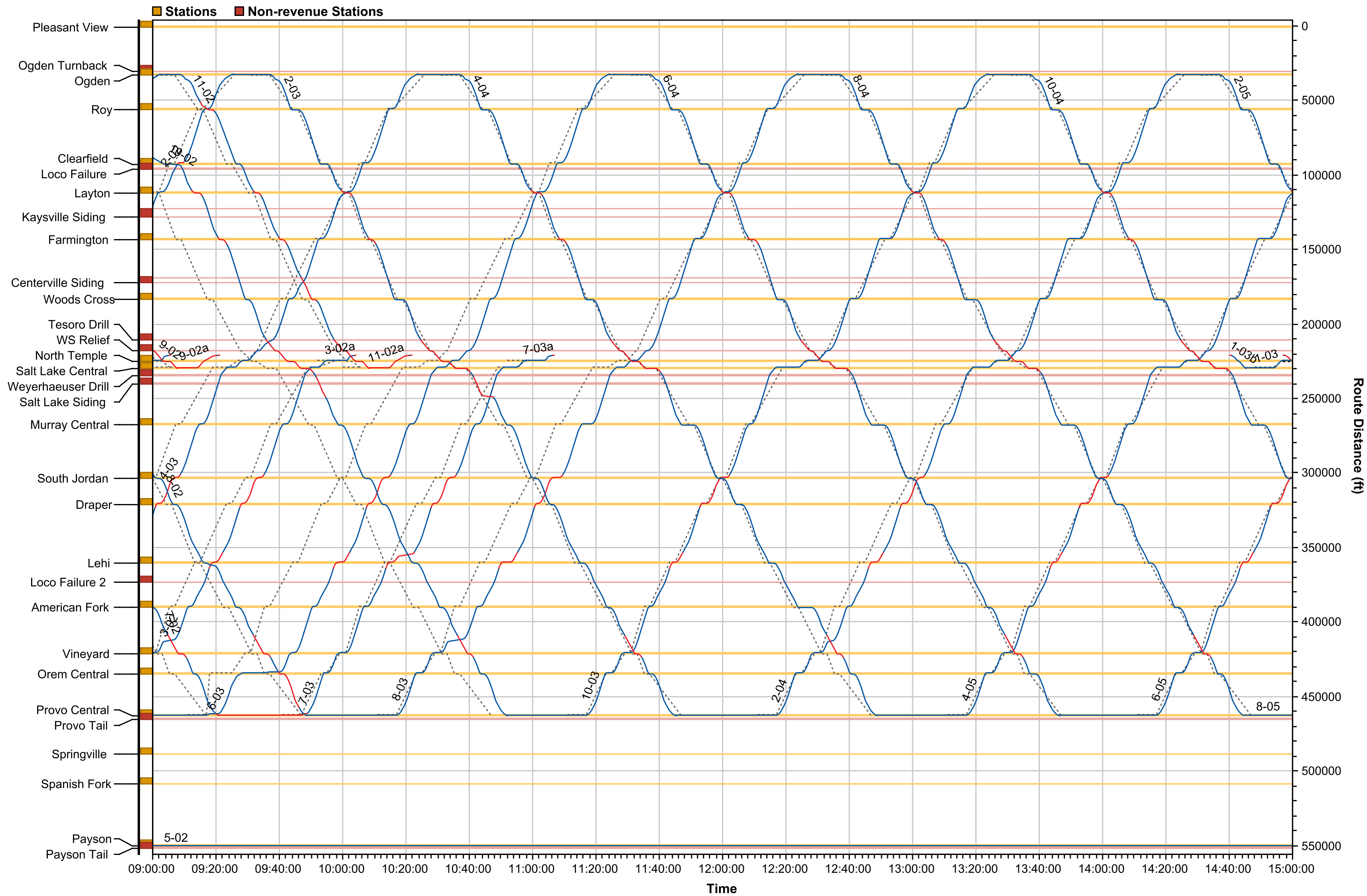


Figure 21-38: Time-Distance (“String”) Chart – 9 AM – 3 PM – Low Investment Scenario Day 4 Simulation Results with Perturbations

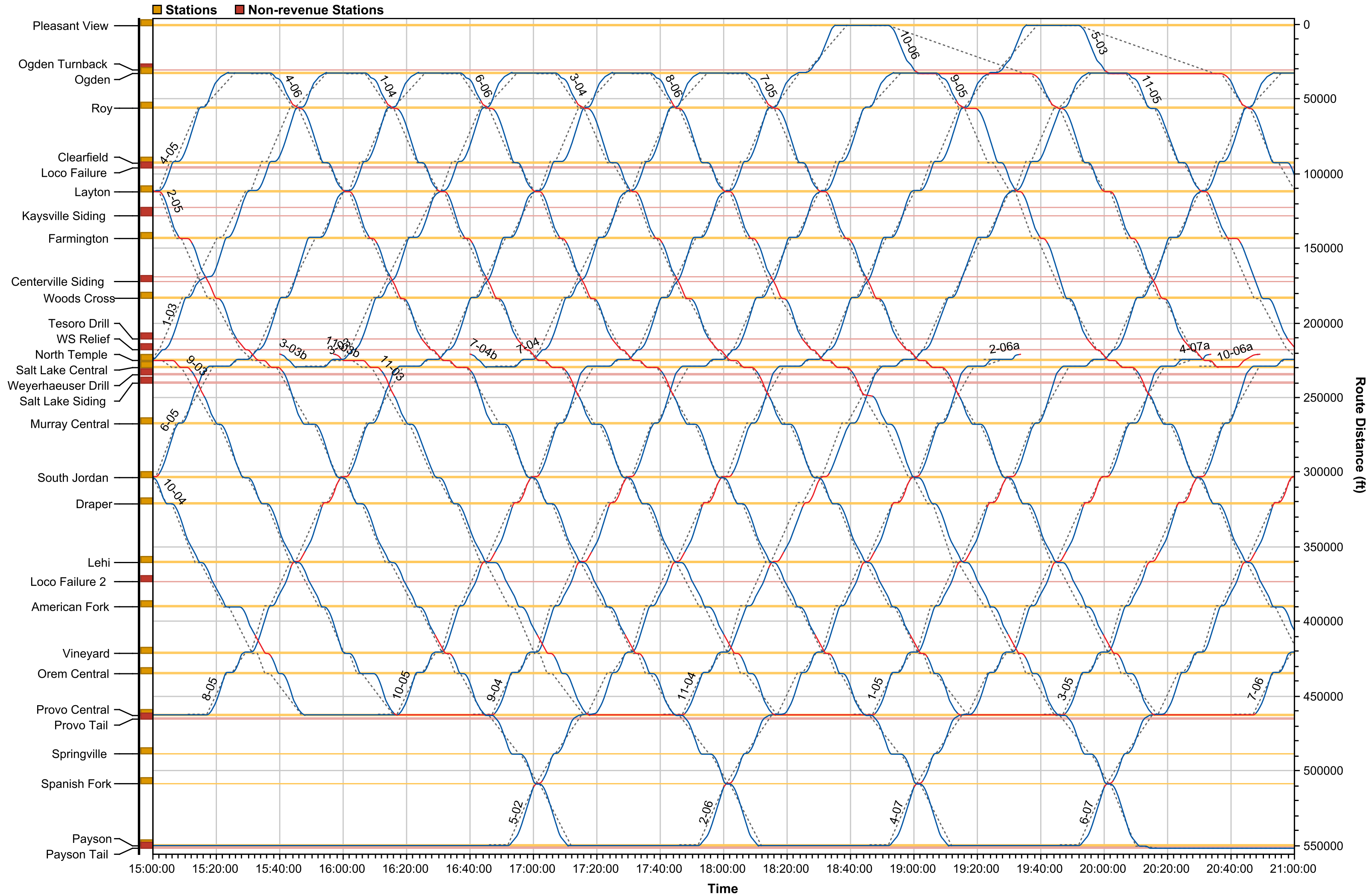


Figure 21-39: Time-Distance ("String") Chart – 3 PM – 9 PM – Low Investment Scenario Day 4 Simulation Results with Perturbations

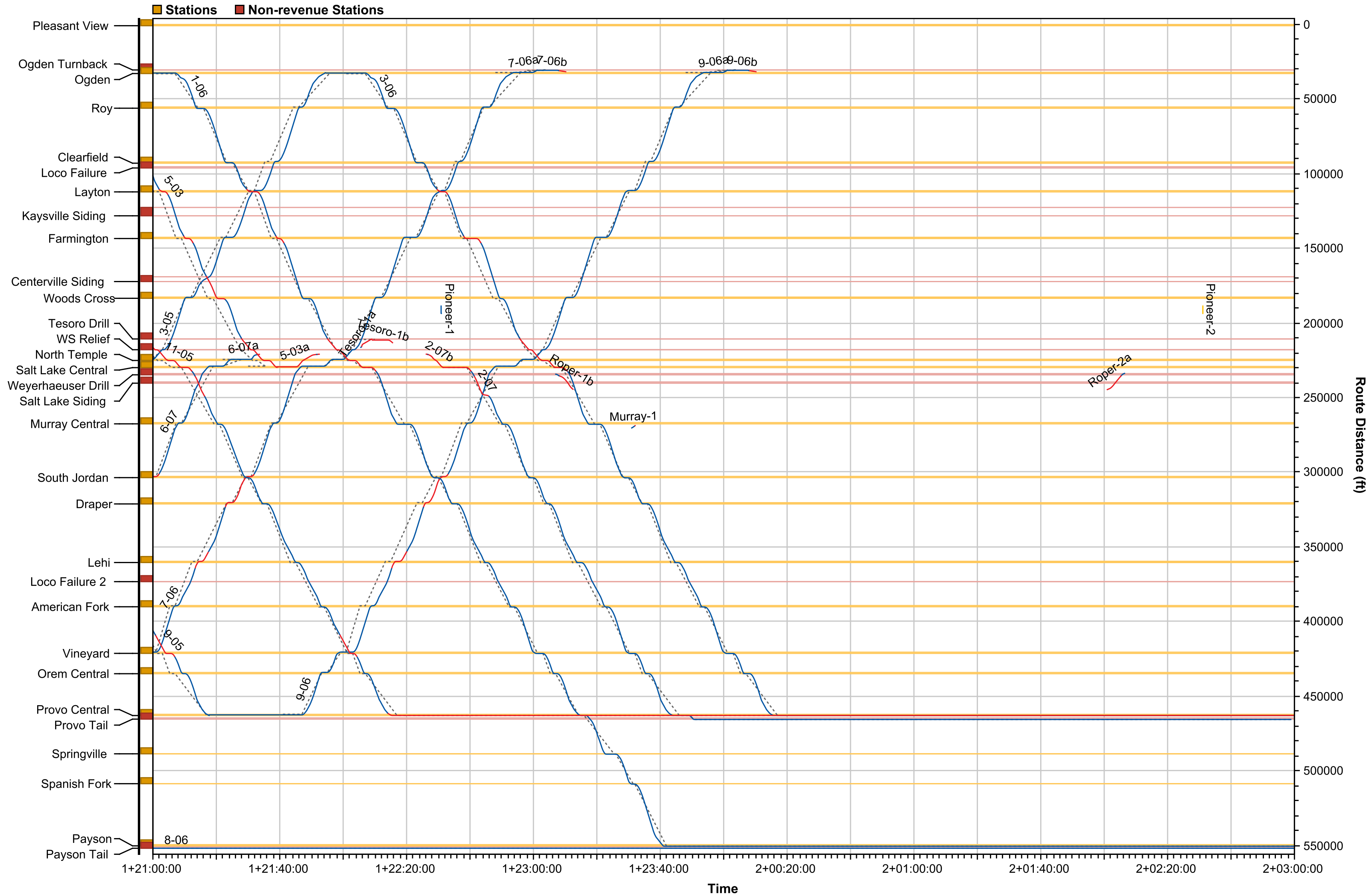


Figure 21-40: Time-Distance ("String") Chart – 9 PM – 3 AM – Low Investment Scenario Day 4 Simulation Results with Perturbations

21.6 Day 5 Low Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 5 operating plan includes a 5-minute delay for train 10-01 at North Temple due to assumed need to hold for a late connecting TRAX train. Day 5 also includes a locomotive failure on train 1-05 between Lehi station and American Fork station causing the train to stop for 10-minutes while the locomotive is reset. Station occupancy charts and string charts are included in the following sections.

21.6.1 Station Occupancy Charts – Salt Lake Central

Figure 21-41 shows all northbound trains leaving Salt Lake Central Station on time except for trains 9-01 and 11-01. Six of the eight southbound trains departed the station on time.

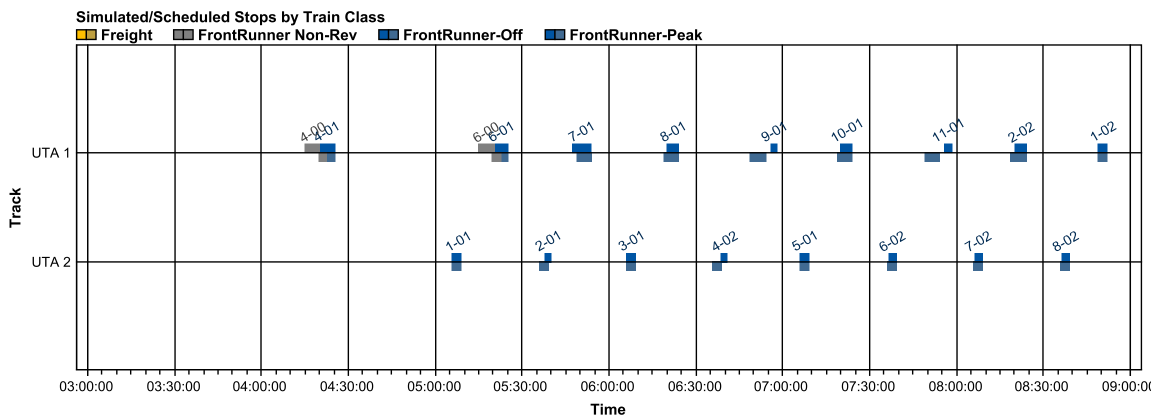


Figure 21-41: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Low Investment Scenario Day 5 Simulation Results with Perturbations

Figure 21-42 shows all revenue through trains in both directions departing the station on time except train 4-04.

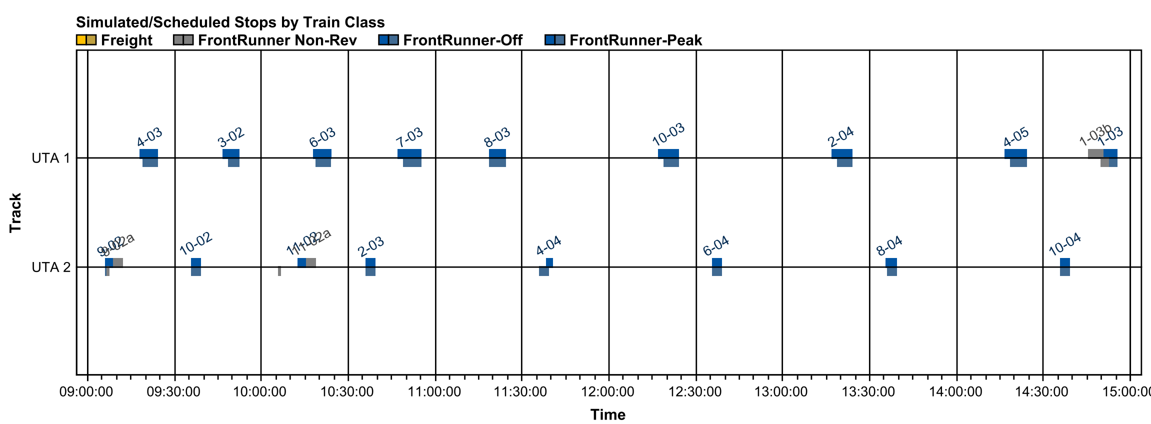


Figure 21-42: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Low Investment Scenario Day 5 Simulation Results with Perturbations

Figure 21-43 shows the impact to train 3-04 of the locomotive failure and resulting 10-minute delay.

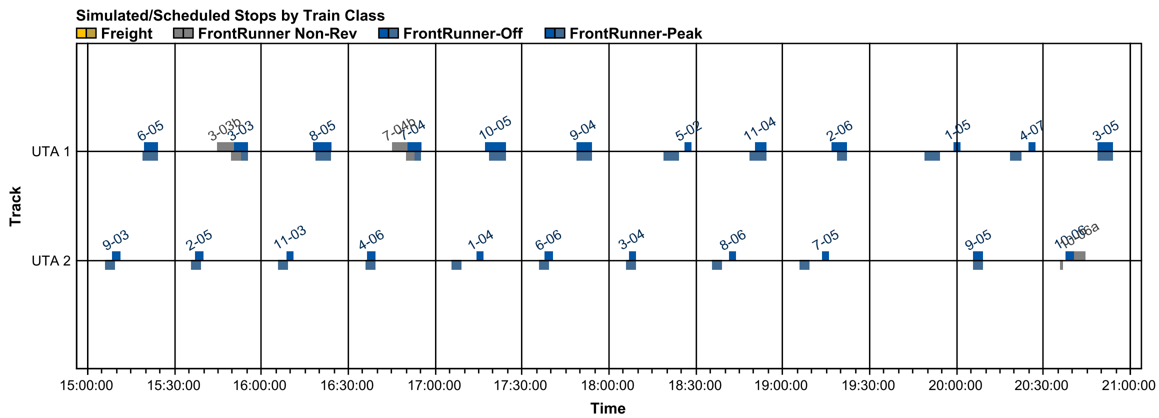


Figure 21-43: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Low Investment Scenario Day 5 Simulation Results with Perturbations

Figure 21-44 shows a majority of the trains arriving to the station late.

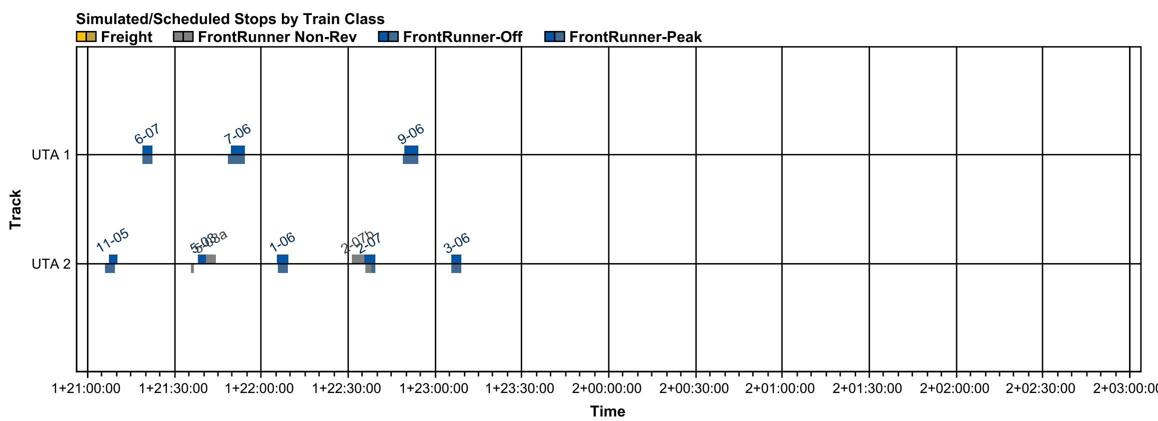


Figure 21-44: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Low Investment Scenario Day 5 Simulation Results with Perturbations

21.6.2 String Charts

Figure 21-45 shows that train 10-01 has been randomly assigned the 5-minute delay perturbation at North Temple station. With the extended Woods Cross-Centerville Siding, the train is able to not cause delays to southbound trains and make up most of the time by Layton Station. Train 1-01 is randomly assigned a significantly long dwell at Draper station. This causes delays for train 9-01 while it waits at Vineyard Siding and then to train 2-01 as it waits for train 9-01 at Lehi station, although the extended sidings help minimize the delays.

Under the Day 5 perturbations, train 1-05 is randomly assigned a locomotive failure and stops for 10-minutes between Lehi station and American Fork station as shown in Figure 21-47. Train 6-05 has a randomly assigned extended dwell at Layton, which causes delays to train 1-04 waiting at Roy, which in turn delays train 3-03 at Layton. Train 5-02 is randomly assigned a significantly long dwell at South Jordan station, although delays to other trains are minimal and train 5-02 largely recovers its schedule by Salt Lake Central.

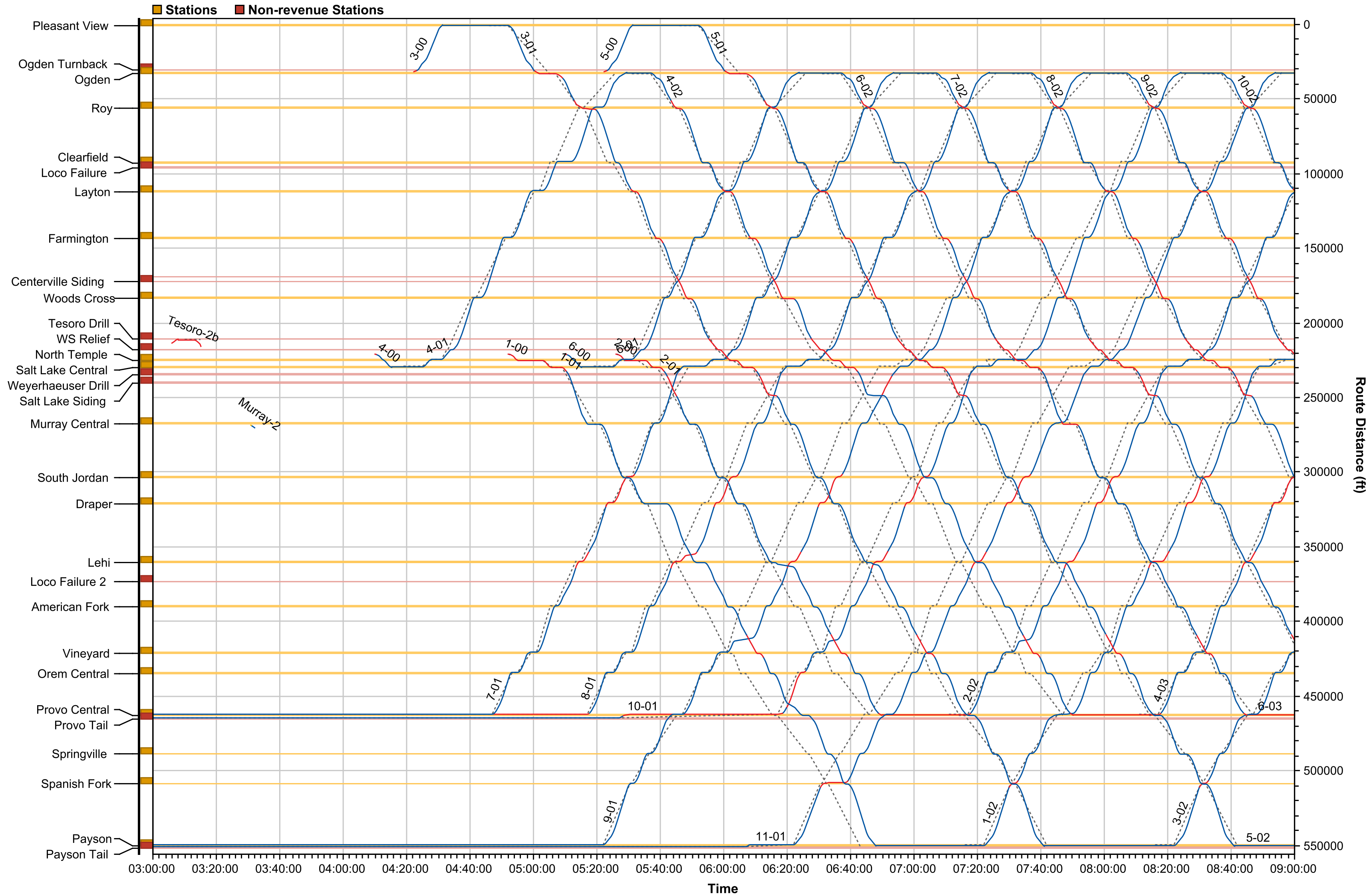


Figure 21-45: Time-Distance ("String") Chart – 3 AM – 9 AM Low Investment Scenario Day 5 Simulation Results with Perturbations

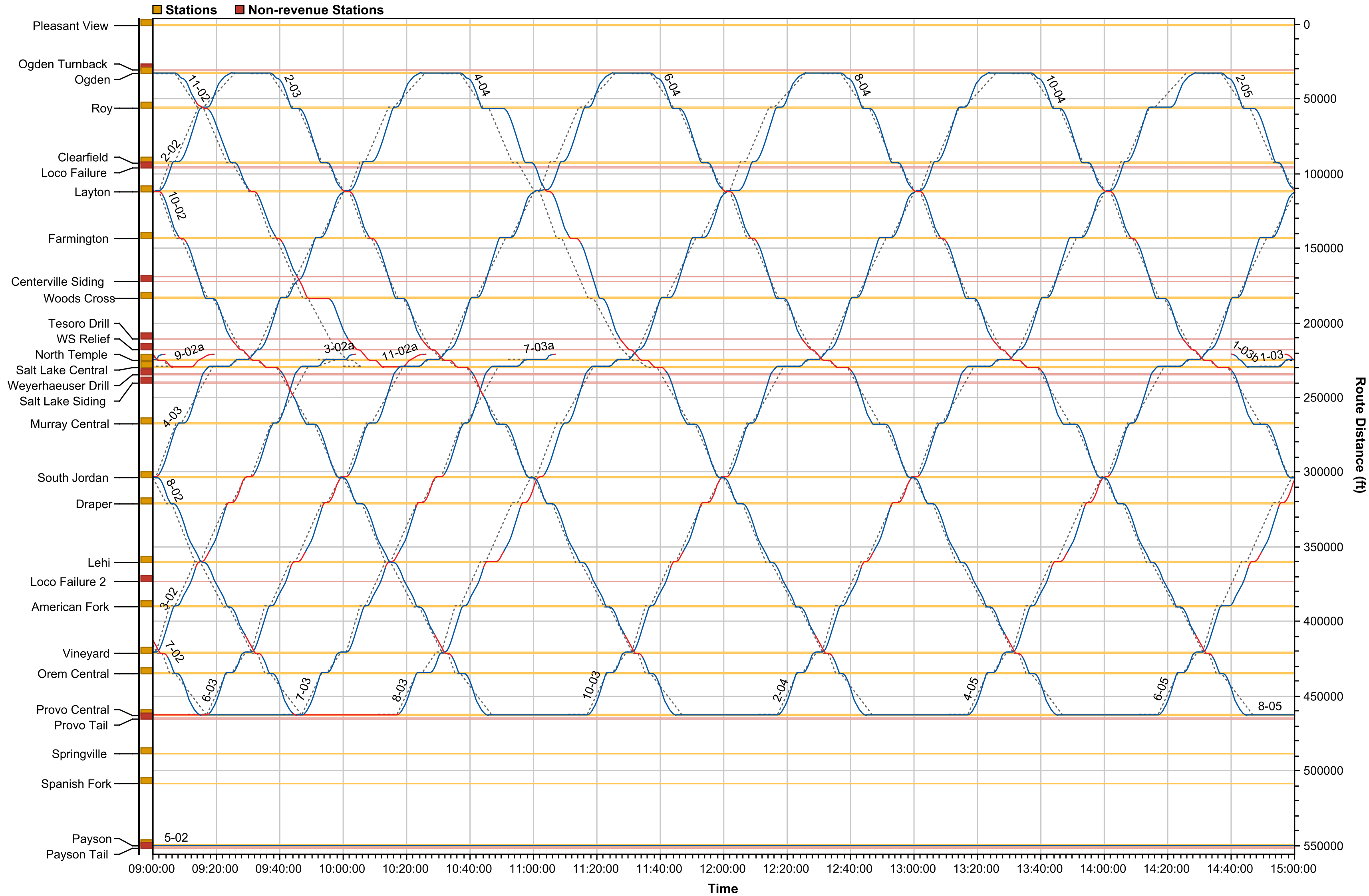


Figure 21-46: Time-Distance ("String") Chart – 9 AM – 3 PM – Low Investment Scenario Day 5 Simulation Results with Perturbations

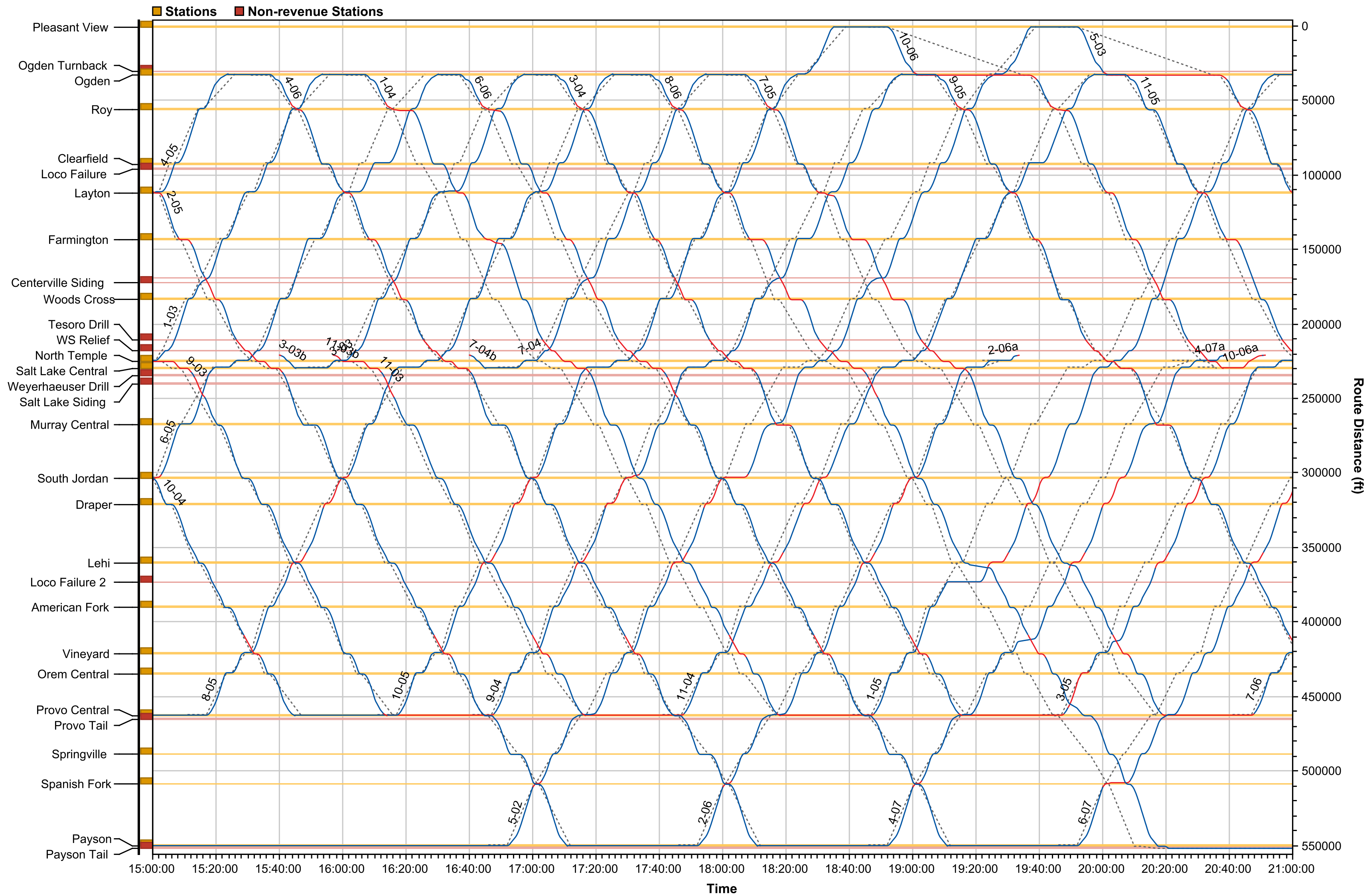


Figure 21-47: Time-Distance ("String") Chart – 3 PM – 9 PM – Low Investment Scenario Day 5 Simulation Results with Perturbations

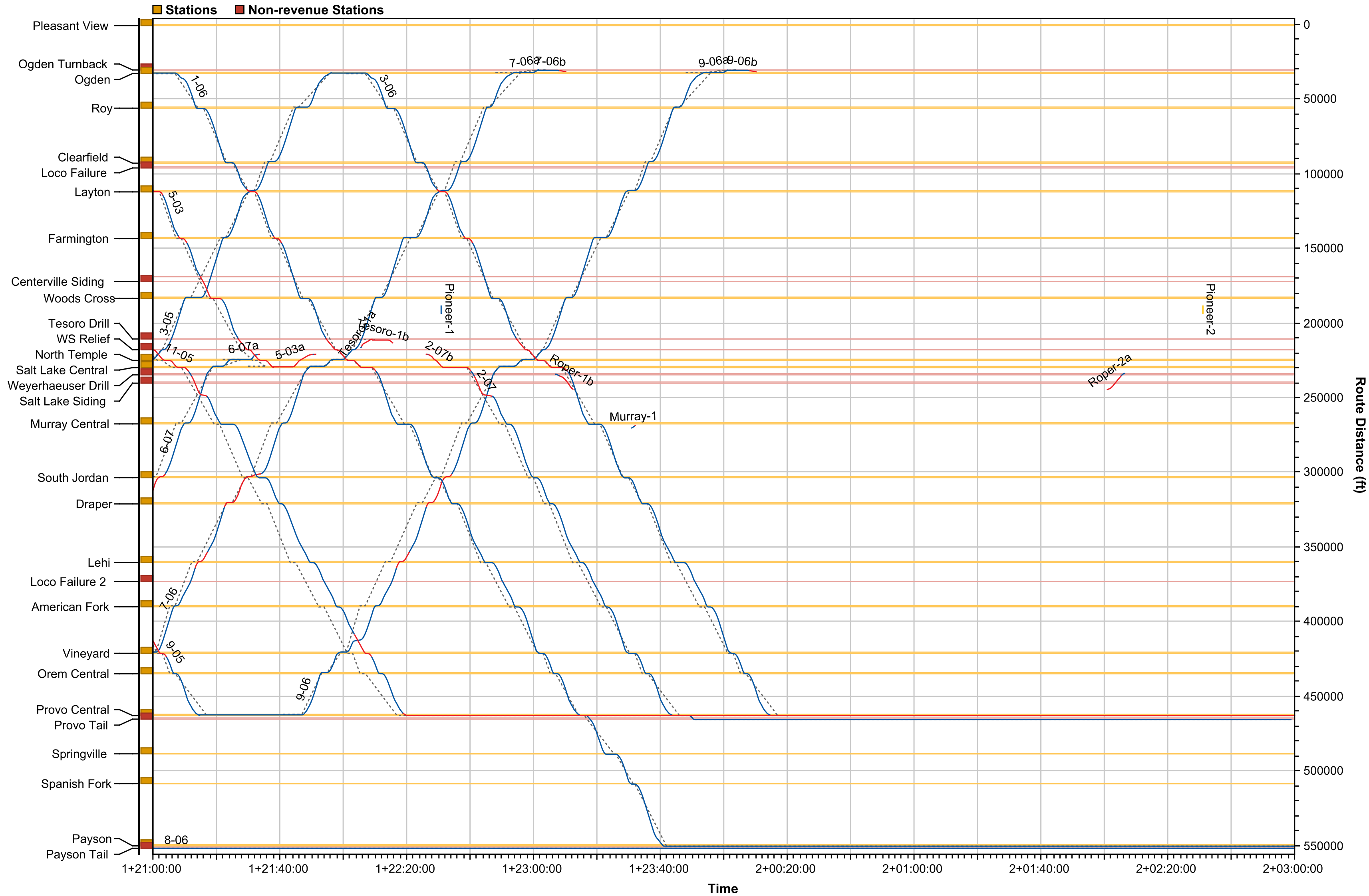


Figure 21-48: Time-Distance ("String") Chart – 9 PM – 3 AM – Low Investment Scenario Day 5 Simulation Results with Perturbations

22 Appendix G Medium Investment Scenario Time-Distance ("String") Charts and Station Occupancy Charts

22.1 Medium Investment Scenario Simulation Results without Perturbations (Ideal Day)

22.1.1 Station Occupancy Charts – Salt Lake Central

Northbound trains are shown on UTA1 with southbound trains on UTA2. Northbound trains begin arriving early and cascading delays cause trains to arrive late, although most still depart on time due to the extended dwell time. Southbound trains arrive and depart on time, except for some random late trains that still depart on time.

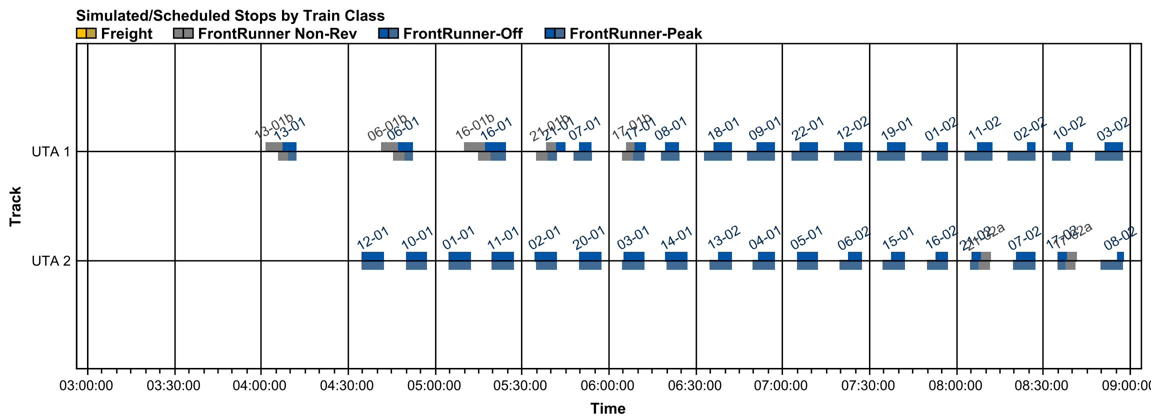


Figure 22-1: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Medium Investment Scenario No Added Perturbations

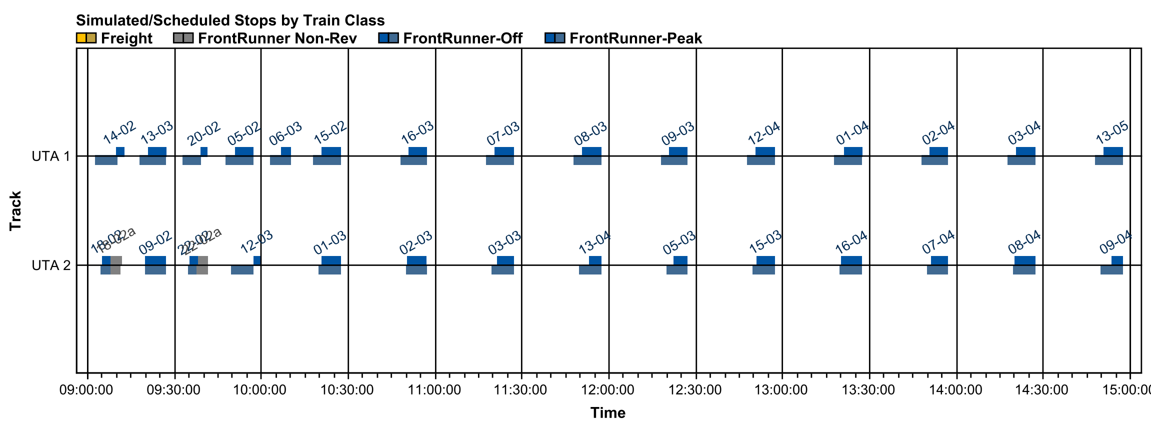


Figure 22-2: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Medium Investment Scenario No Added Perturbations

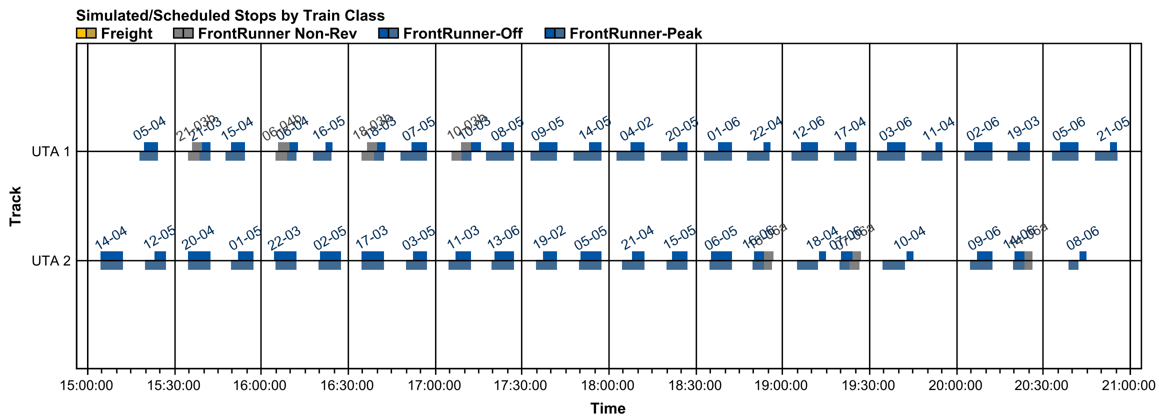


Figure 22-3: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Medium Investment Scenario No Added Perturbations

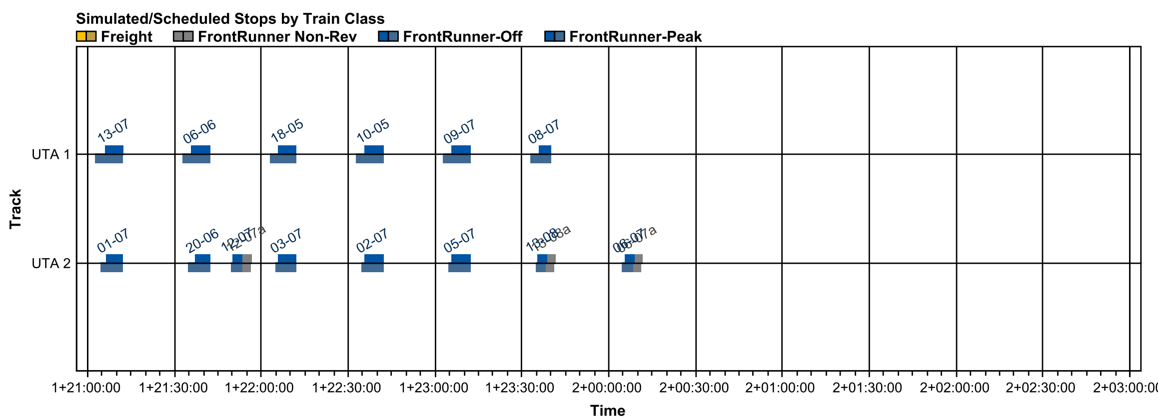


Figure 22-4: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Medium Investment Scenario No Added Perturbations

22.1.2 String Charts

Delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones. The trains run very close to on-time in the No Added Perturbations run, except for cascading delays at the end of each peak. Even with the extended double track sections, cascading delays begin to develop between American Fork and Draper after the peak service has been running for about an hour. However, because of the relaxed schedule in this area, trains generally get back on time before Provo southbound and Salt Lake Central northbound.

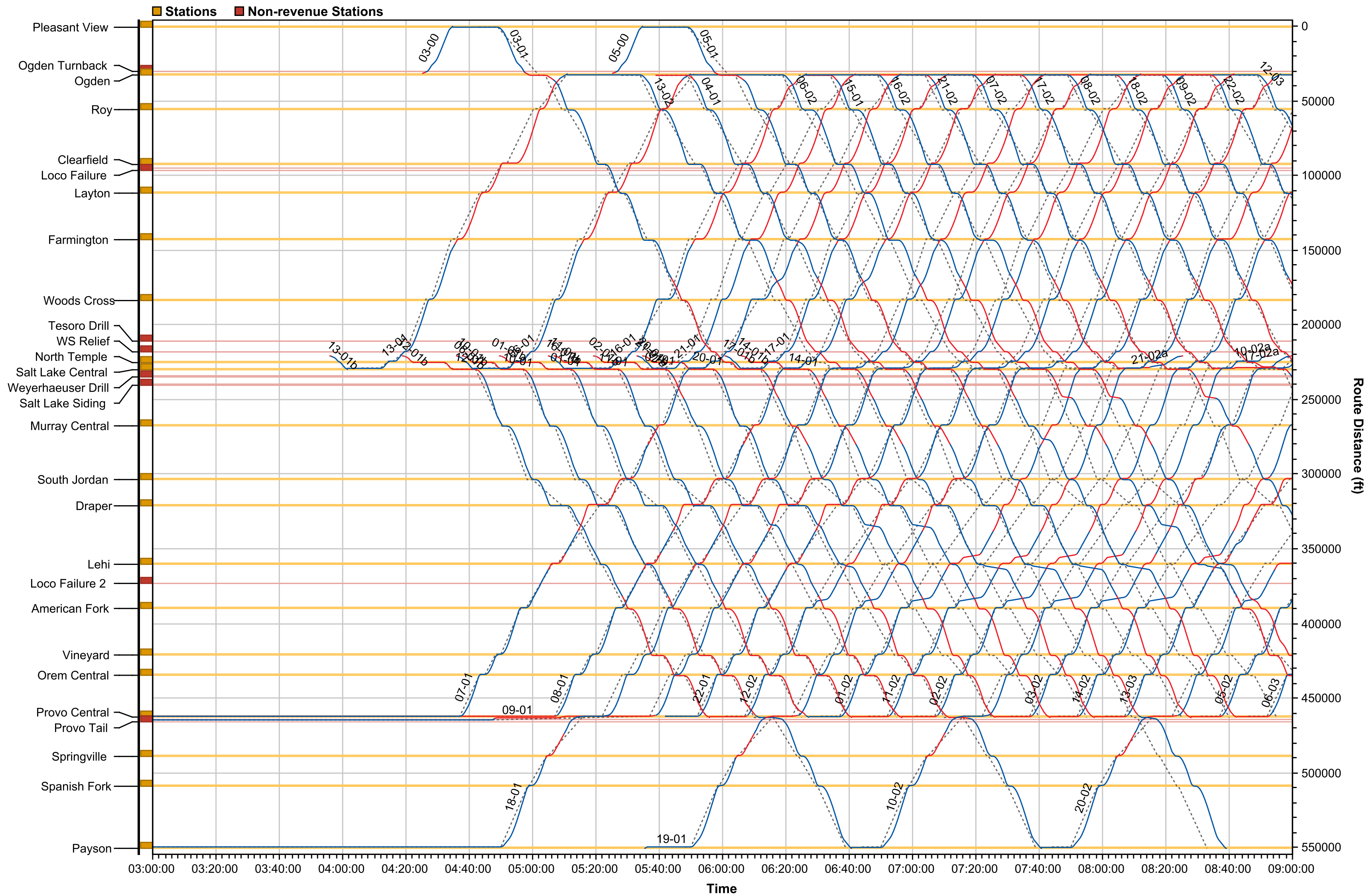


Figure 22-5: Time-Distance ("String") Chart – 3 AM – 9 AM – Medium Investment Scenario No Added Perturbations

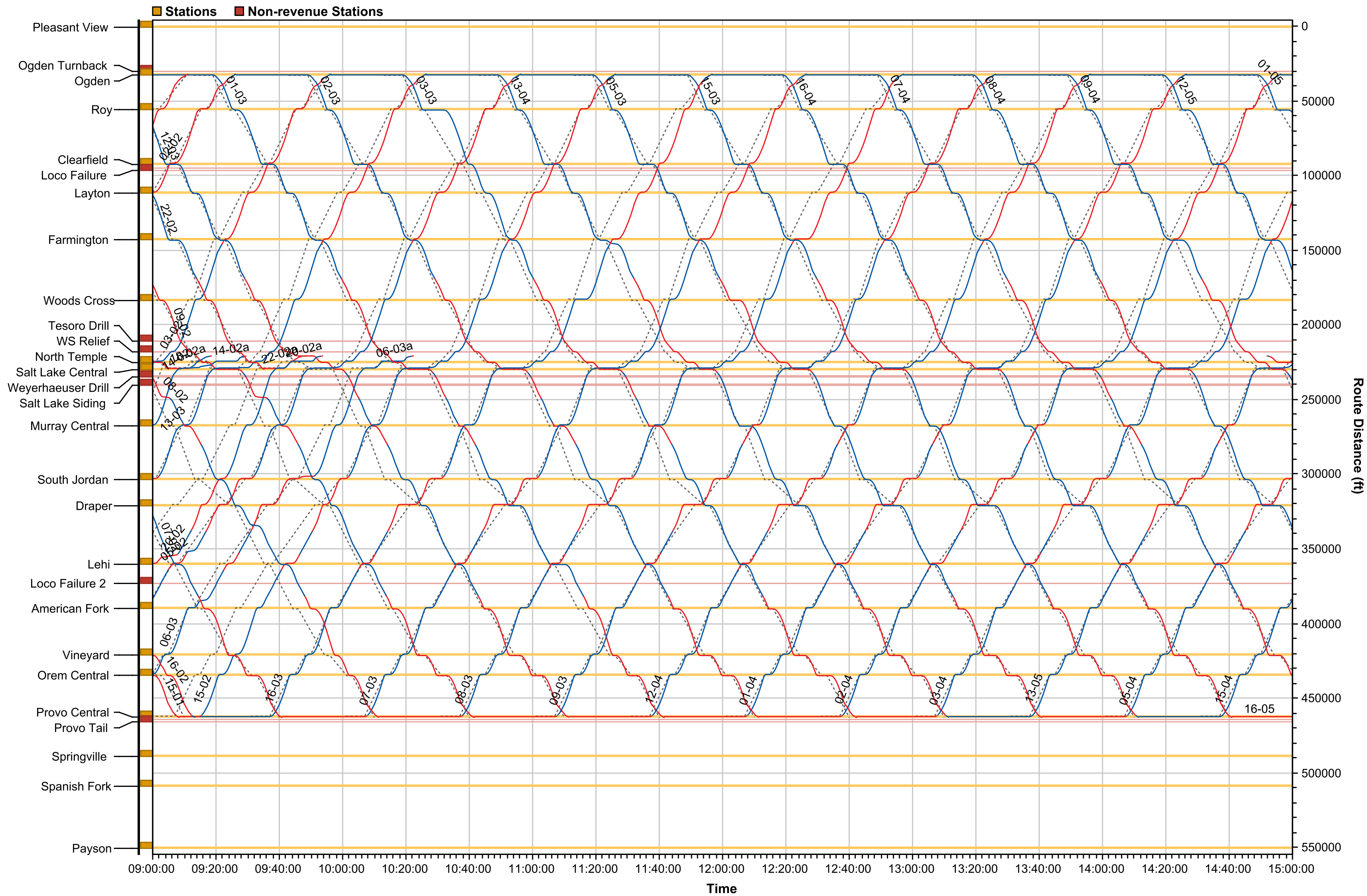


Figure 22-6: Time-Distance ("String") Chart – 9 AM – 3 PM – Medium Investment Scenario No Added Perturbations

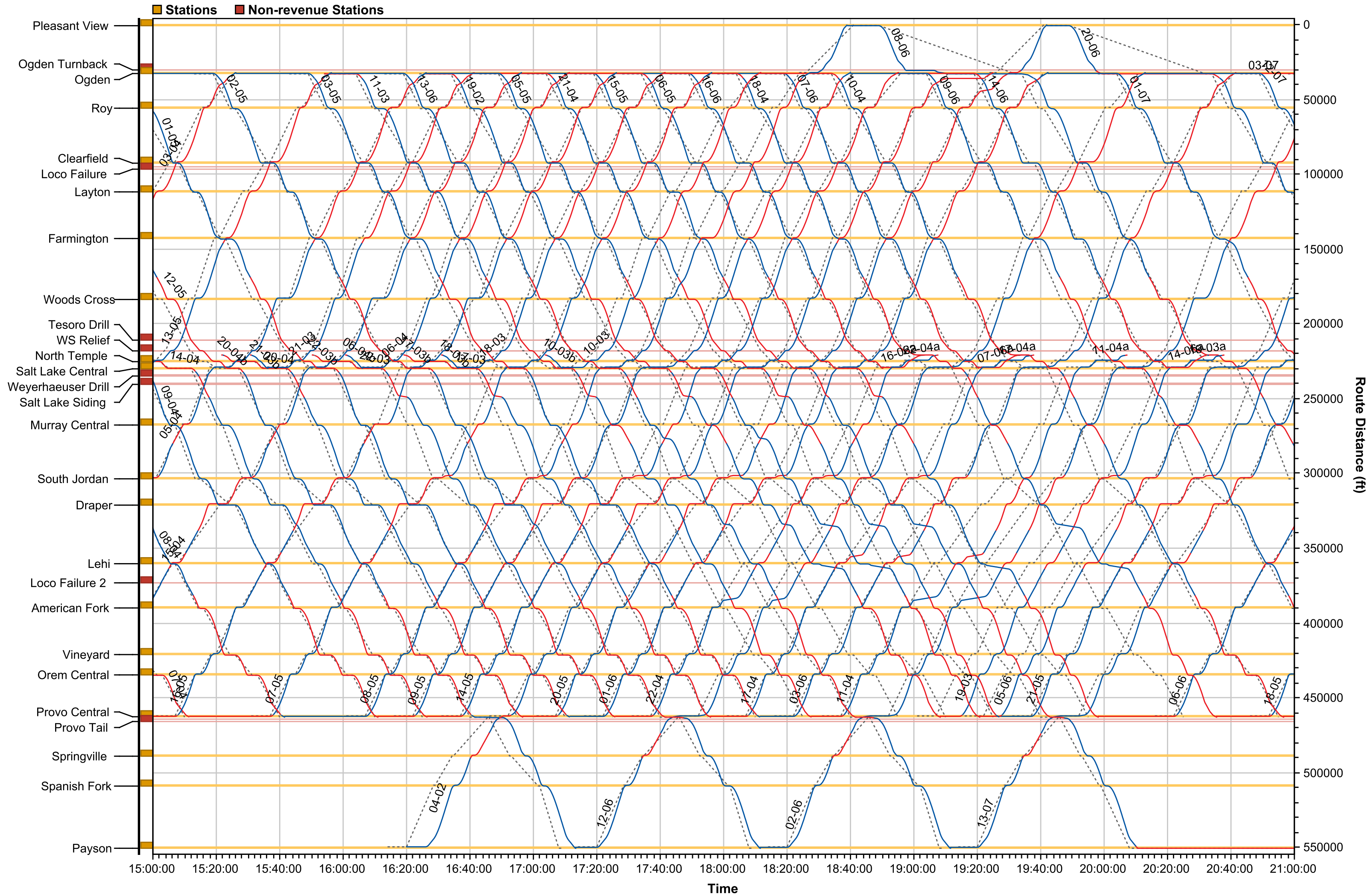


Figure 22-7: Time-Distance ("String") Chart – 3 PM – 9 PM – Medium Investment Scenario No Added Perturbations

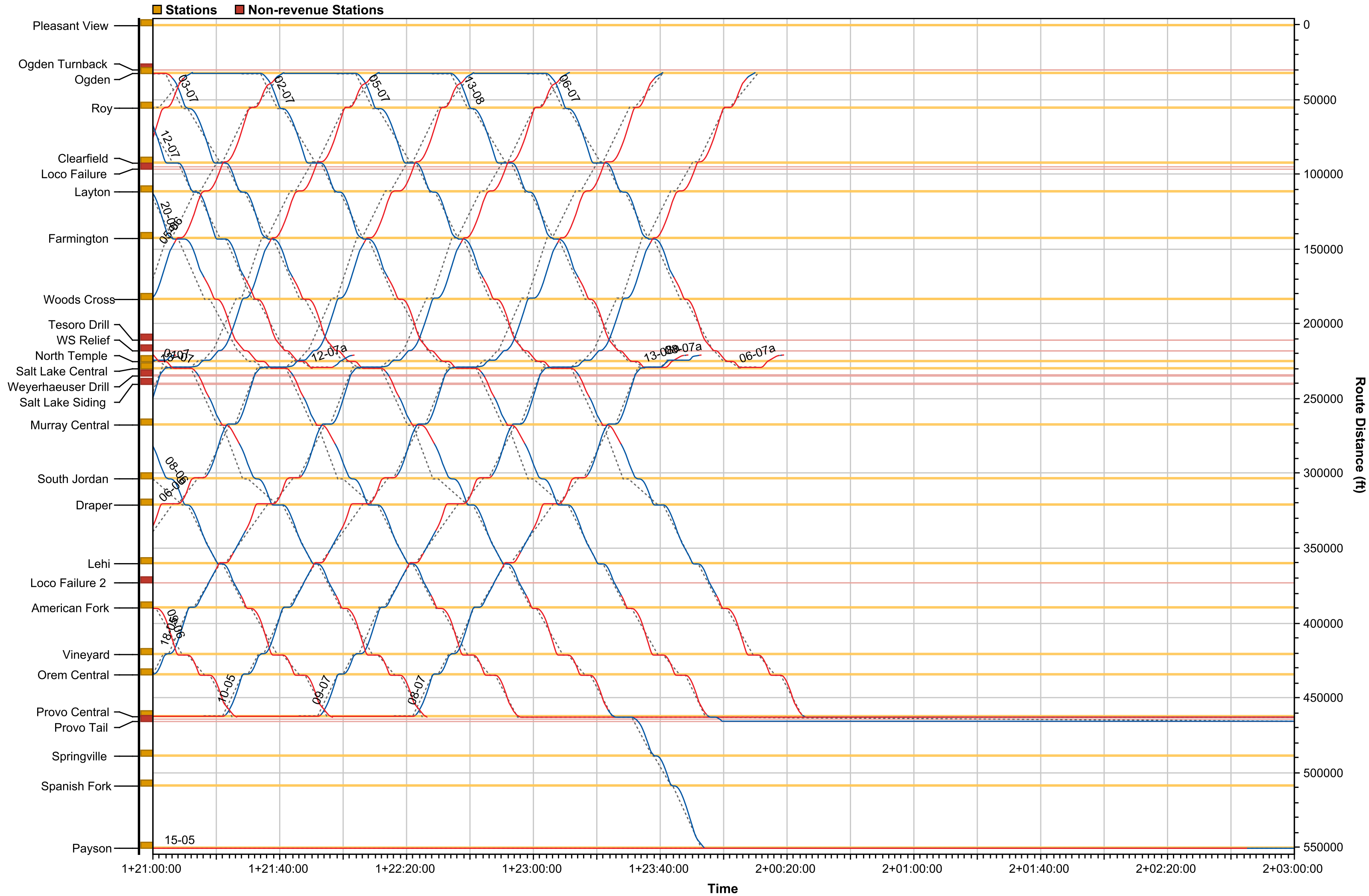


Figure 22-8: Time-Distance (“String”) Chart – 9 PM – 3 AM – Medium Investment Scenario No Added Perturbations

22.2 Day 1 Medium Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 1 operating plan includes a randomly-assigned door failure for train 15-05 at South Jordan station. This causes a 7-minute extended dwell. Day 1 also includes a 5-minute delay for train 12-02 at North Temple due to the randomly-assigned need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

22.2.1 Station Occupancy Charts – Salt Lake Central

Most northbound trains arrive late and depart on time and most southbound trains arrive and depart on time. In both directions, trains are impacted by the service disruptions and cascading delays near the end of the peak periods.

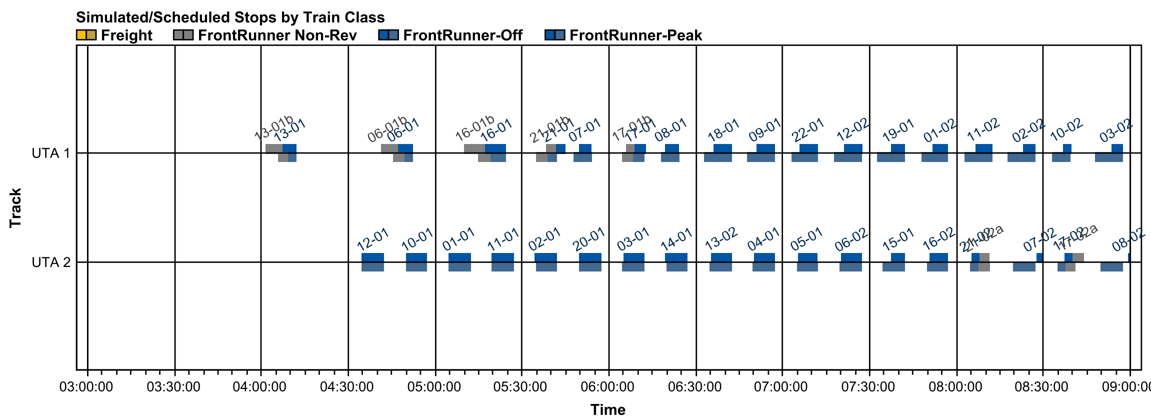


Figure 22-9: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Medium Investment Scenario Day 1 Simulation Results with Perturbations

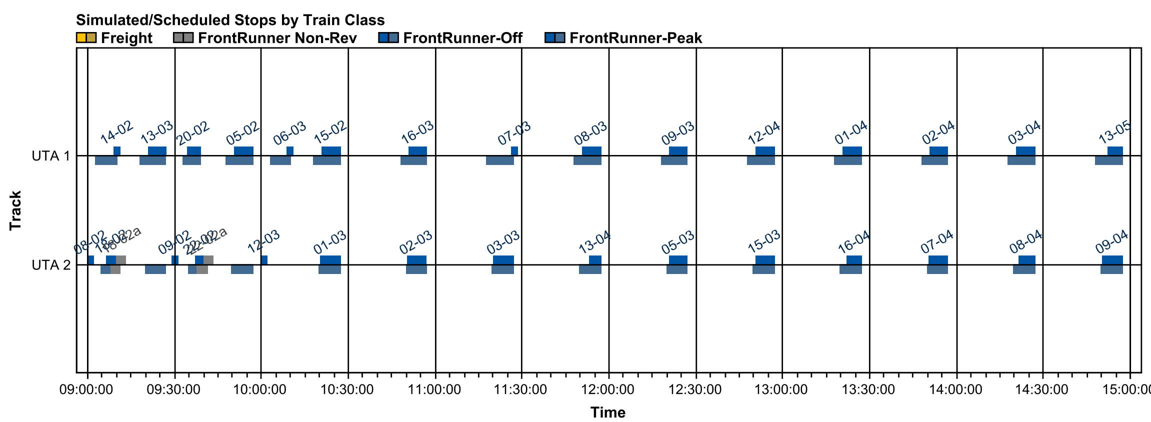


Figure 22-10: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Medium Investment Scenario Day 1 Simulation Results with Perturbations

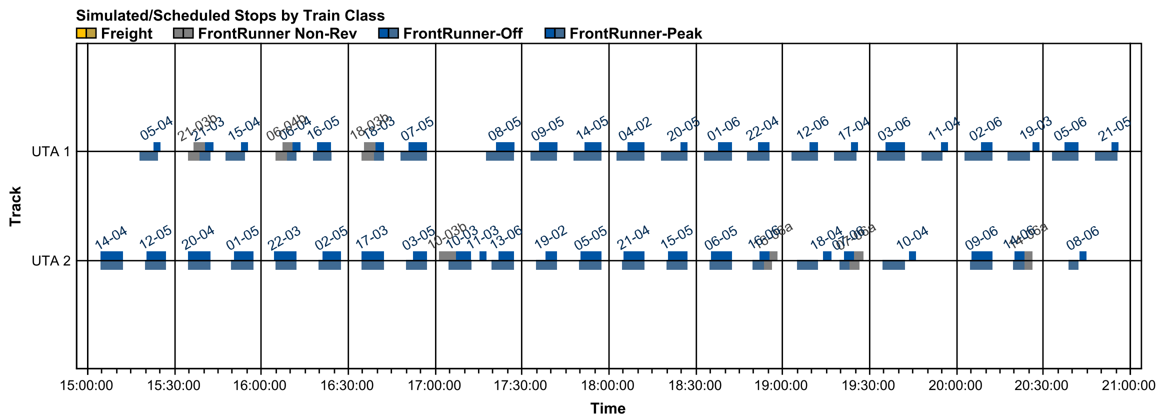


Figure 22-11: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Medium Investment Scenario Day 1 Simulation Results with Perturbations

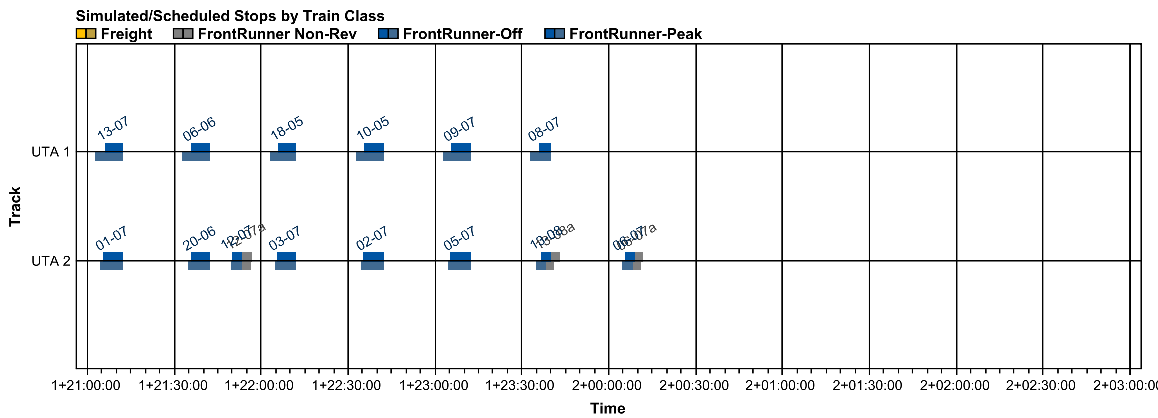


Figure 22-12: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Medium Investment Scenario Day 1 Simulation Results with Perturbations

22.2.2 String Charts

Figure 22-13 shows the randomly-assigned 5-minute delay for train 12-02 at North Temple due to the need to hold for a late TRAX connection. Due to this prolonged delay, train 12-02 meets train 7-02 at the lengthened Woods Cross-Centerville Siding. With the help of the extended siding between Farmington and Ogden, train 12-02 is able to arrive Ogden nearly on time and 12-03 departs Ogden on time.

Figure 22-15 shows the 7-minute extended dwell perturbation to train 15-05. This causes a delay to train 6-05, the next southbound train, although the extended sidings help lessen the delay. However, the delays to both northbound and southbound trains cause issues until after the peak period.

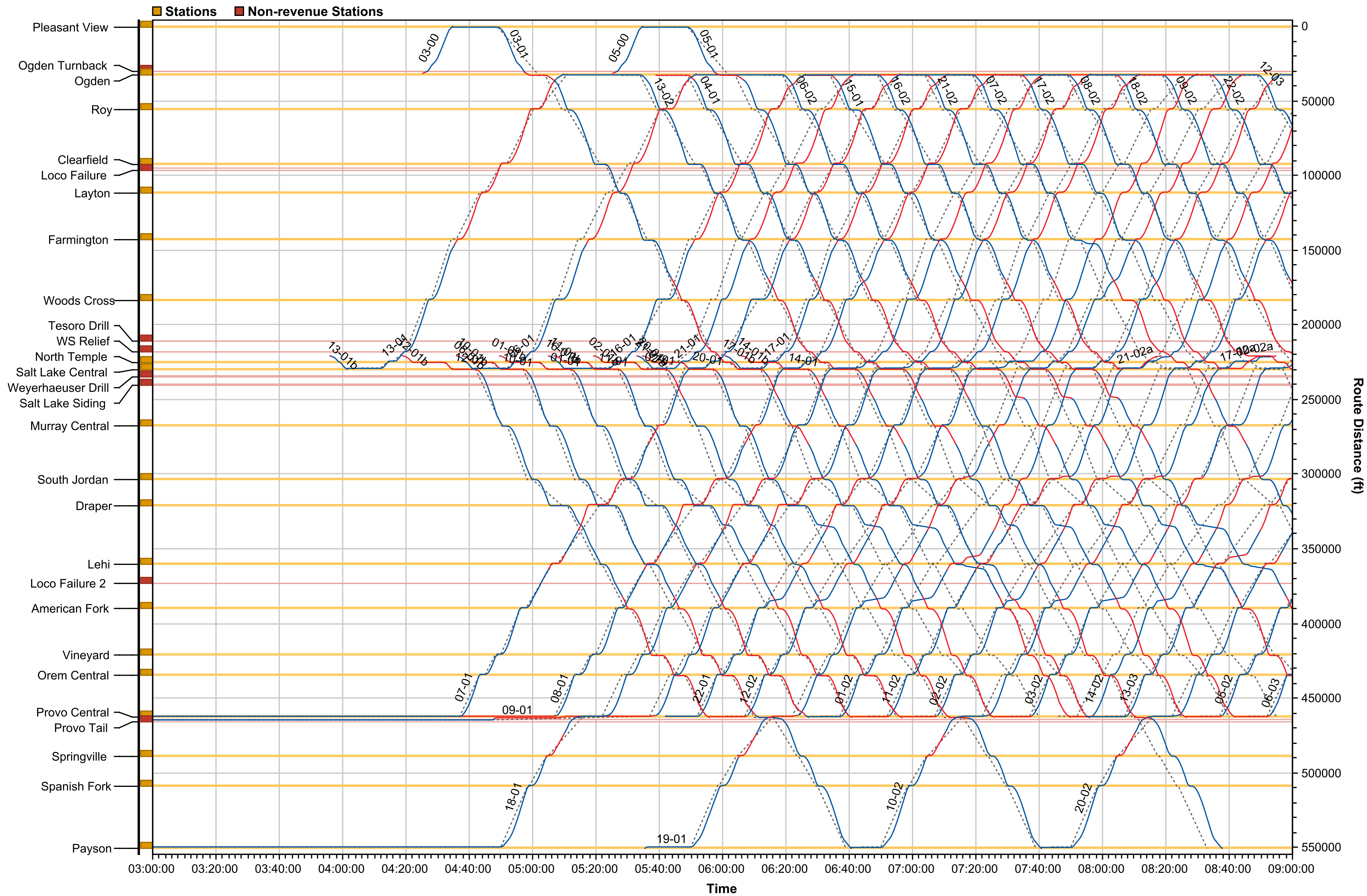


Figure 22-13: Time-Distance ("String") Chart – 3 AM – 9 AM – Medium Investment Scenario Day 1 Simulation Results with Perturbations

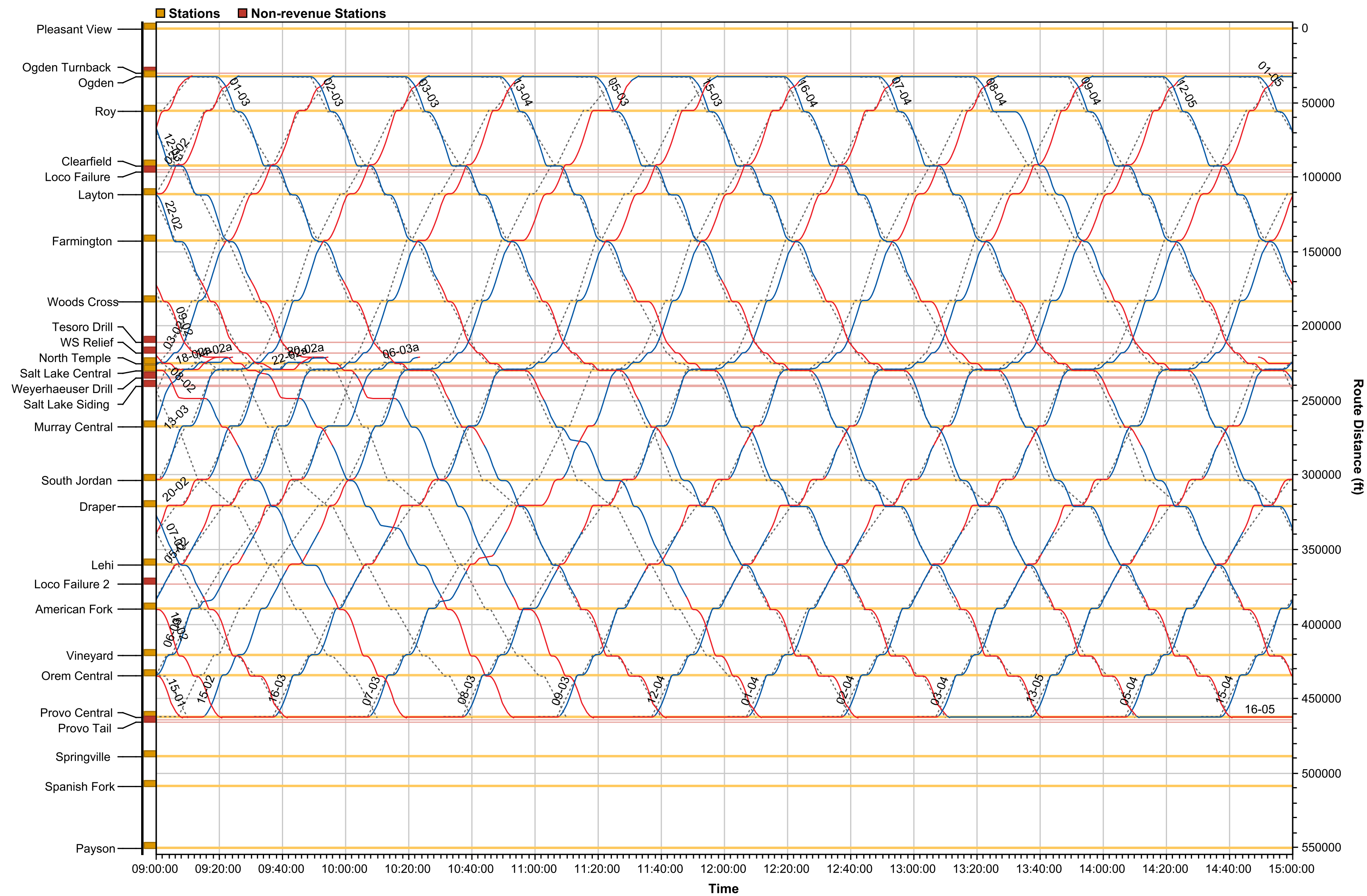


Figure 22-14: Time-Distance ("String") Chart – 9 AM – 3 PM – Medium Investment Scenario Day 1 Simulation Results with Perturbations

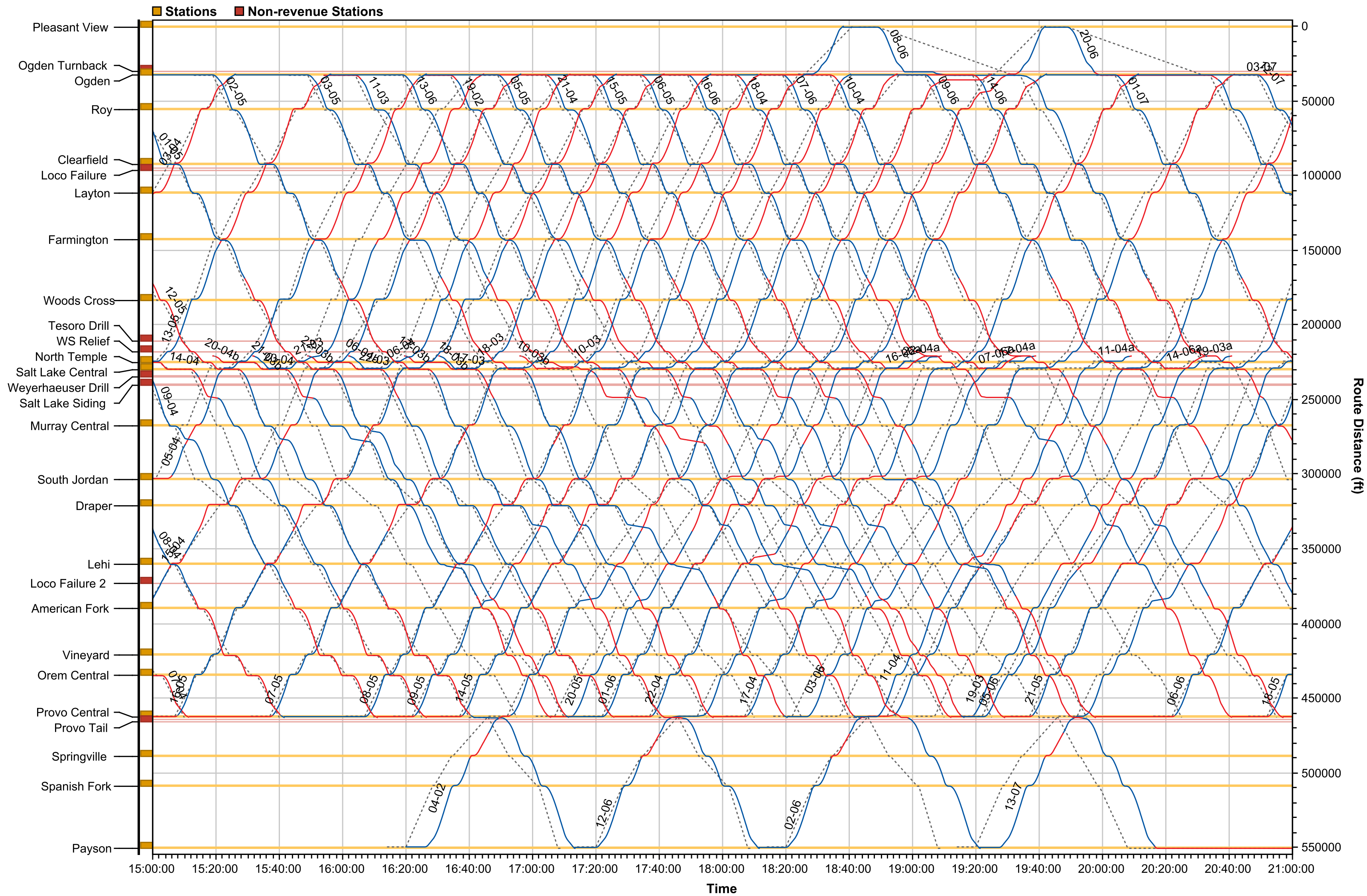


Figure 22-15: Time-Distance ("String") Chart – 3 PM – 9 PM – Medium Investment Scenario Day 1 Simulation Results with Perturbations

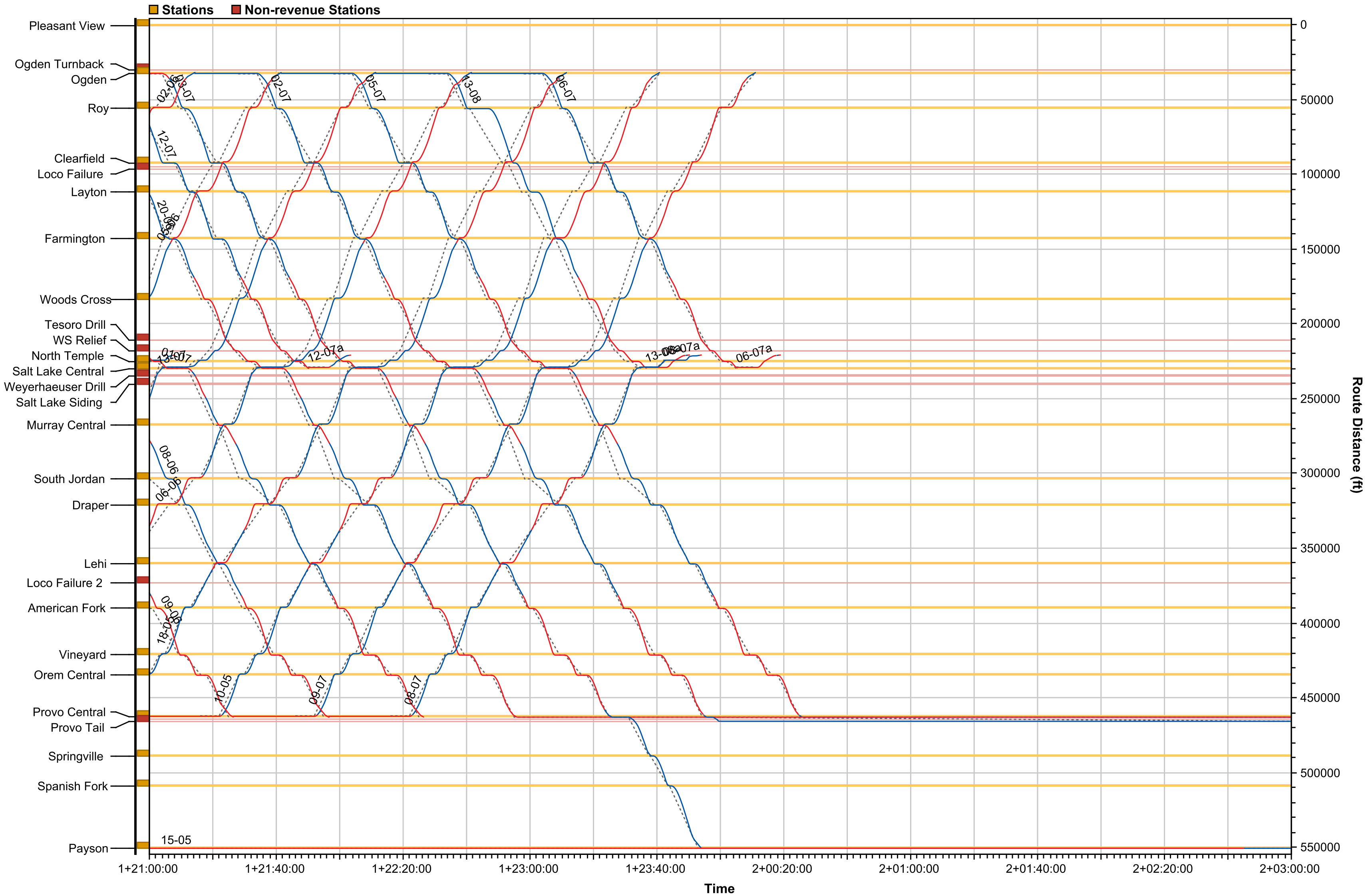


Figure 22-16: Time-Distance ("String") Chart – 9 PM – 3 AM – Medium Investment Scenario Day 1 Simulation Results with Perturbations

22.3 Day 2 Medium Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 2 operating plan perturbations include a 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM due to a crossing failure/broken gate. Day 2 also includes a 5-minute delay for train 2-02 at North Temple due to the need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

22.3.1 Station Occupancy Charts – Salt Lake Central

Most northbound trains arrive late and depart on time and most southbound trains arrive and depart on time. In both directions, trains are impacted by the service disruptions and cascading delays near the end of the peak periods, with the afternoon peak having more serious issues due to the crossing failure north of Murray Central at that time.

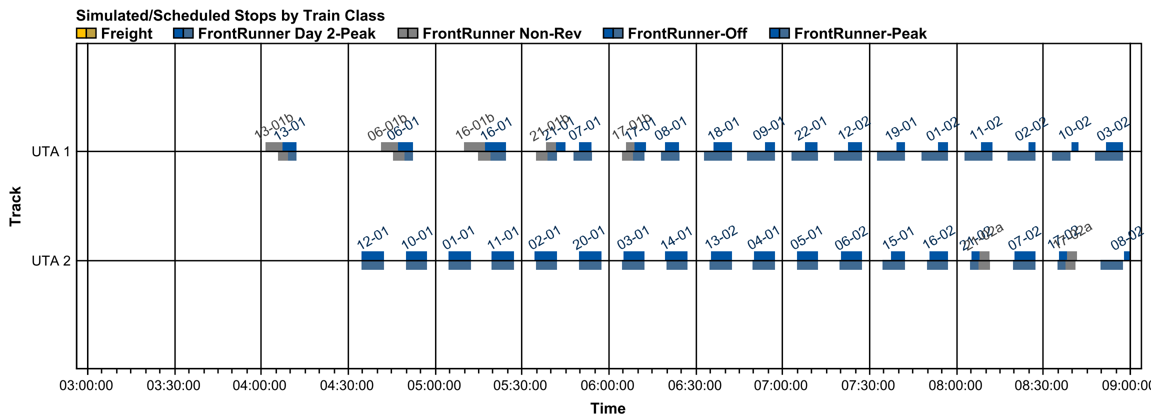


Figure 22-17: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Medium Investment Scenario Day 2 Simulation Results with Perturbations

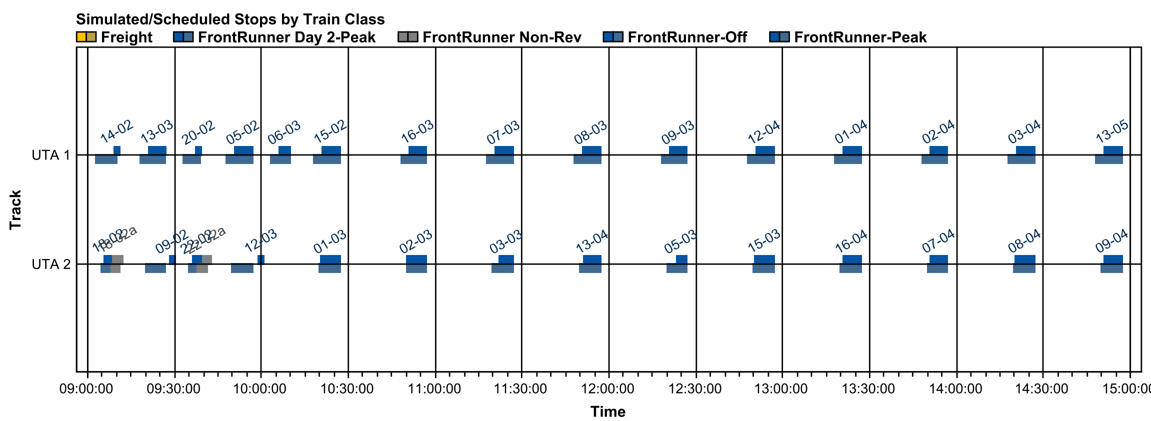


Figure 22-18: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Medium Investment Scenario Day 2 Simulation Results with Perturbations

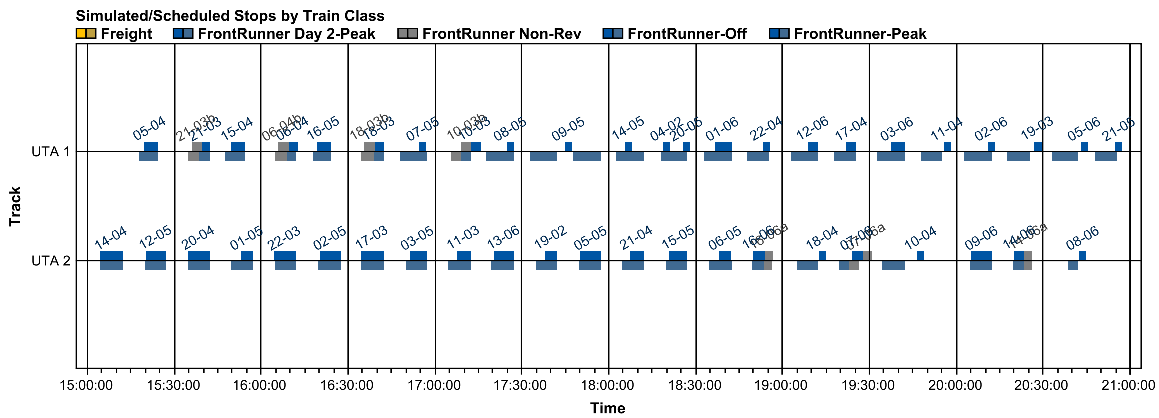


Figure 22-19: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Medium Investment Scenario Day 2 Simulation Results with Perturbations

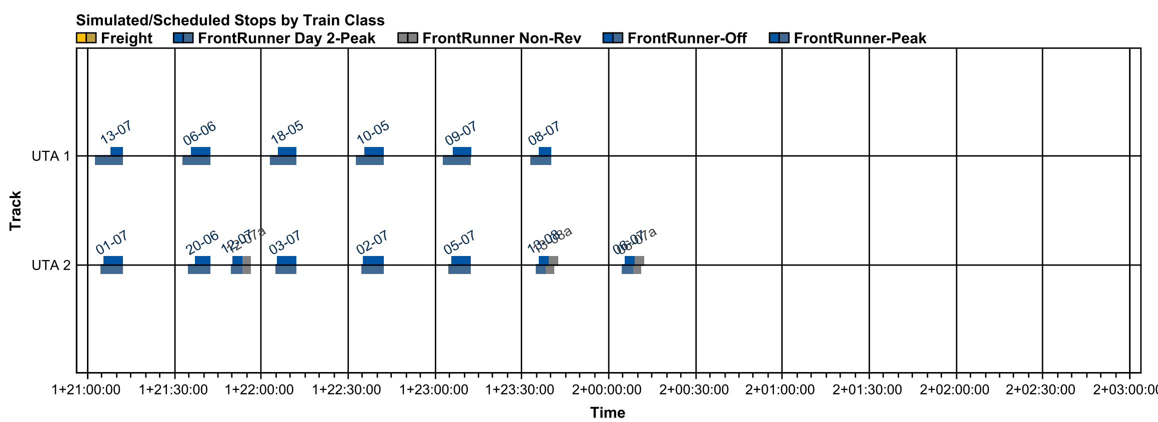


Figure 22-20: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Medium Investment Scenario Day 2 Simulation Results with Perturbations

22.3.2 String Charts

Figure 22-21 shows the randomly-assigned 5-minute delay for train 2-02 at North Temple due to the need to hold for a late TRAX connection. There are very few consequences from this delay and the train arrives Ogden on time due to the extended siding between Farmington and Ogden.

Figure 22-23 shows the 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM. The lower speed is evident in the more horizontal slopes of the string lines through this period. With the disruption occurring in a single track section that is bracketed by short double track segments, compounded by trains every 15 minutes in each direction, it is very difficult for the system to recover during the peak and trains are not running back to normal until well after the afternoon peak, about 9:00 PM.

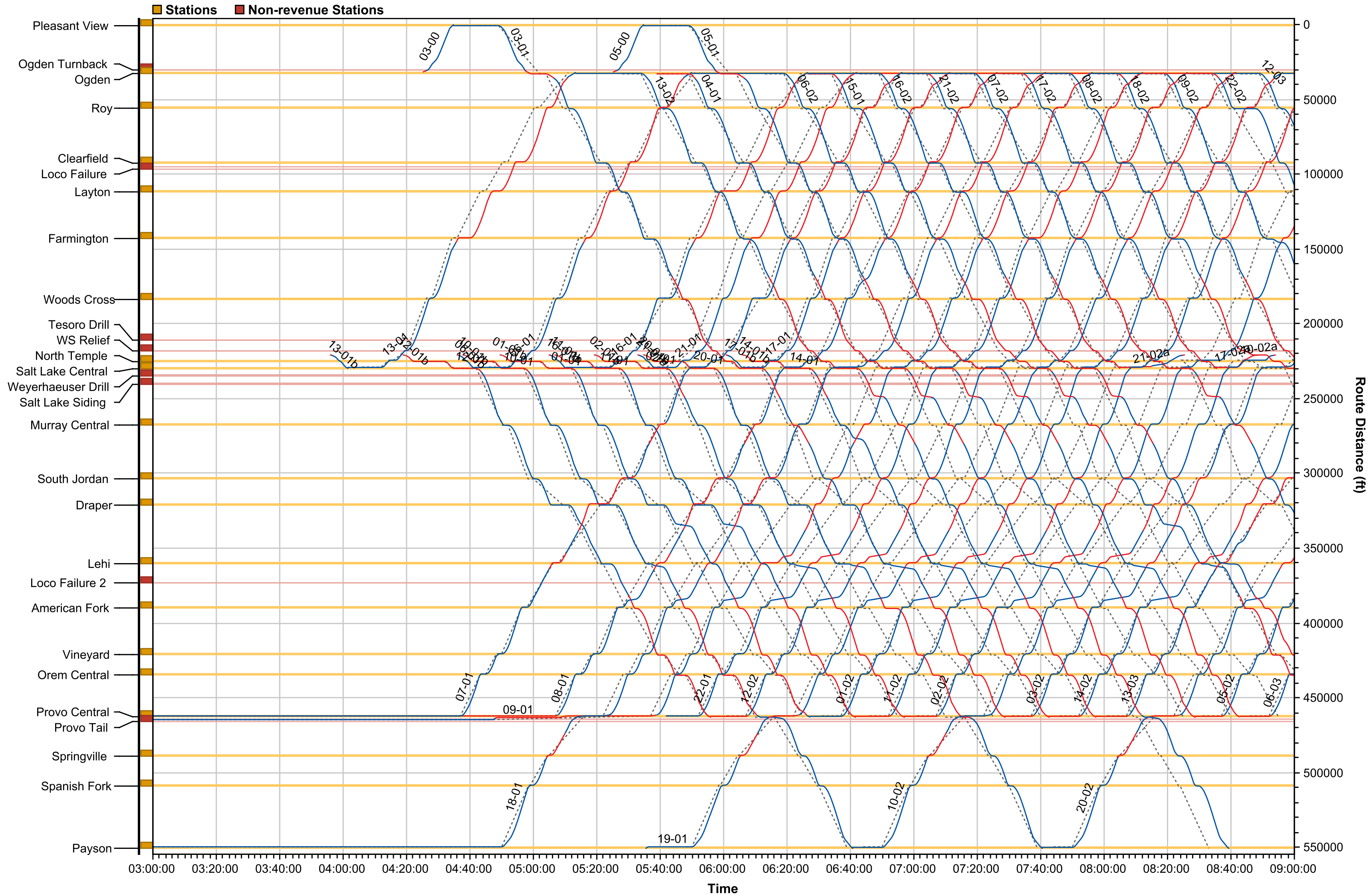


Figure 22-21: Time-Distance ("String") Chart – 3 AM – 9 AM – Medium Investment Scenario Day 2 Simulation Results with Perturbations

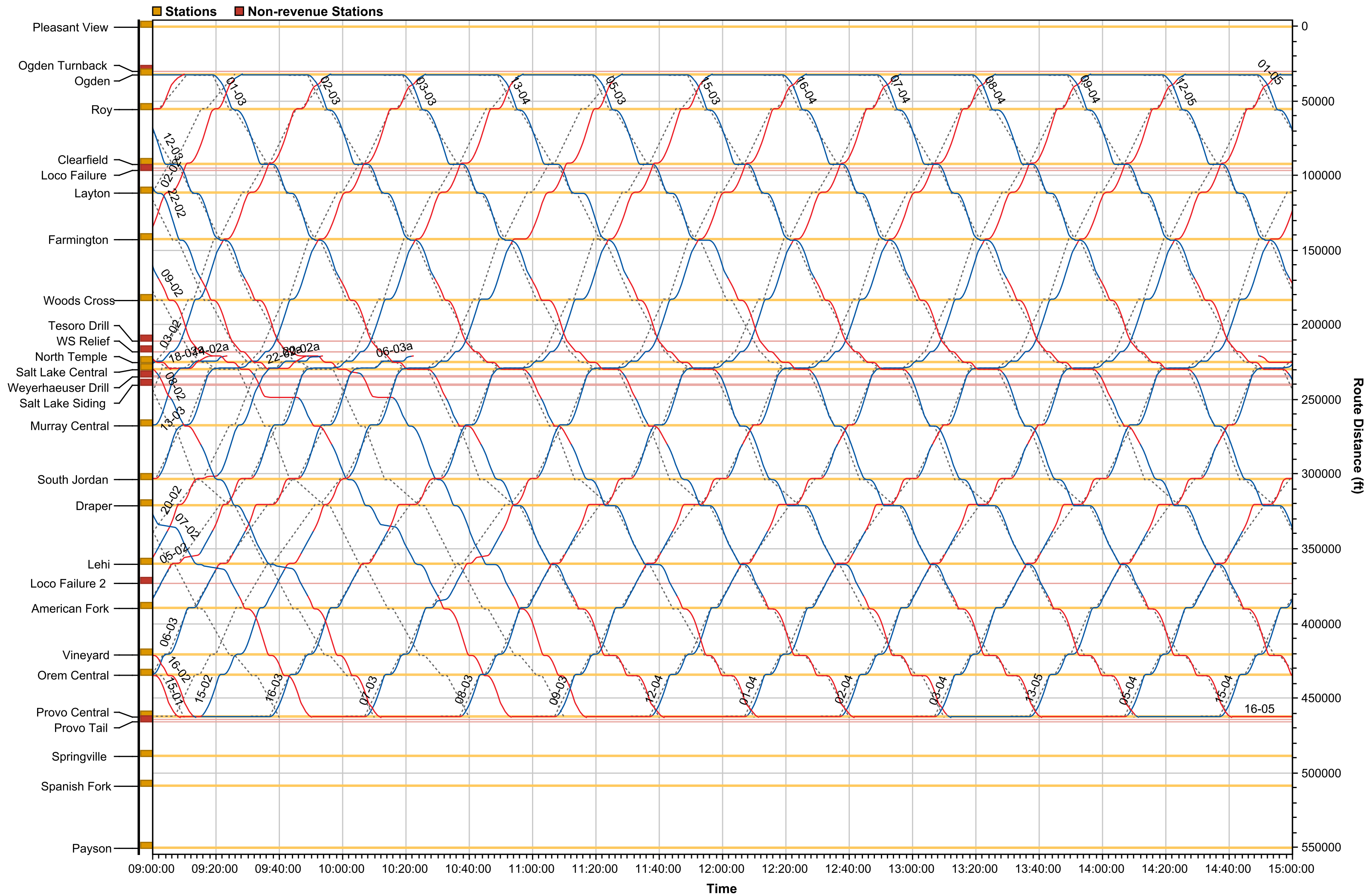


Figure 22-22: Time-Distance ("String") Chart – 9 AM – 3 PM – Medium Investment Scenario Day 2 Simulation Results with Perturbations

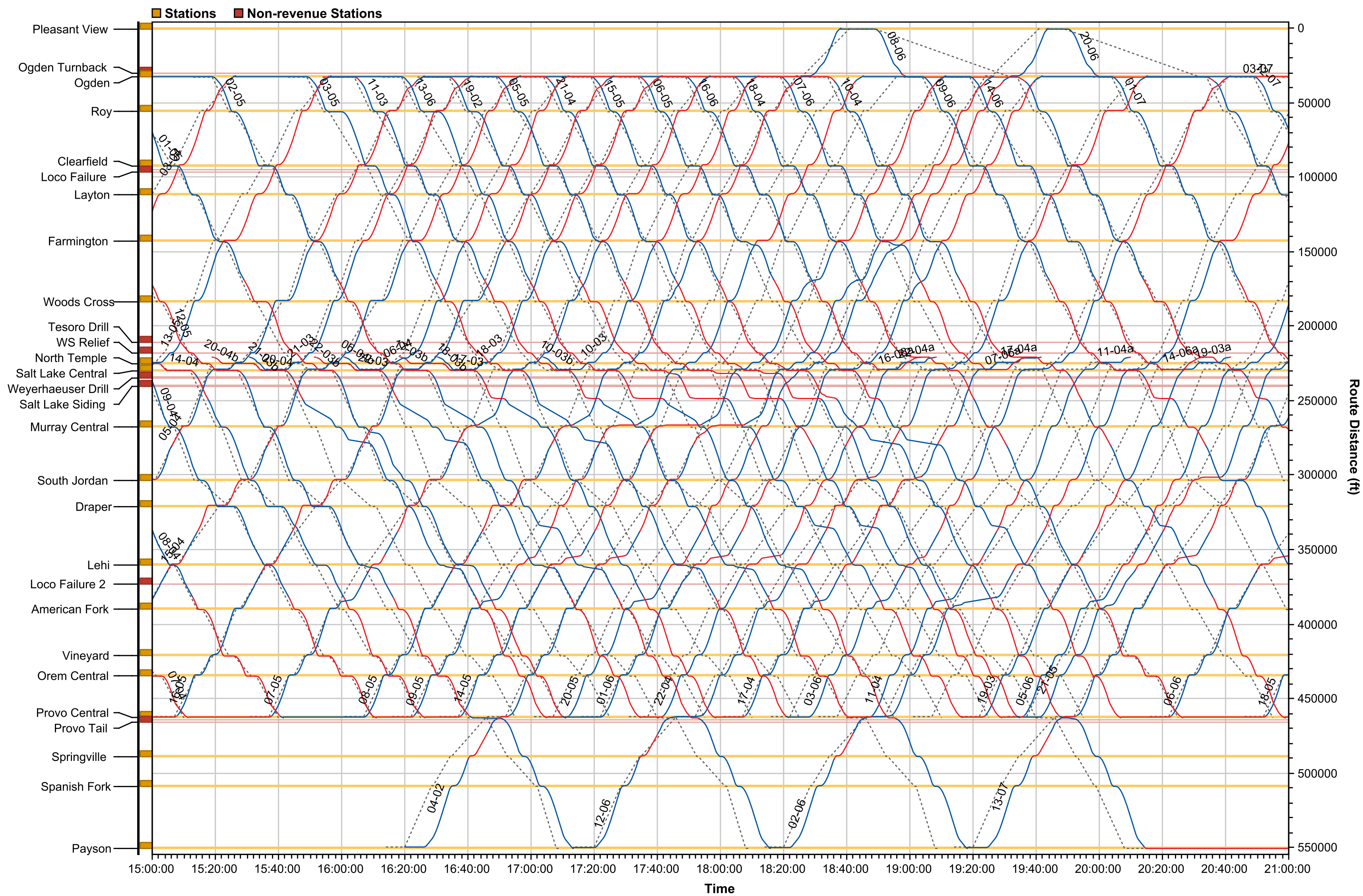


Figure 22-23: Time-Distance ("String") Chart – 3 PM – 9 PM – Medium Investment Scenario Day 2 Simulation Results with Perturbations

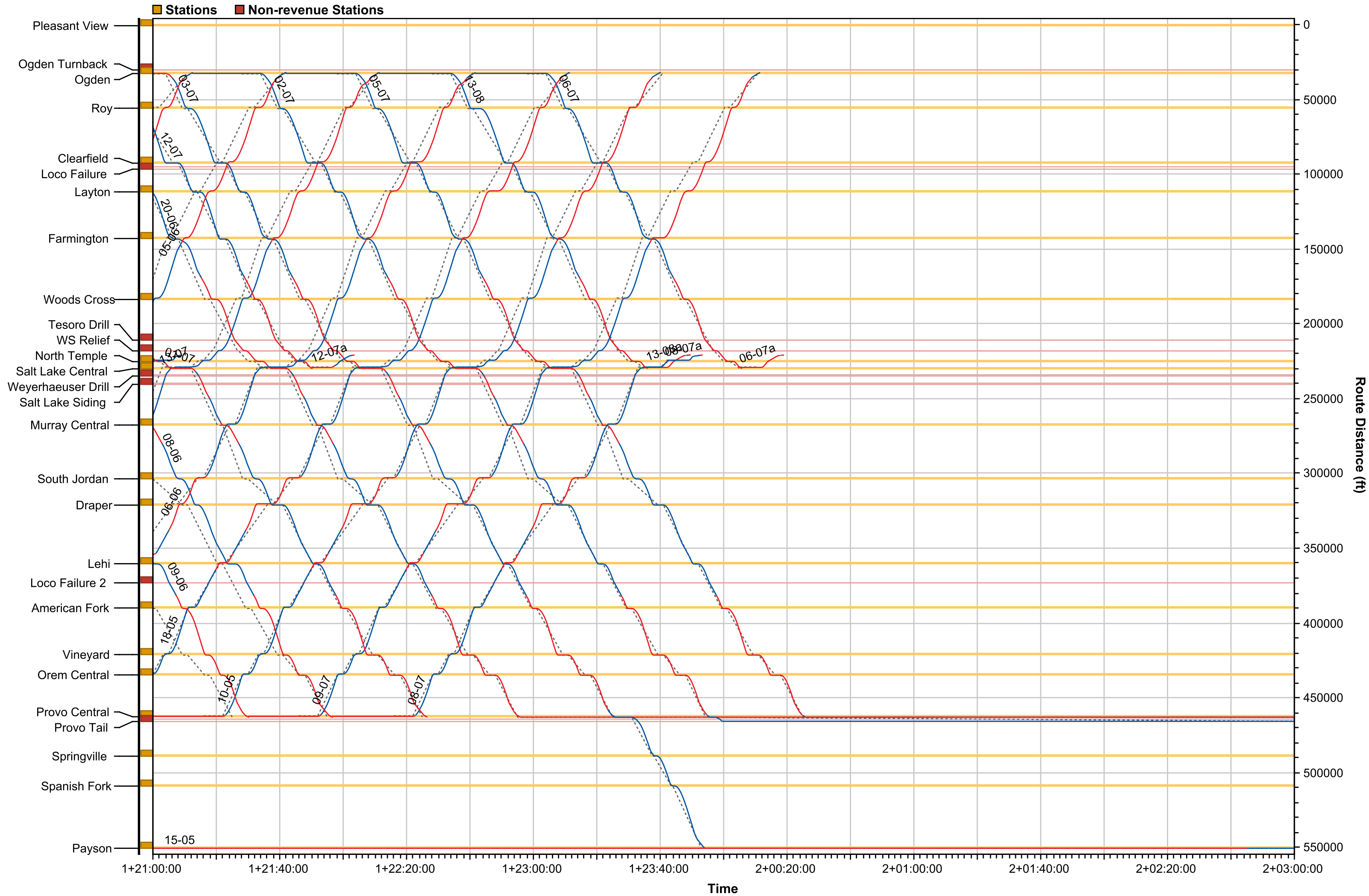


Figure 22-24: Time-Distance (“String”) Chart – 9 PM – 3 AM – Medium Investment Scenario Day 2 Simulation Results with Perturbations

22.4 Day 3 Medium Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 3 operating plan includes a locomotive failure on train 12-03 between Layton station and Clearfield station causing the train to stop for 10-minutes while the locomotive is reset. Day 3 also includes a door failure for train 11-02 at Woods Cross Station. This causes an assumed 7-minute extended dwell while the door is cut out and removed from service. Station occupancy charts and string charts are included in the following sections.

22.4.1 Station Occupancy Charts – Salt Lake Central

Most northbound trains arrive late and depart on time and most southbound trains arrive and depart on time. In both directions, trains are impacted by the service disruptions and cascading delays near the end of the peak periods.

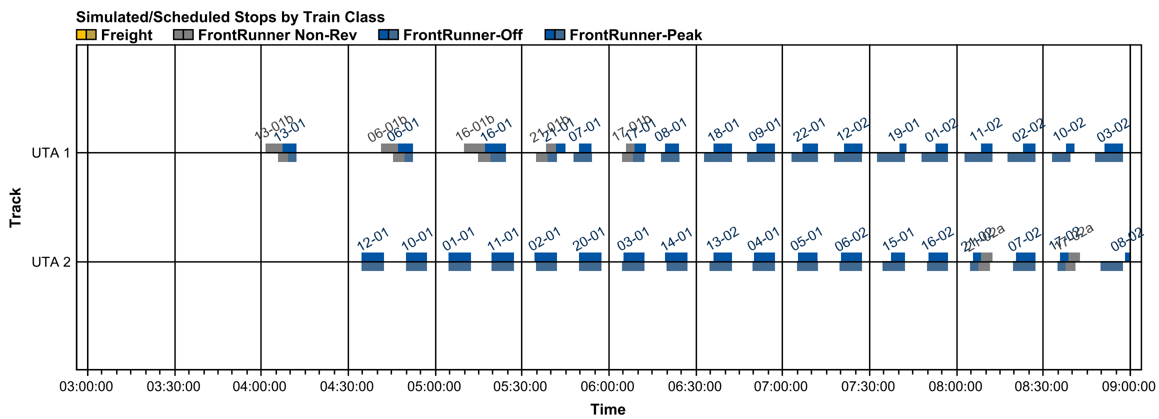


Figure 22-25: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Medium Investment Scenario Day 3 Simulation Results with Perturbations

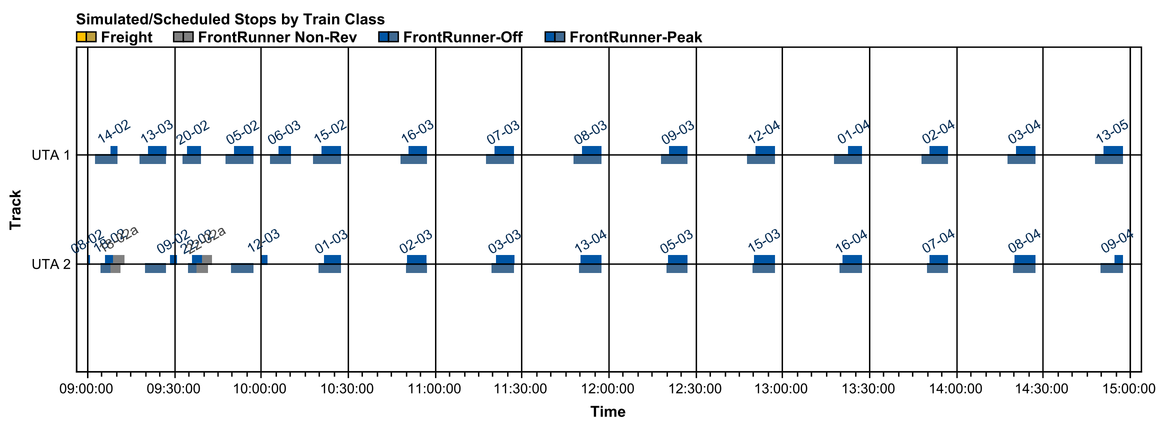


Figure 22-26: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Medium Investment Scenario Day 3 Simulation Results with Perturbations

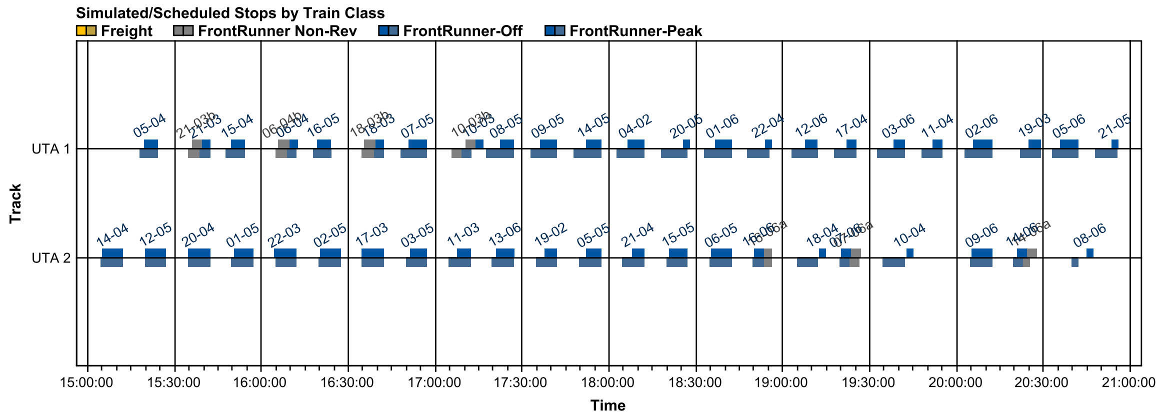


Figure 22-27: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Medium Investment Scenario Day 3 Simulation Results with Perturbations

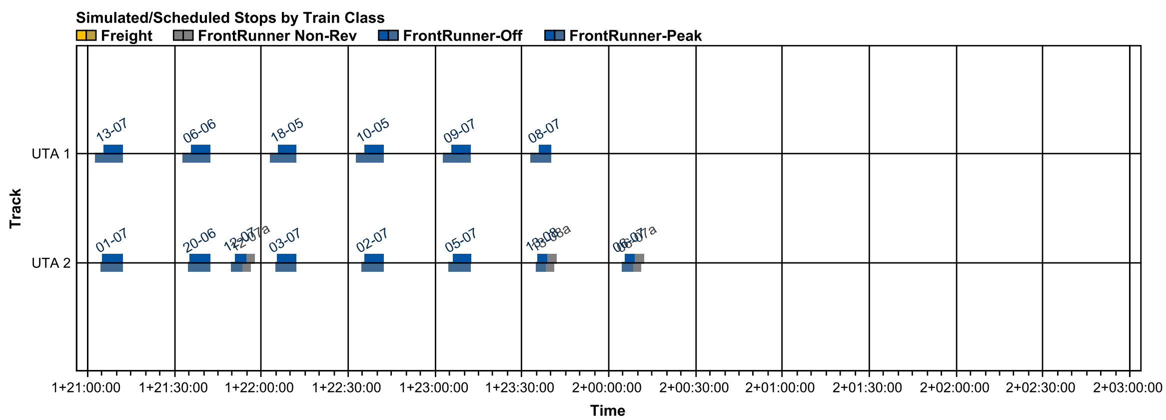


Figure 22-28: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Medium Investment Scenario Day 3 Simulation Results with Perturbations

22.4.2 String Charts

The Day 3 perturbation of train 12-03 experiencing a 10-minute delay in between Clearfield station and Layton station is shown in Figure 22-29 and Figure 22-30. The delays occur after the morning peak period, so the impacts are not as severe and train 12-03 is nearly on time when it arrives at Provo. The 7-minute extended dwell for train 11-02 at Woods Cross station is also shown in Figure 22-30. There is enough time built into the schedule that the delay is resolved at Ogden station and the extended siding between Farmington and Ogden helps keep the southbound trains on time.

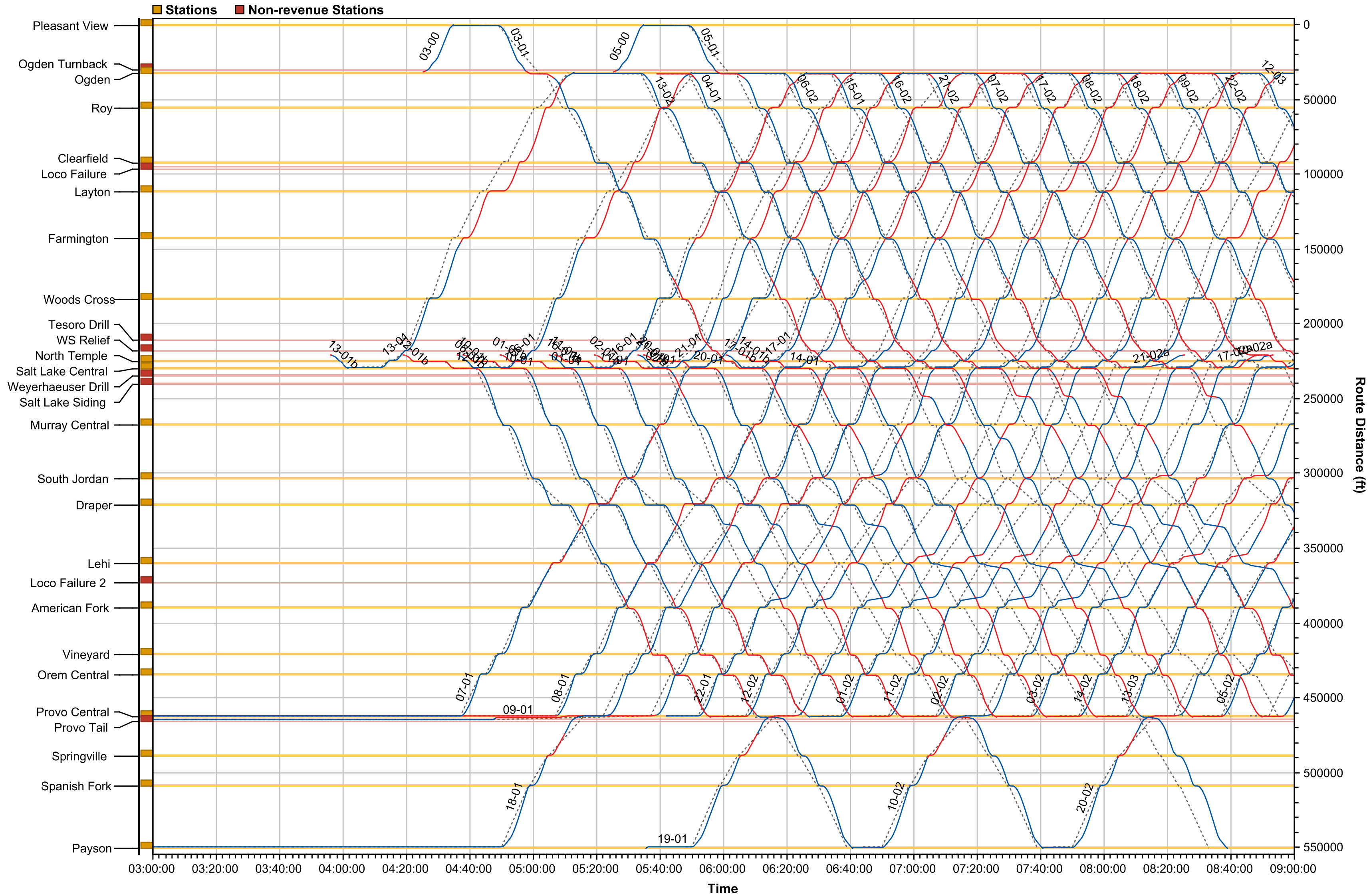


Figure 22-29: Time-Distance ("String") Chart – 3 AM – 9 AM – Medium Investment Scenario Day 3 Simulation Results with Perturbations

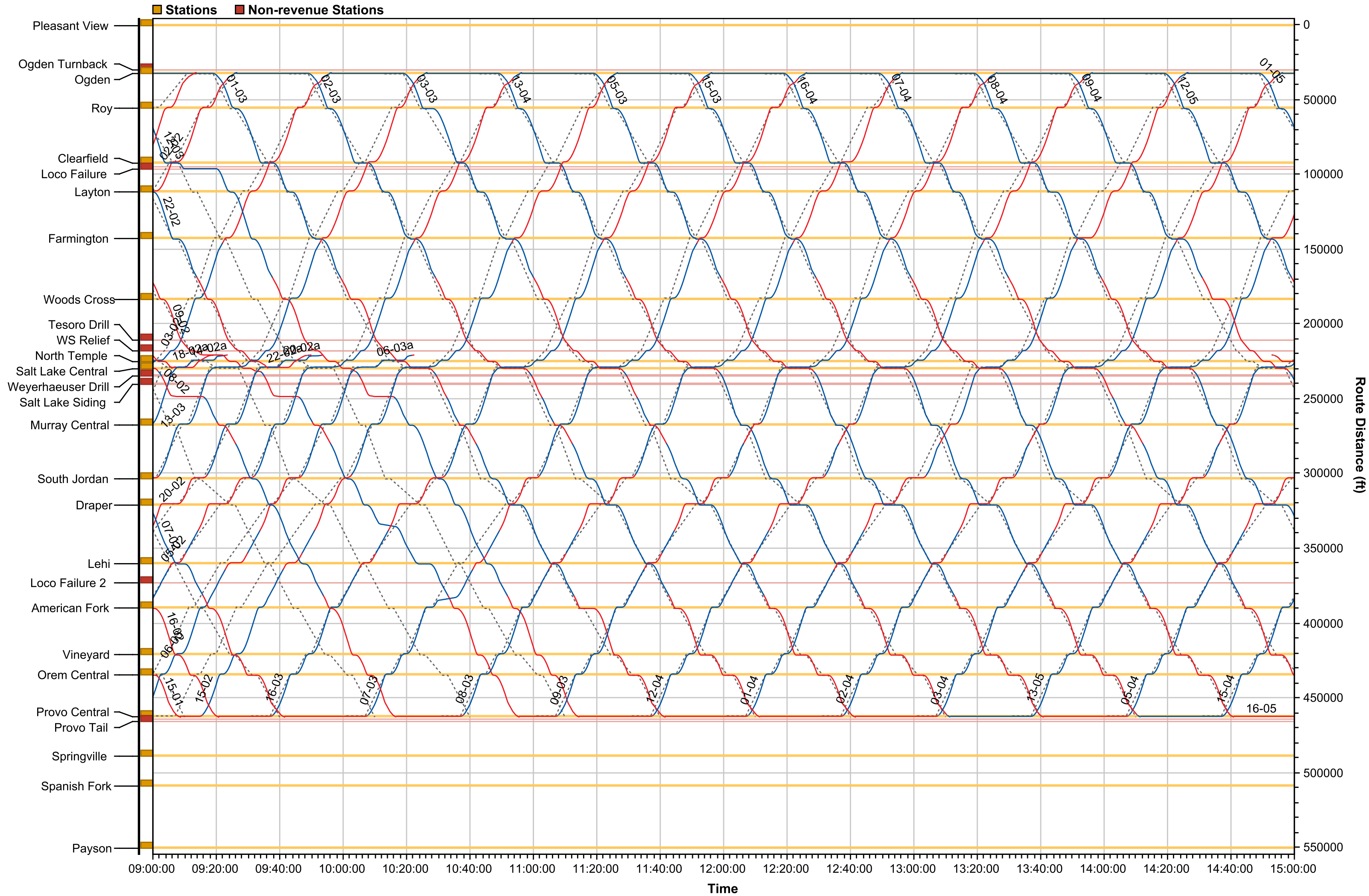


Figure 22-30: Time-Distance ("String") Chart – 9 AM – 3 PM – Medium Investment Scenario Day 3 Simulation Results with Perturbations

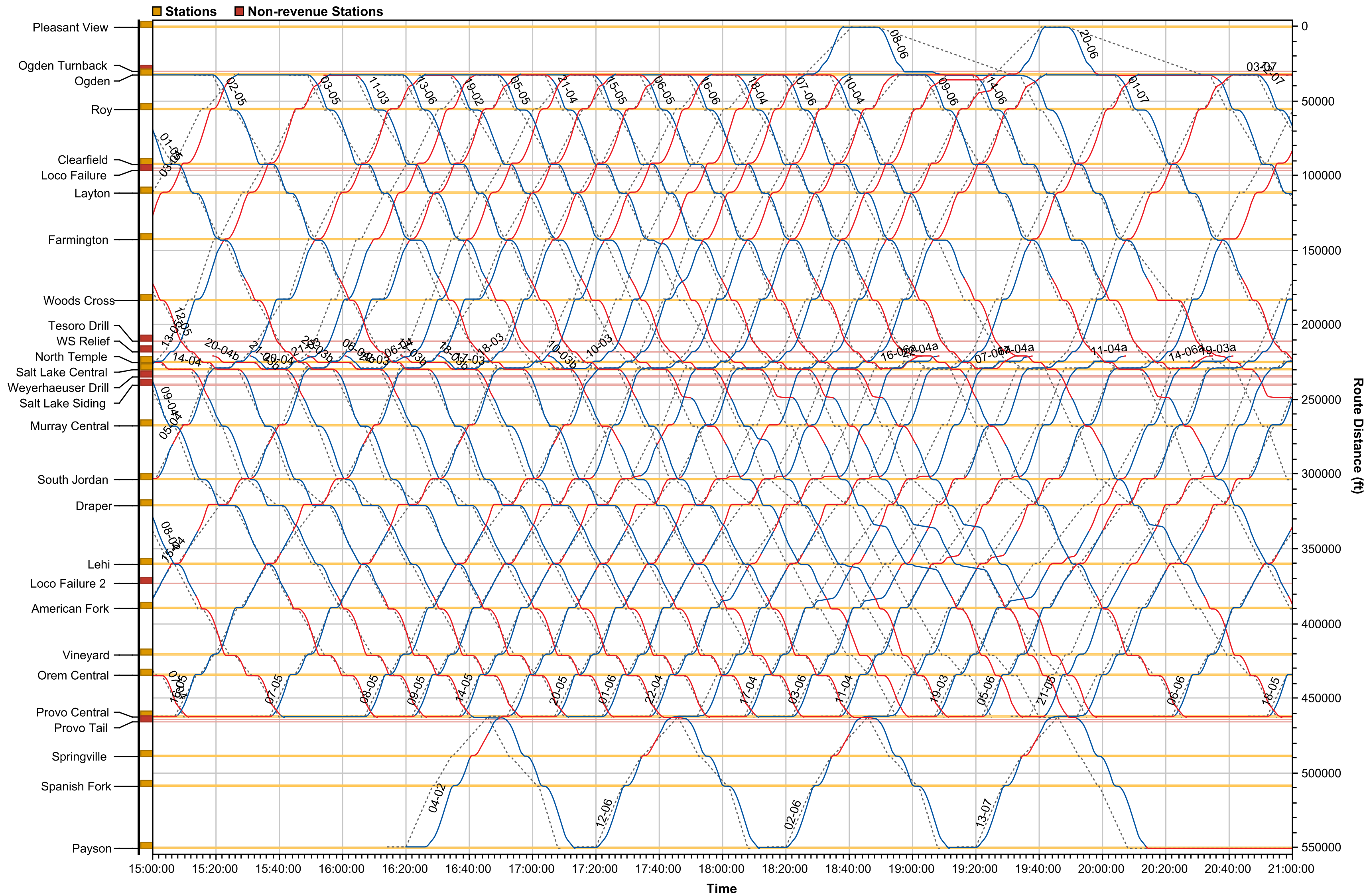


Figure 22-31: Time-Distance ("String") Chart – 3 PM – 9 PM – Medium Investment Scenario Day 3 Simulation Results with Perturbations

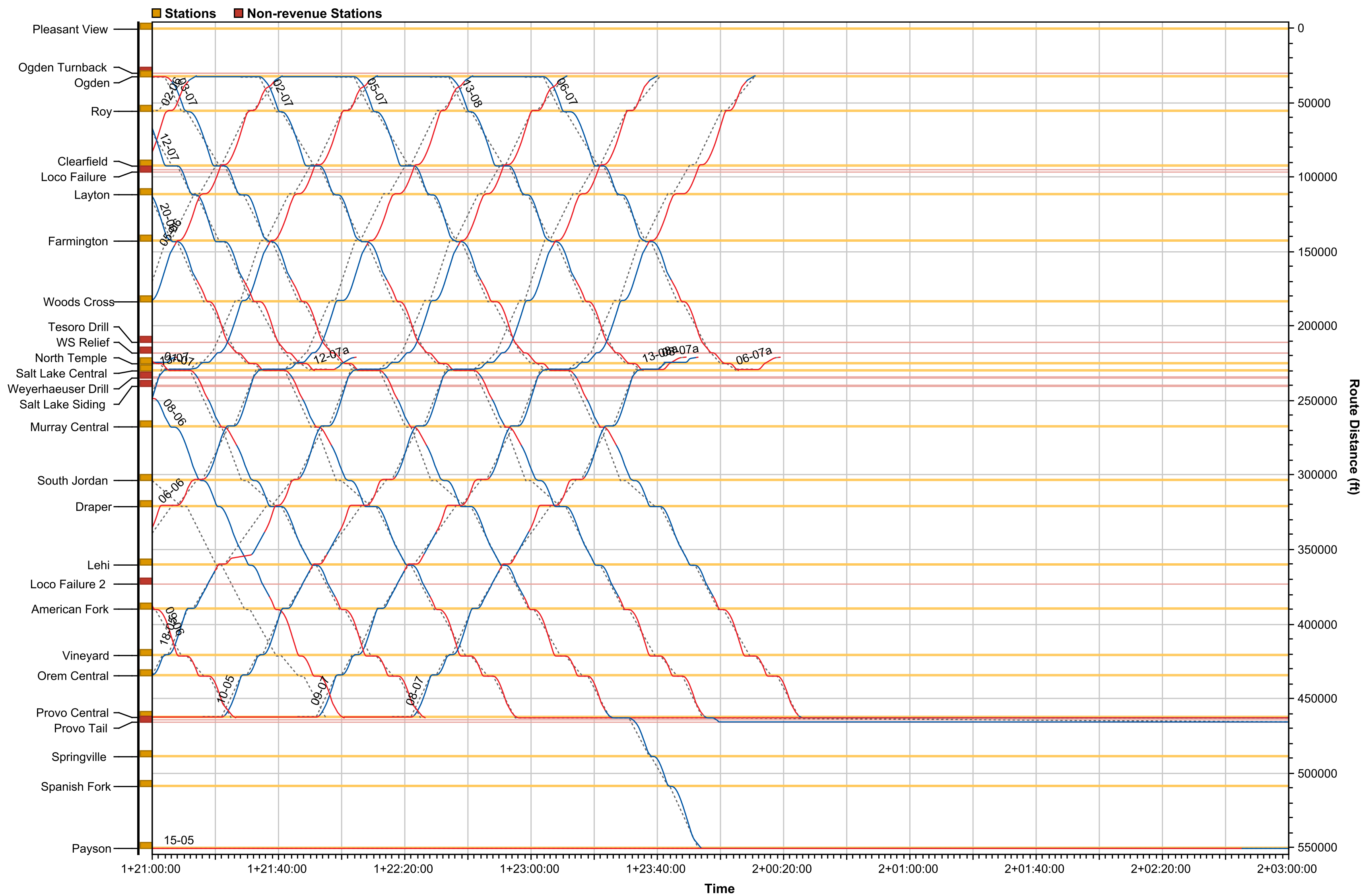


Figure 22-32: Time-Distance (“String”) Chart – 9 PM – 3 AM – Medium Investment Scenario Day 3 Simulation Results with Perturbations

22.5 Day 4 Medium Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 4 operating plan includes a door failure for train 15-02 at Orem Station. This causes an assumed 7-minute extended dwell while the door failure is resolved. Day 4 also includes a 15 MPH speed restriction through 9400 South Grade Crossing (North of South Jordan) from 6:30 AM through 8:30 AM due to a crossing failure/broken gate. Salt Lake Central station occupancy charts and full network string charts are included in the following sections.

22.5.1 Station Occupancy Charts – Salt Lake Central

Most afternoon/evening northbound trains arrive late and depart on time and most southbound trains arrive and depart on time. In both directions, trains are impacted by the service disruptions and cascading delays near the end of the peak periods. Delays are even greater to northbound trains in the morning due to the crossing failure.

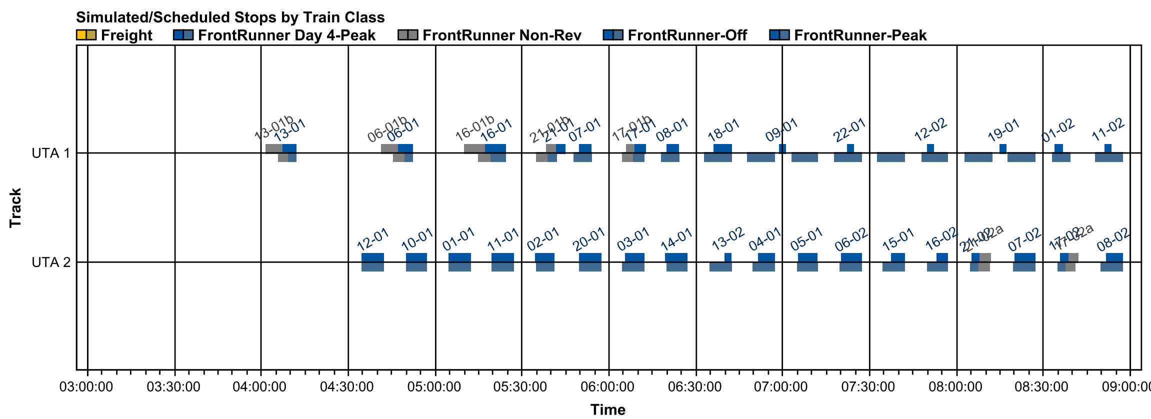


Figure 22-33: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Medium Investment Scenario Day 4 Simulation Results with Perturbations

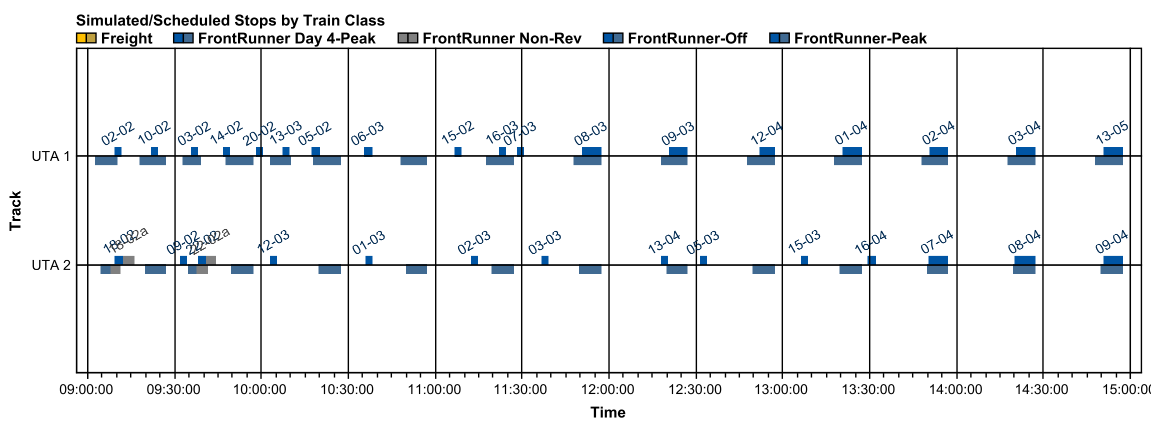


Figure 22-34: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Medium Investment Scenario Day 4 Simulation Results with Perturbations

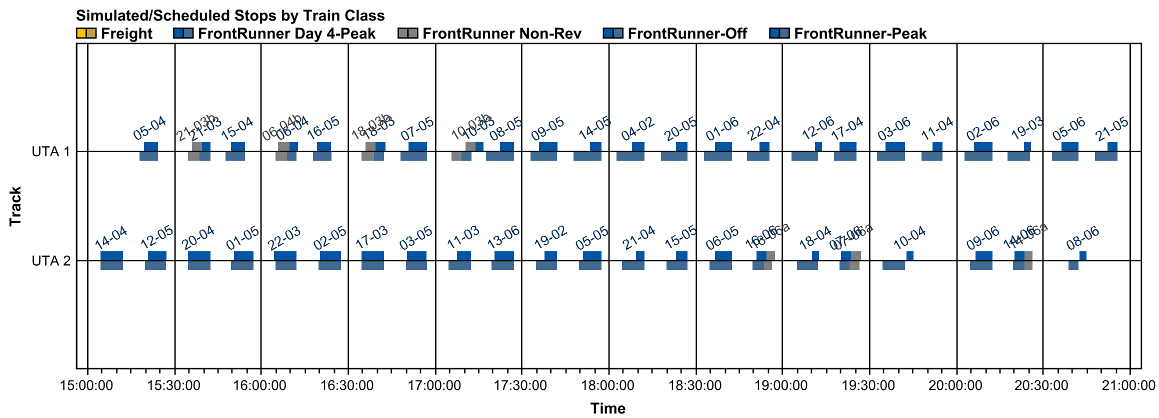


Figure 22-35: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Medium Investment Scenario Day 4 Simulation Results with Perturbations

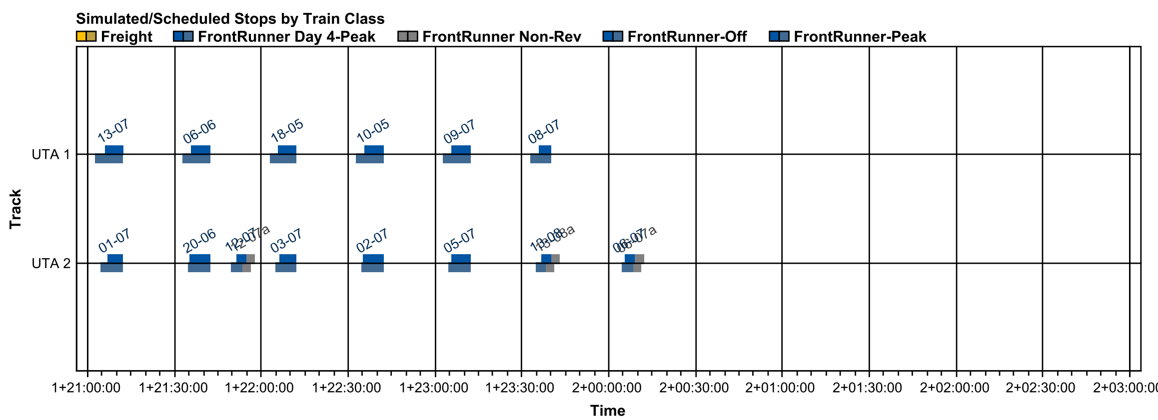


Figure 22-36: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Medium Investment Scenario Day 4 Simulation Results with Perturbations

22.5.2 String Charts

The Day 4 perturbation of a 15 MPH speed restriction through a grade crossing just north of South Jordan is shown in Figure 22-37. This causes severe cascading delays to the trains throughout the morning peak period. The delays are compounded by the frequency of trains, every 15 minutes in each direction, and the crossing failure occurring in a very fragile area of the system with shorter sidings and more single track segments. Service is back to normal by the end of the midday, just before service ramps up for the afternoon peak.

Figure 22-38 shows the door failure for train 15-02 at Orem Station. This assumed 7-minute extended dwell while the door is disabled causes train 15-02, which is already late because of the crossing failure, to run even later and hold up the two following northbound trains. The delay is so severe that its next trip, 15-03, departs Ogden Station late and arrives Provo Station late. Trip 15-04 is able to depart Provo Station northbound on time.

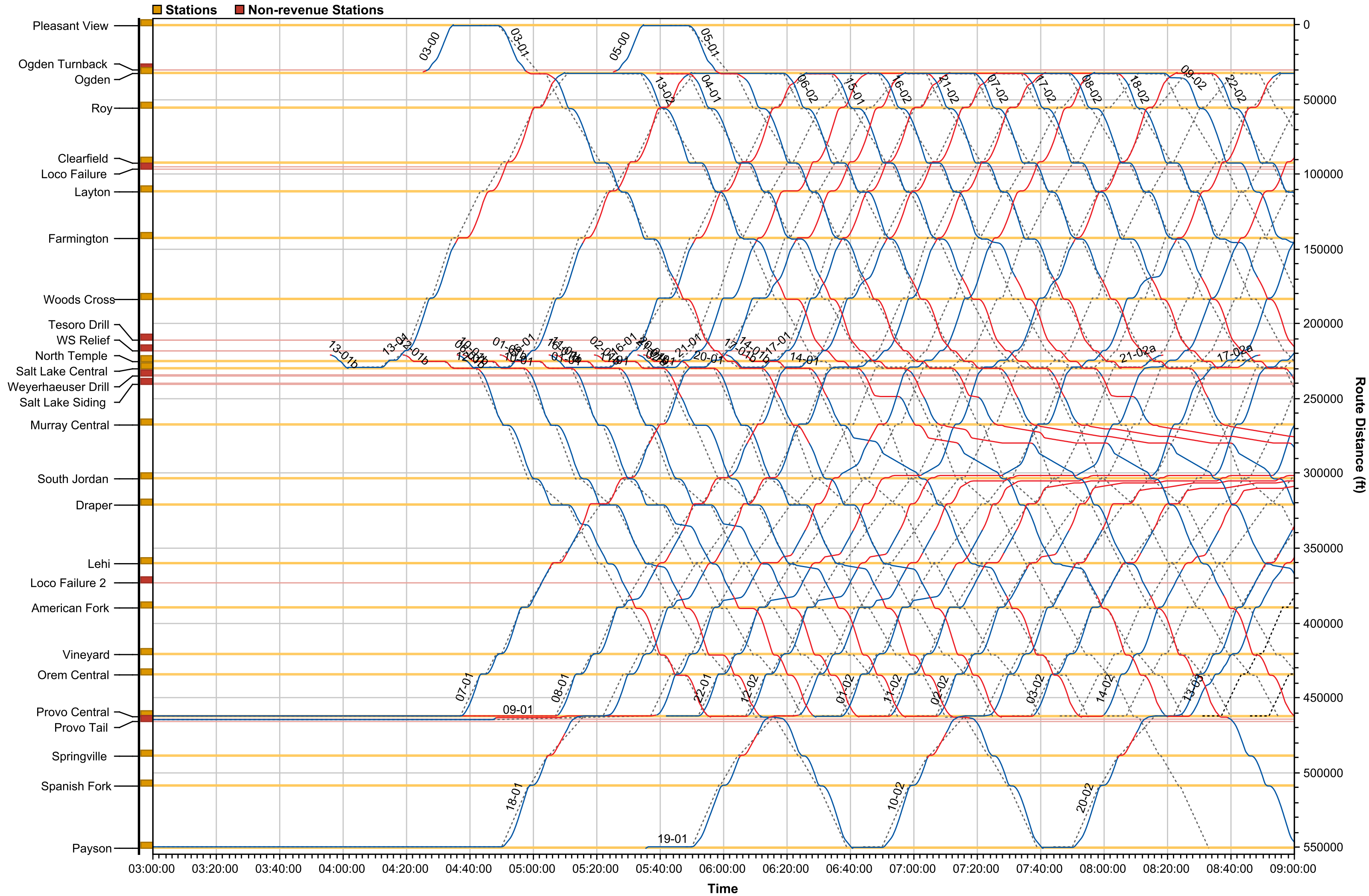


Figure 22-37: Time-Distance ("String") Chart – 3 AM – 9 AM – Medium Investment Scenario Day 4 Simulation Results with Perturbations

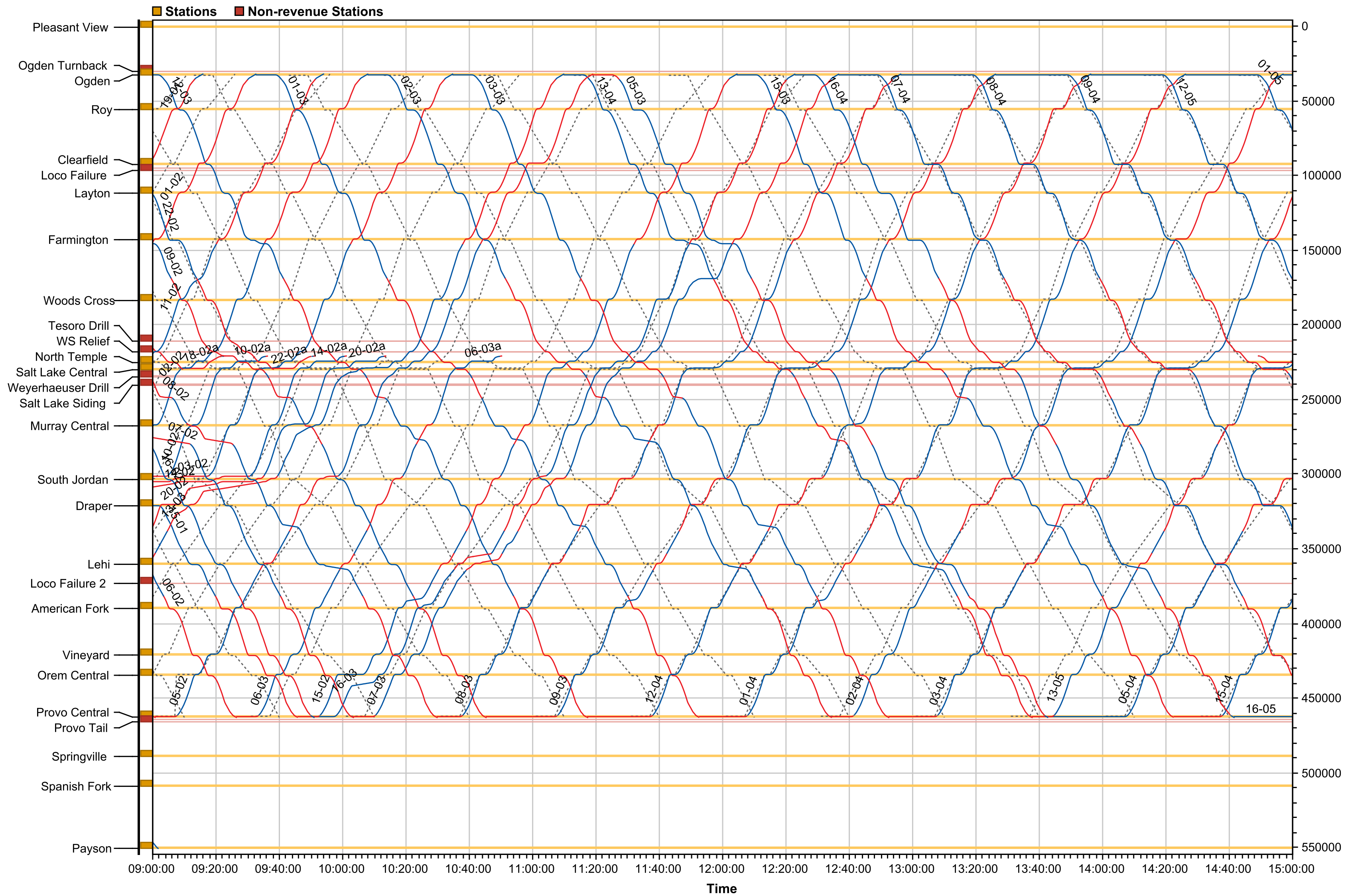


Figure 22-38: Time-Distance ("String") Chart – 9 AM – 3 PM – Medium Investment Scenario Day 4 Simulation Results with Perturbations

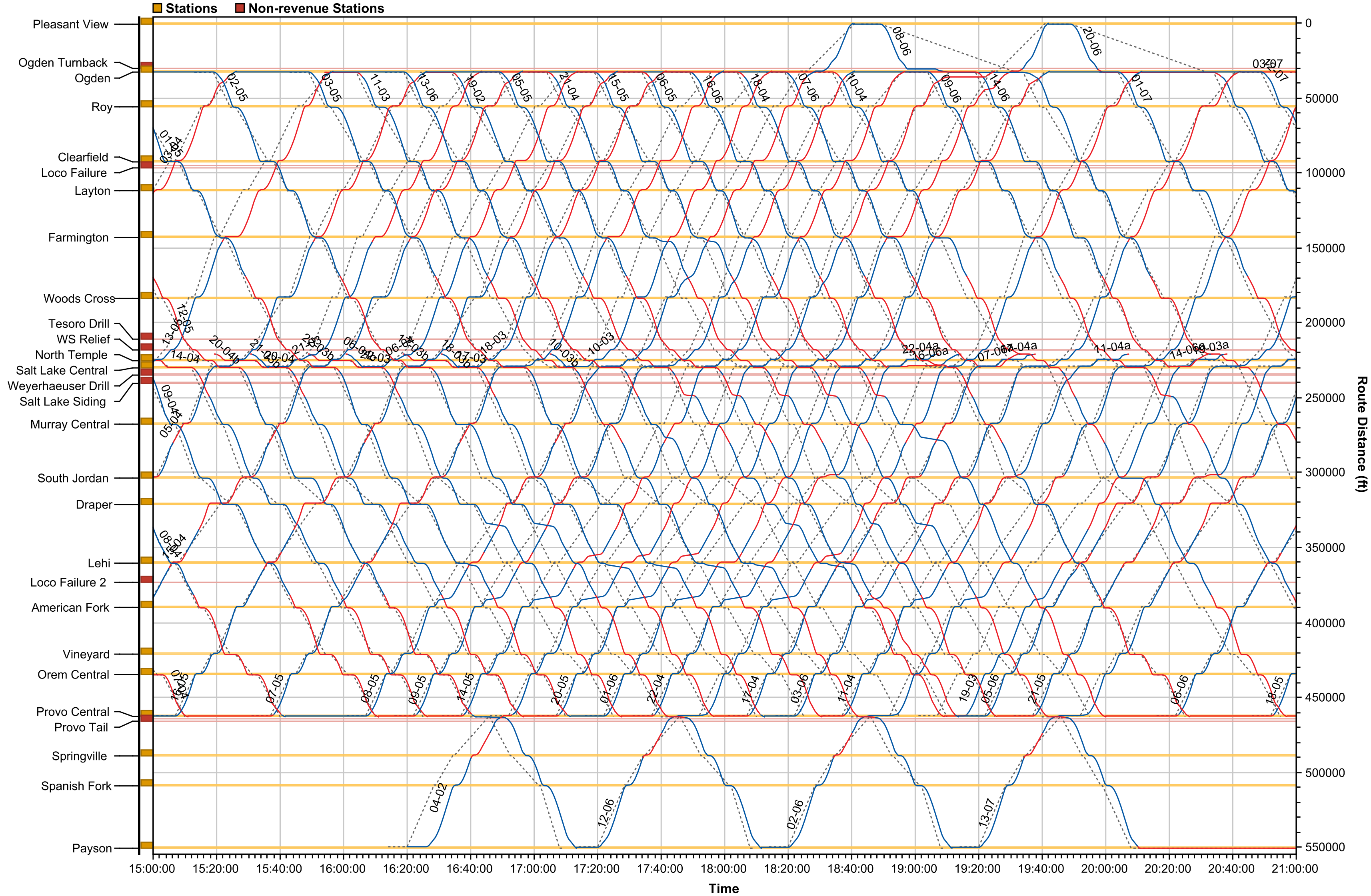


Figure 22-39: Time-Distance ("String") Chart – 3 PM – 9 PM – Medium Investment Scenario Day 4 Simulation Results with Perturbations

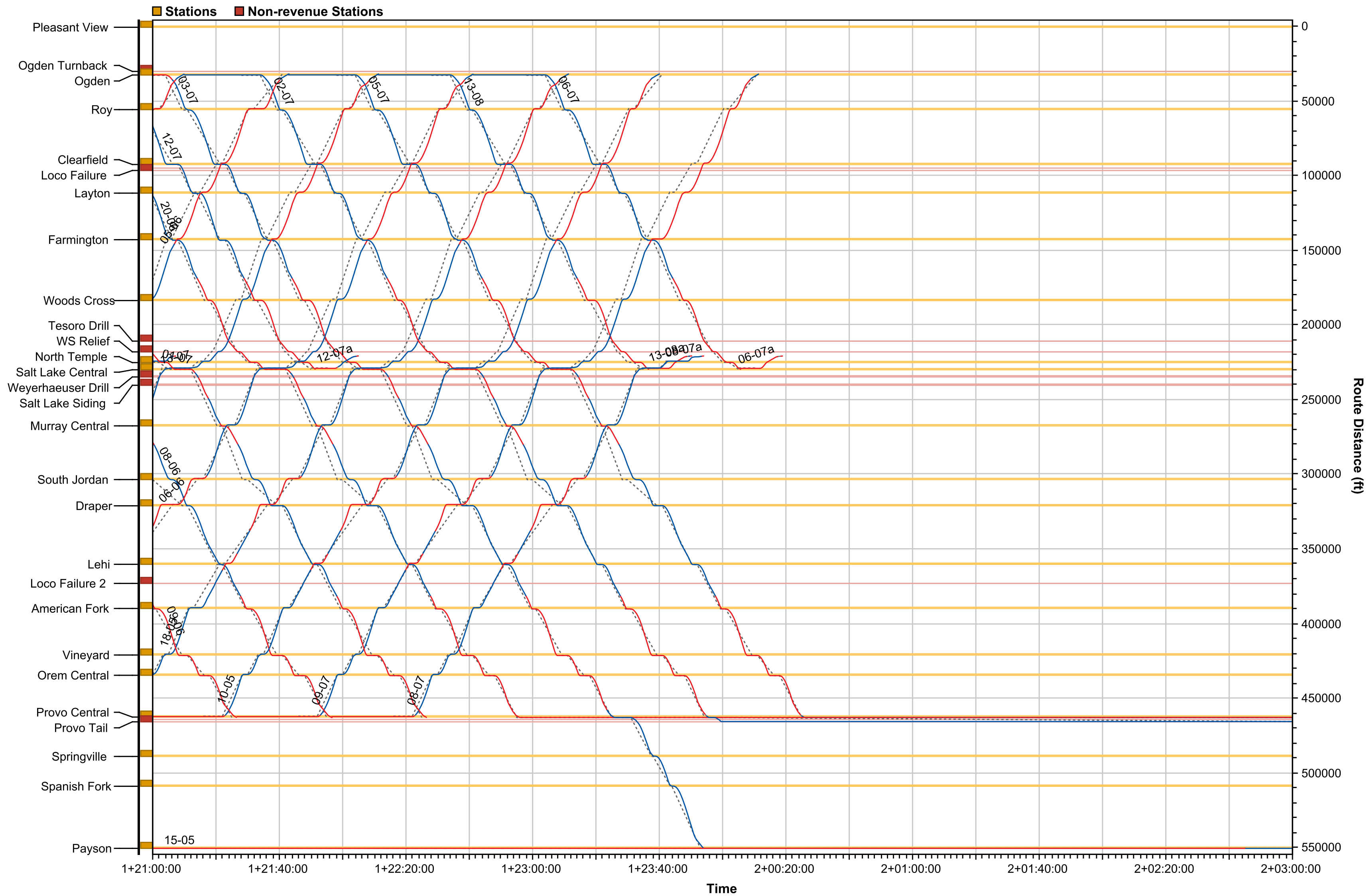


Figure 22-40: Time-Distance (“String”) Chart – 9 PM – 3 AM – Medium Investment Scenario Day 4 Simulation Results with Perturbations

22.6 Day 5 Medium Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 5 operating plan includes a 5-minute delay for train 19-01 at North Temple due to assumed need to hold for a late connecting TRAX train. Day 5 also includes a locomotive failure on train 22-04 between Lehi station and American Fork station causing the train to stop for 10 minutes while the locomotive is reset. Station occupancy charts and string charts are included in the following sections.

22.6.1 Station Occupancy Charts – Salt Lake Central

Most northbound trains arrive late and depart on time and most southbound trains arrive and depart on time. In both directions, trains are impacted by the service disruptions and cascading delays near the end of the peak periods. The northbound trains are nearly 15 minutes late by the end of the afternoon peak as a result of the cascading delays compounded by the locomotive failure.

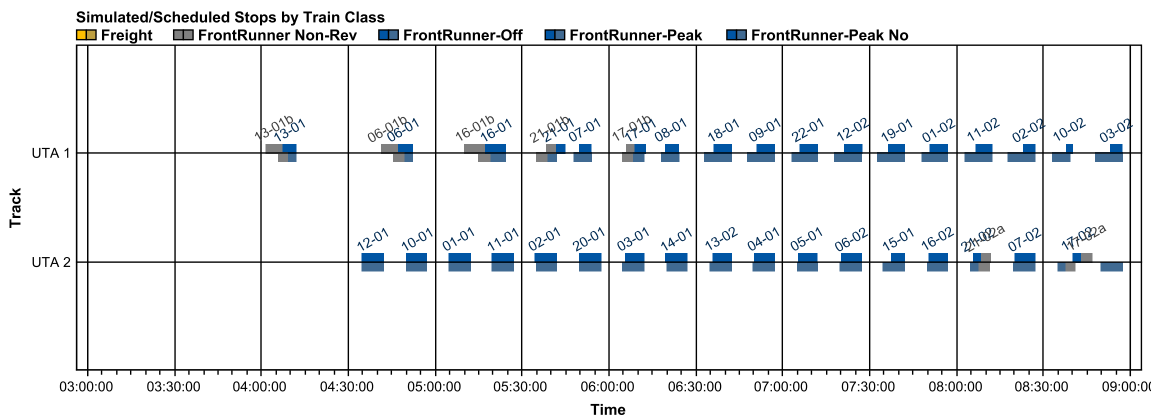


Figure 22-41: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – Medium Investment Scenario Day 5 Simulation Results with Perturbations

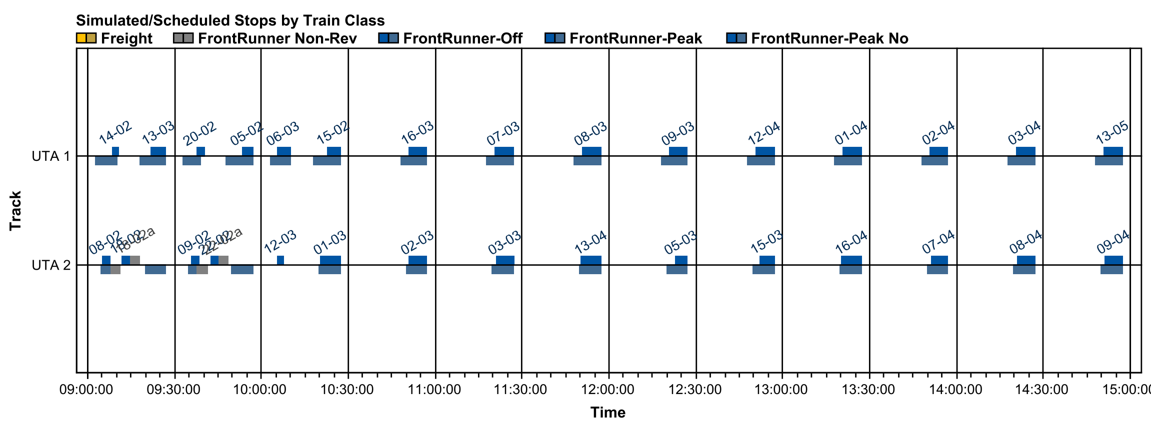


Figure 22-42: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – Medium Investment Scenario Day 5 Simulation Results with Perturbations

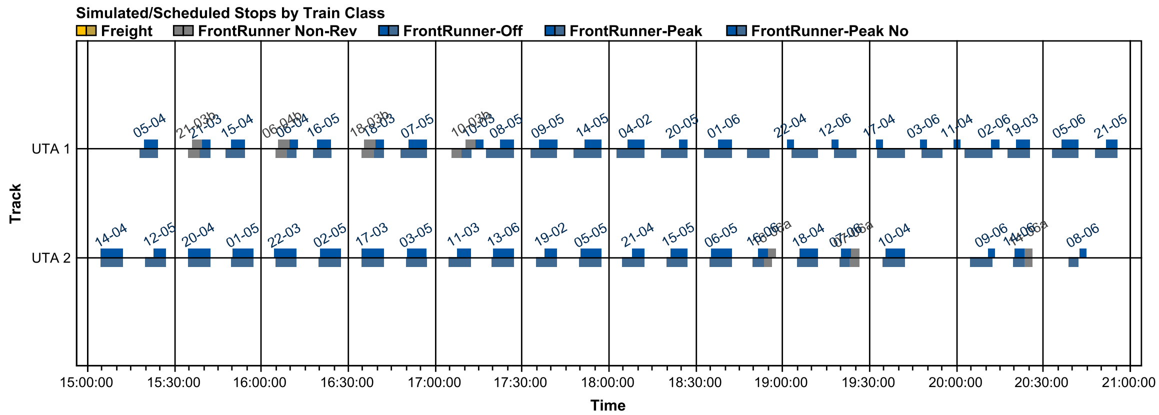


Figure 22-43: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – Medium Investment Scenario Day 5 Simulation Results with Perturbations

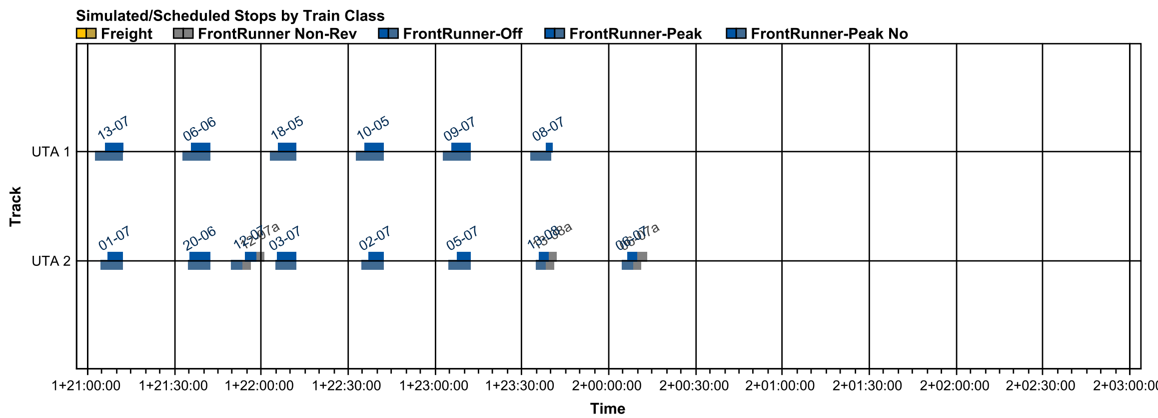


Figure 22-44: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – Medium Investment Scenario Day 5 Simulation Results with Perturbations

22.6.2 String Charts

Figure 22-45 shows that train 19-01 has been randomly assigned the 5-minute delay perturbation at North Temple station. With the extended Woods Cross-Centerville Siding, the train minimizes delays to southbound trains and makes up most of the time by Ogden Station.

Under the Day 5 perturbations, train 22-04 is randomly assigned a locomotive failure and stops for 10 minutes between Lehi station and American Fork station as shown in Figure 22-47. This causes more delays to the trains that are already getting off schedule from the cascading delays and trains are not back to normal until well after the afternoon peak, about 9:00 PM.

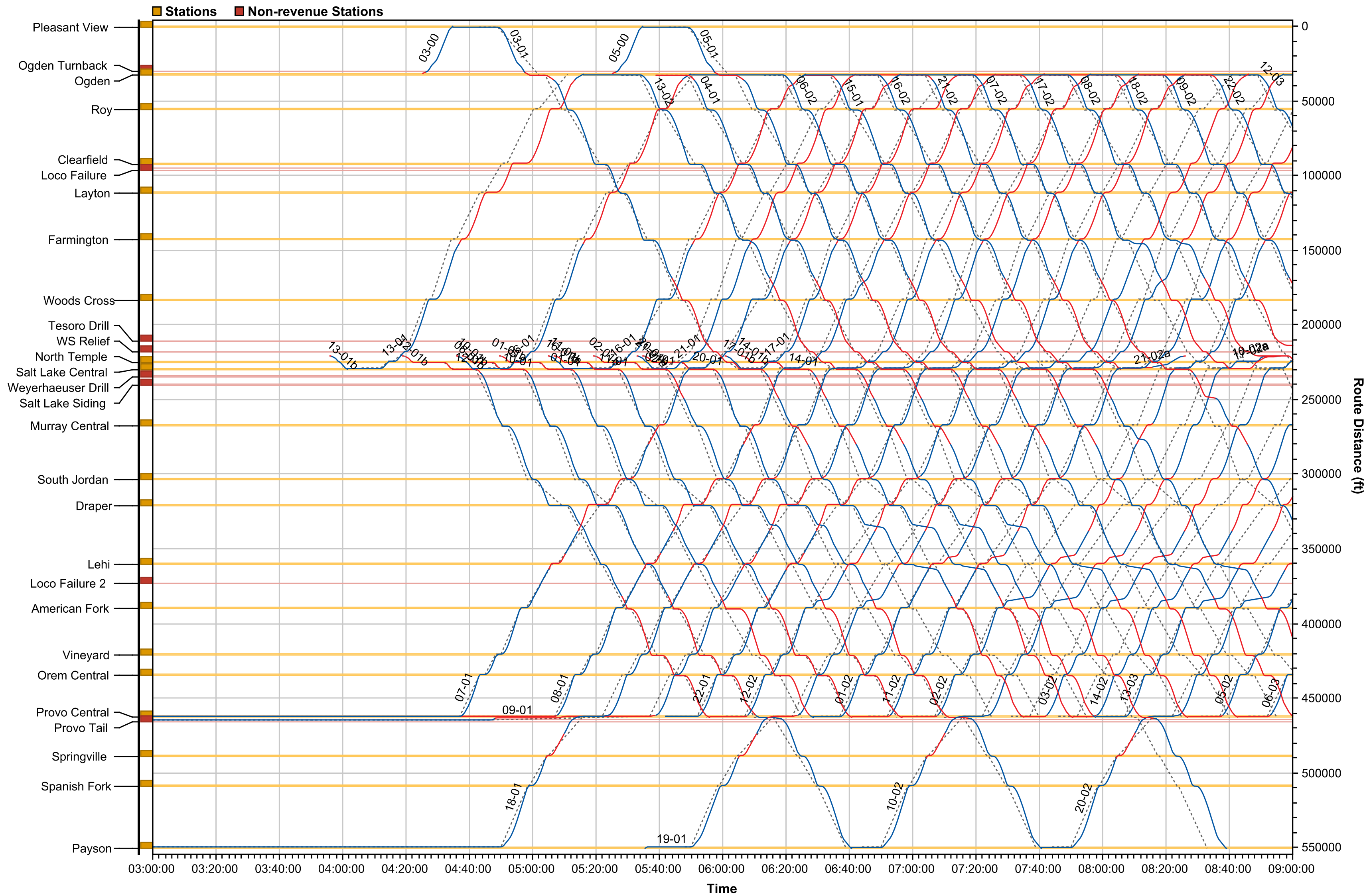


Figure 22-45: Time-Distance (“String”) Chart – 3 AM – 9 AM – Medium Investment Scenario Day 5 Simulation Results with Perturbations

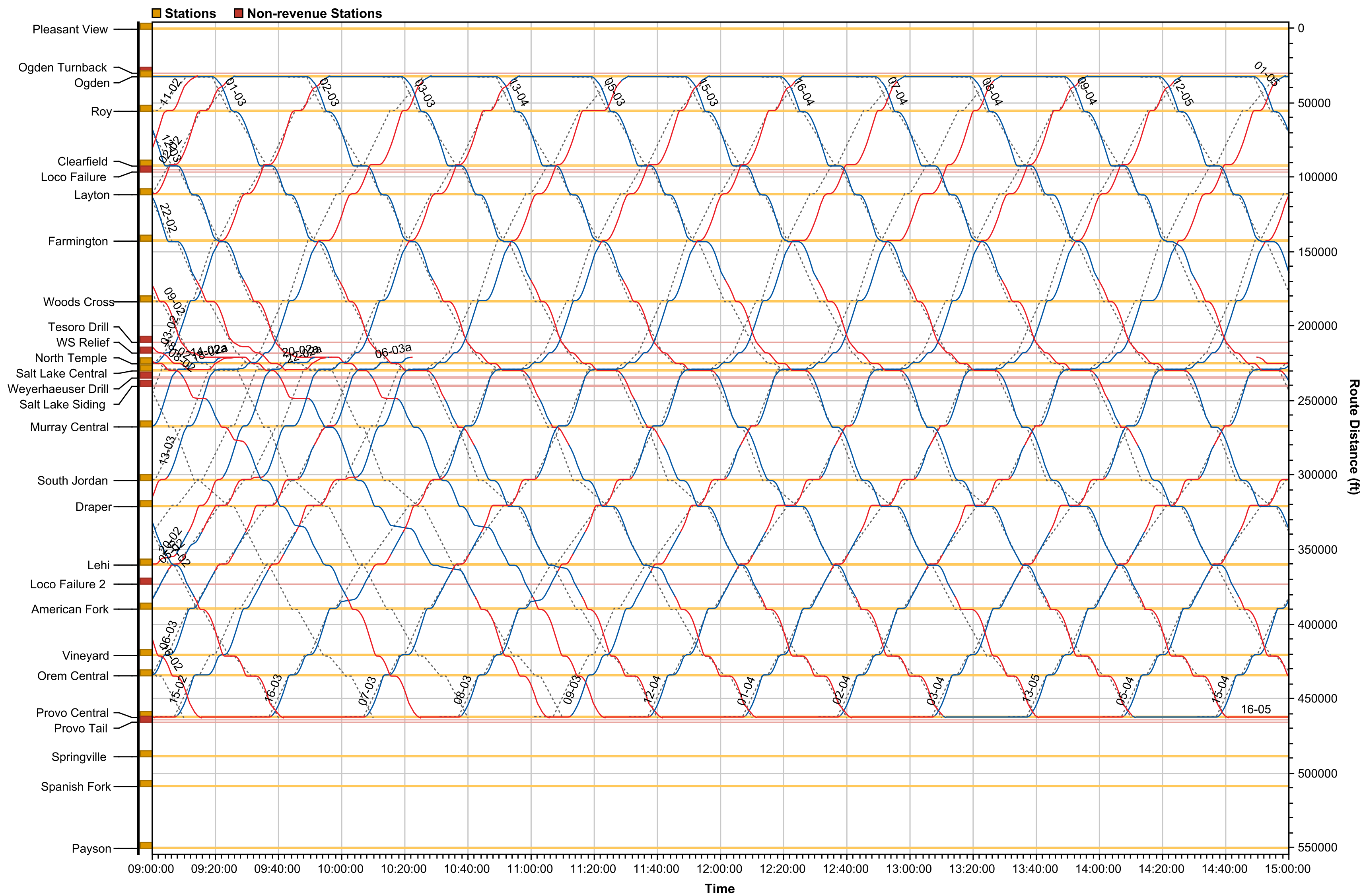


Figure 22-46: Time-Distance ("String") Chart – 9 AM – 3 PM – Medium Investment Scenario Day 5 Simulation Results with Perturbations

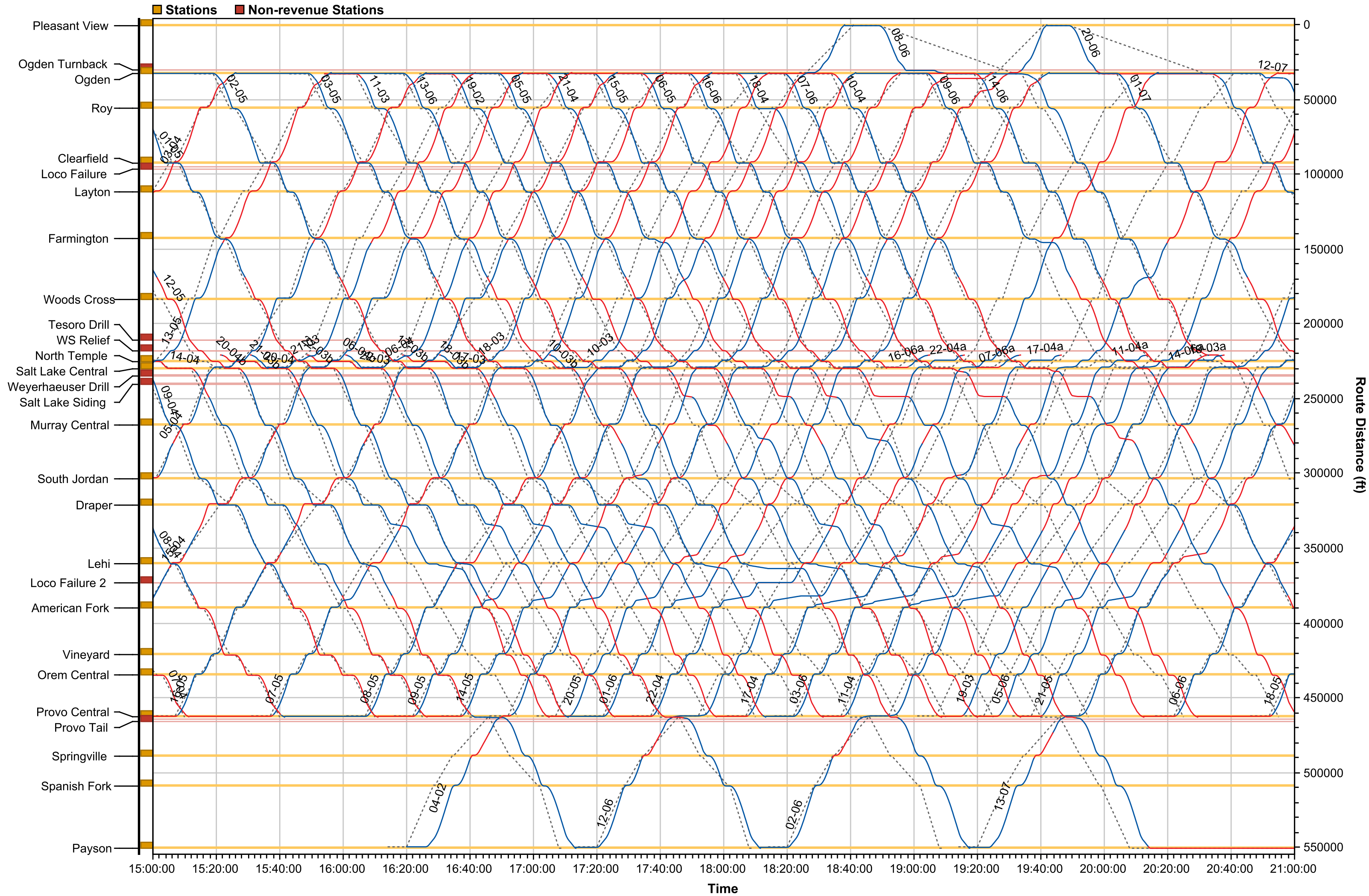


Figure 22-47: Time-Distance ("String") Chart – 3 PM – 9 PM – Medium Investment Scenario Day 5 Simulation Results with Perturbations

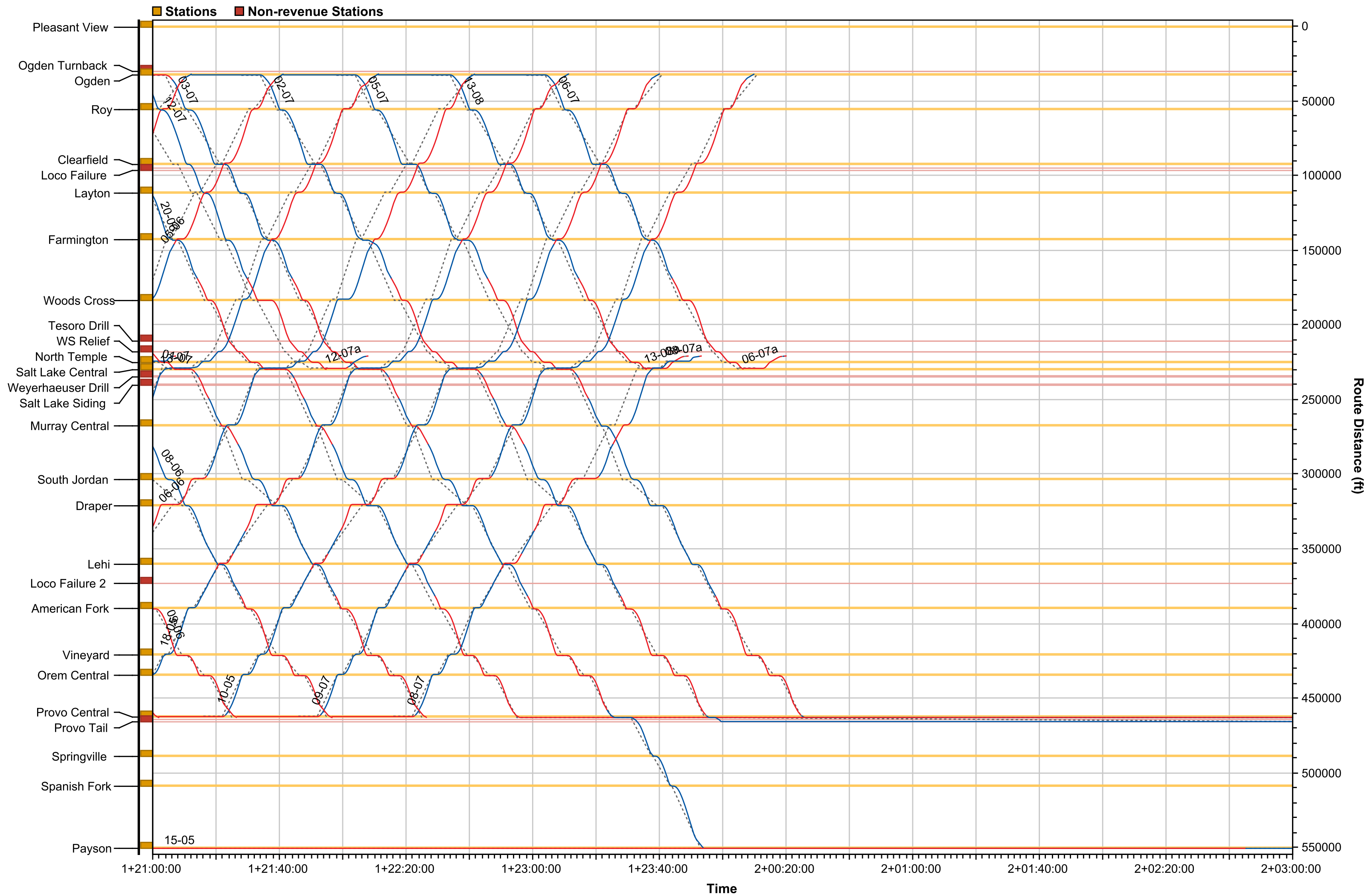


Figure 22-48: Time-Distance (“String”) Chart – 9 PM – 3 AM – Medium Investment Scenario Day 5 Simulation Results with Perturbations

23 Appendix H High Investment Scenario Time-Distance (“String”) Charts and Station Occupancy Charts

23.1 High Investment Scenario Simulation Results without Perturbations (Ideal Day)

23.1.1 Station Occupancy Charts – Salt Lake Central

Northbound trains are shown on UTA1 with southbound trains on UTA2. Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. In both directions, trains stay on schedule with the help of the long dwells at Salt Lake Central Station. The EMU consists also help keep trains on schedule through this station with the ability to accelerate and decelerate faster through interlockings.

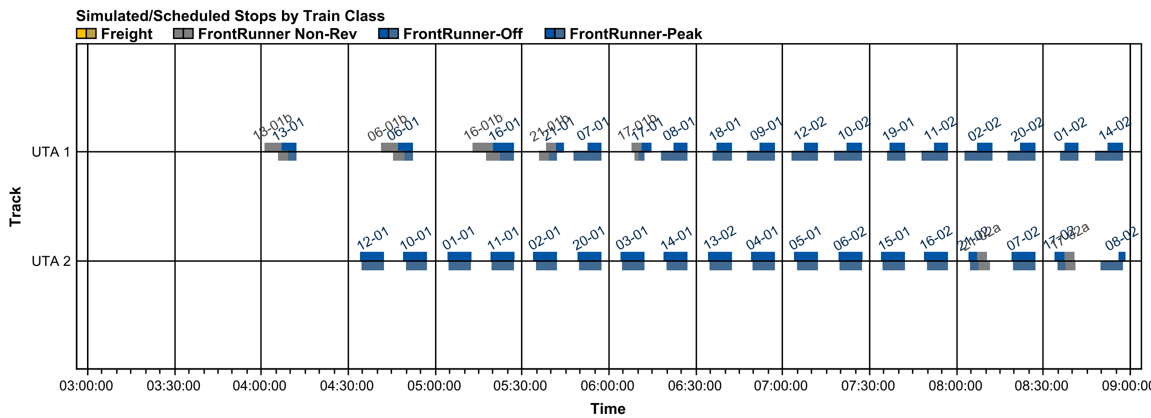


Figure 23-1: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario No Added Perturbations

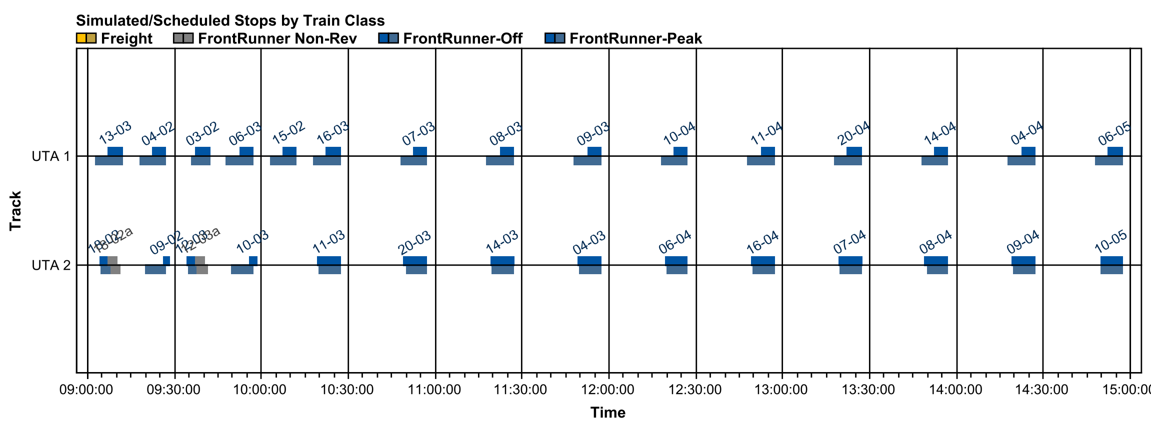


Figure 23-2: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario No Added Perturbations

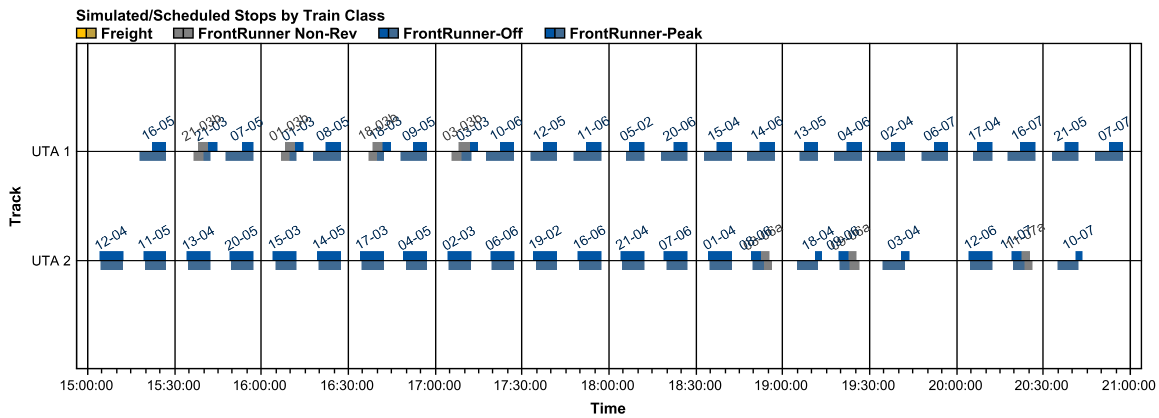


Figure 23-3: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario No Added Perturbations

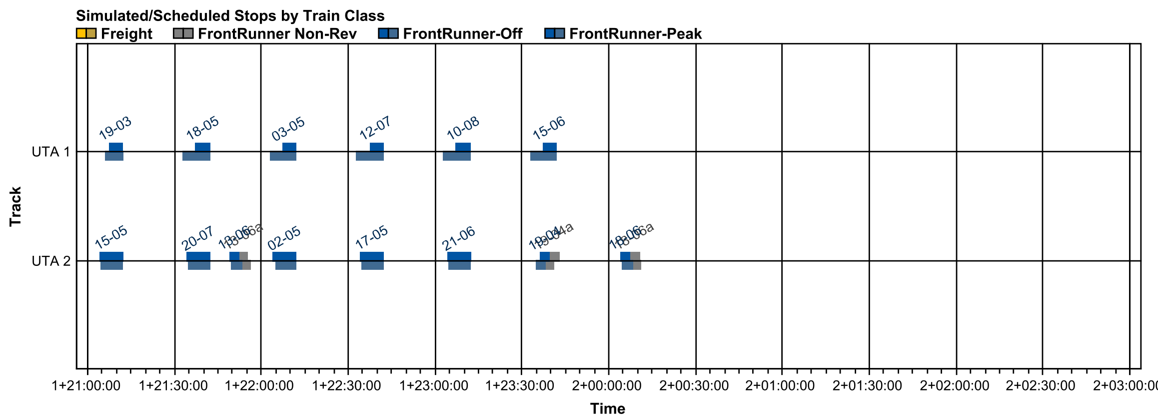


Figure 23-4: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario No Added Perturbations

23.1.2 String Charts

Delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones. The trains run very close to on-time in the No Added Perturbations run. Even with shorter double track sections, there are no cascading delays, unlike the Medium Investment Scenario. This is due to the faster acceleration and deceleration, and the ability to stay at a higher speed longer, with the EMU consists.

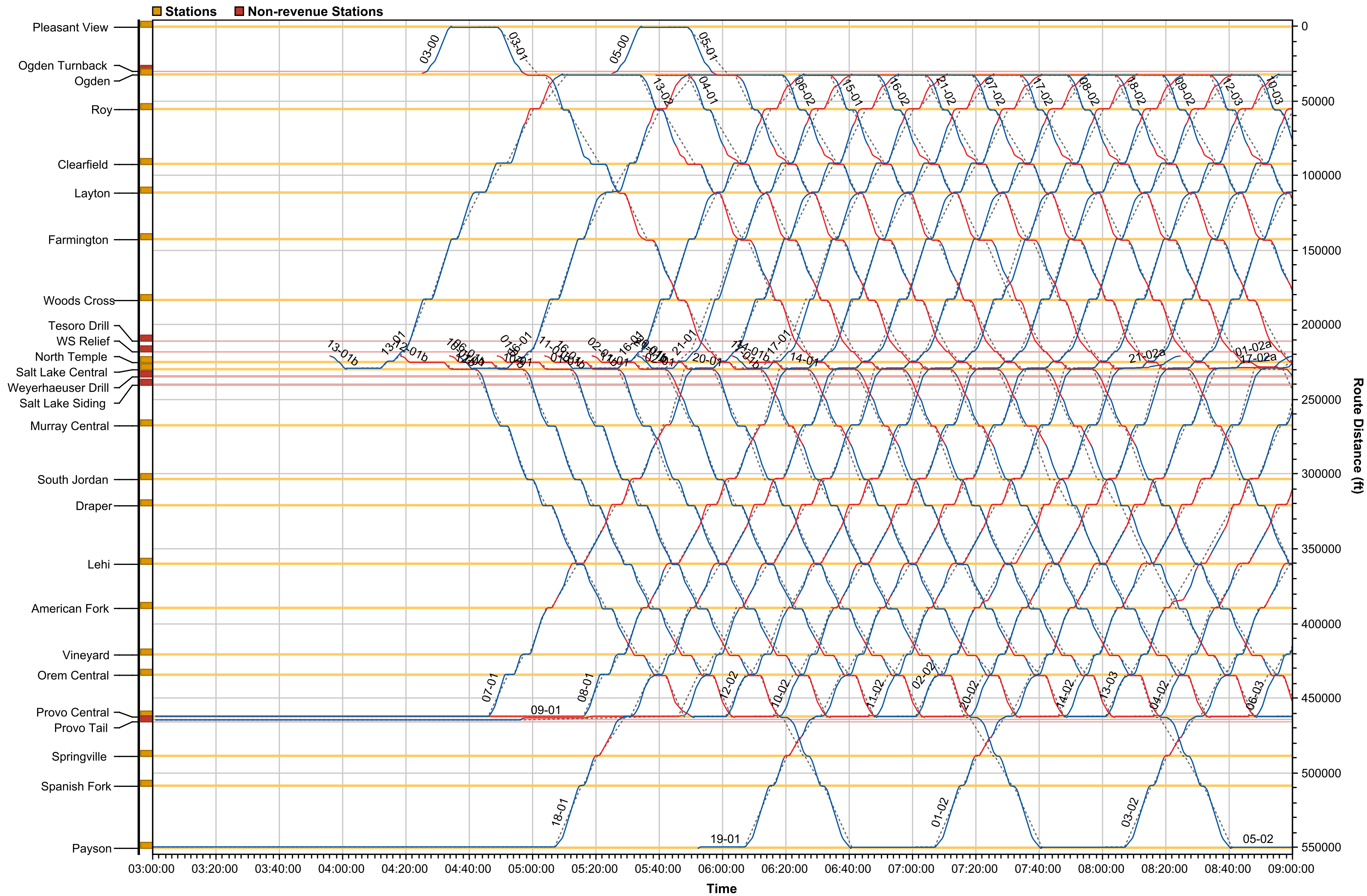


Figure 23-5: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario No Added Perturbations

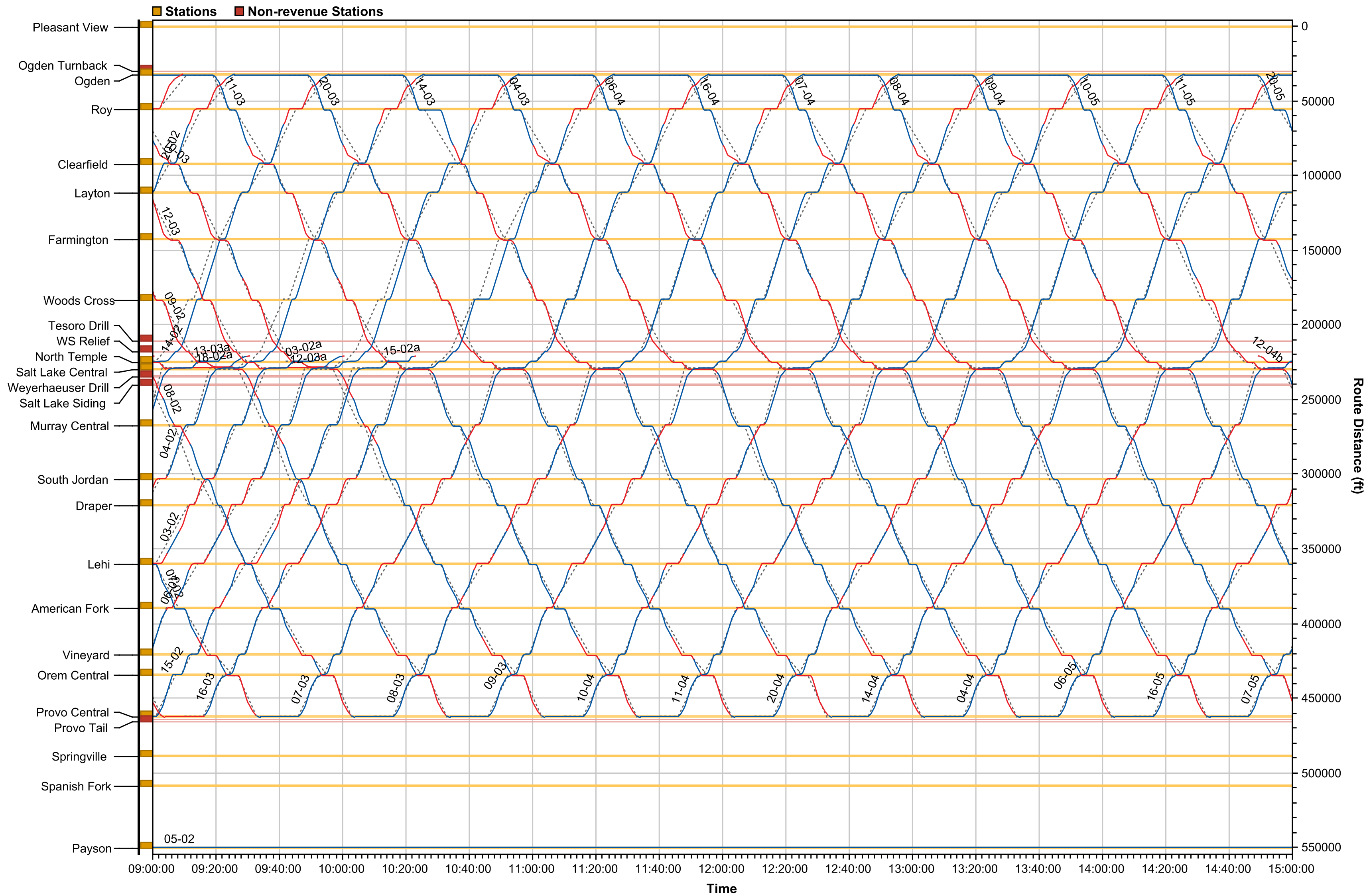


Figure 23-6: Time-Distance ("String") Chart – 9 AM – 3 PM – High Investment Scenario No Added Perturbations

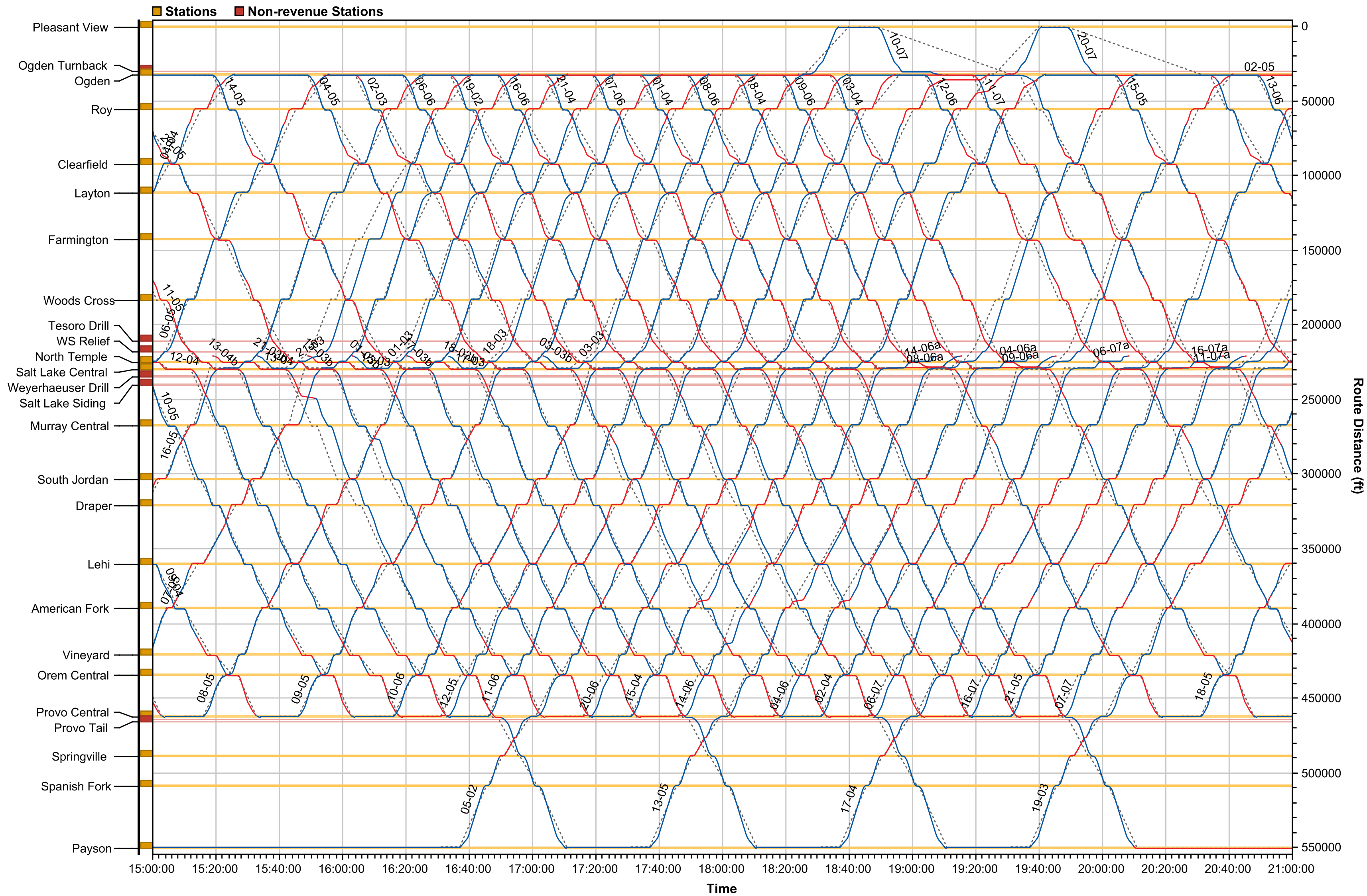


Figure 23-7: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario No Added Perturbations

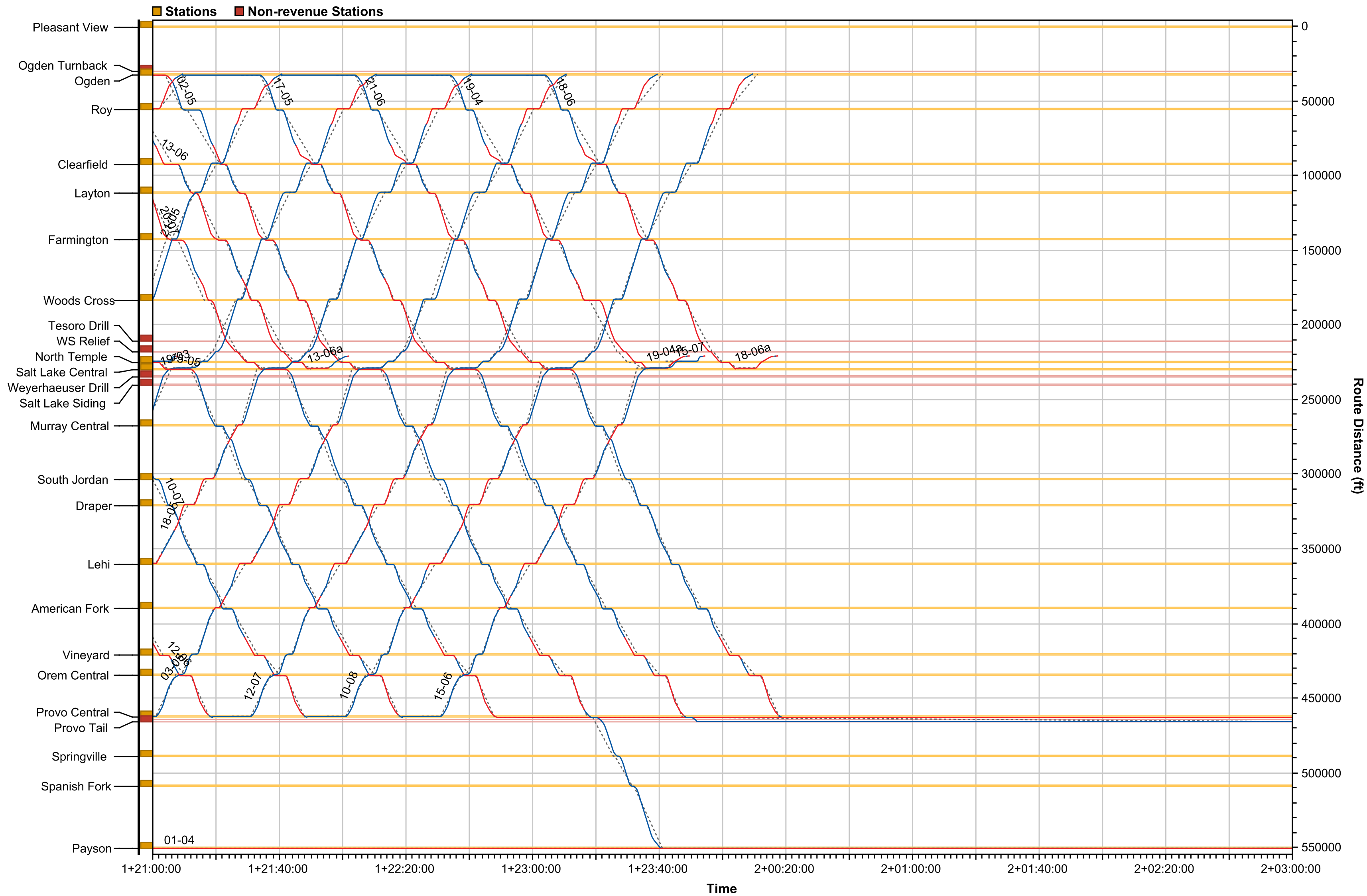


Figure 23-8: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario No Added Perturbations

23.2 Day 1 High Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 1 operating plan includes a randomly-assigned door failure for train 1-04 at South Jordan station. This causes a 7-minute extended dwell. Day 1 also includes a 5-minute delay for train 10-02 at North Temple due to the randomly-assigned need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

23.2.1 Station Occupancy Charts – Salt Lake Central

Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. The end of the afternoon peak period sees some late northbound trains as a result of the door failure on train 1-04.

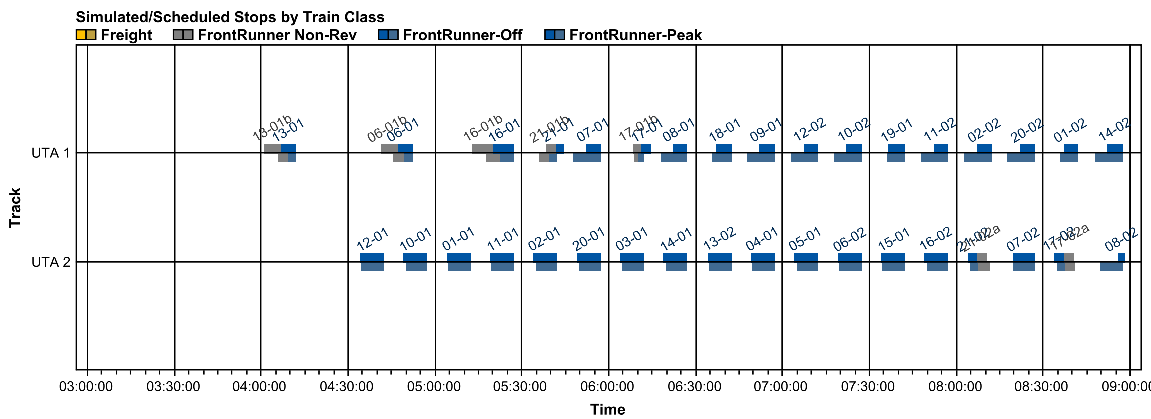


Figure 23-9: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario Day 1 Simulation Results with Perturbations

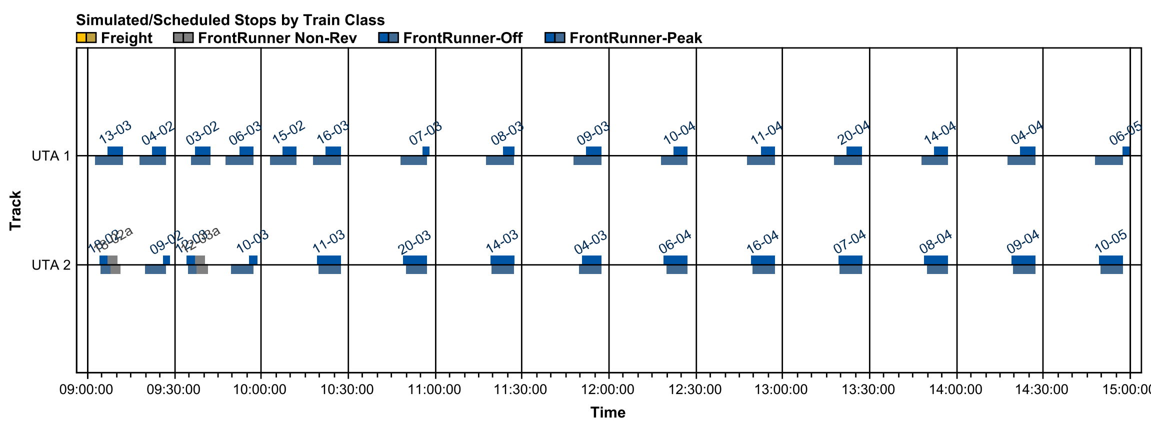


Figure 23-10: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario Day 1 Simulation Results with Perturbations

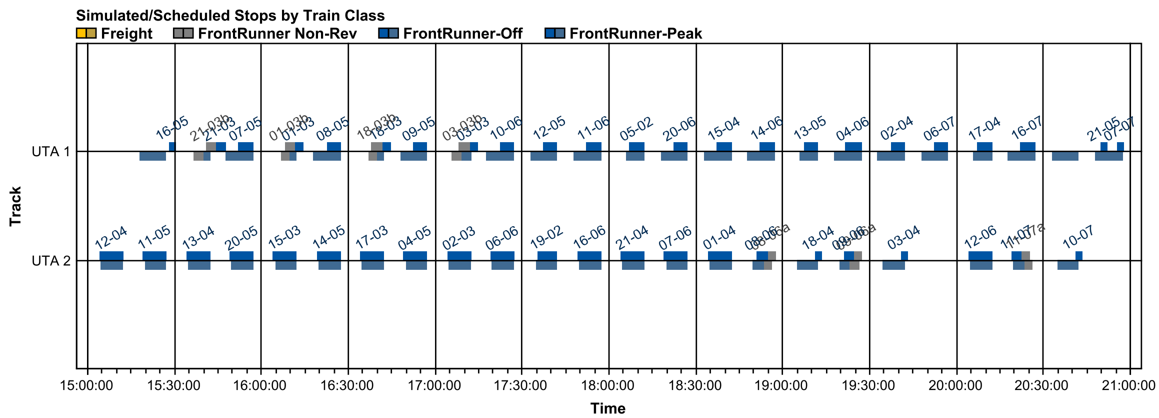


Figure 23-11: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario Day 1 Simulation Results with Perturbations

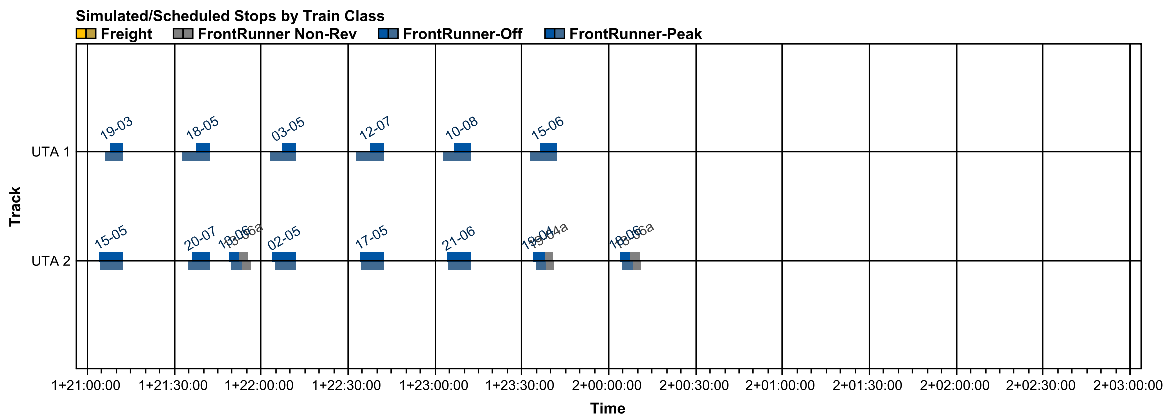


Figure 23-12: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario Day 1 Simulation Results with Perturbations

23.2.2 String Charts

Figure 23-13 shows the randomly-assigned 5-minute delay for train 10-02 at North Temple due to the need to hold for a late TRAX connection. With the help of the extended sidings and faster acceleration and deceleration, train 10-02 is able to get back on time by Clearfield. The additional extended sidings help keep the southbound trains on time.

Figure 23-15 shows the 7-minute extended dwell perturbation to train 1-04. This causes a delay to some northbound trains, especially 21-05, as a result of cascading delays that begin to develop. Southbound train 1-04 is on time at Orem Station and northbound train 21-05 is able to get back on schedule at Roy Station.

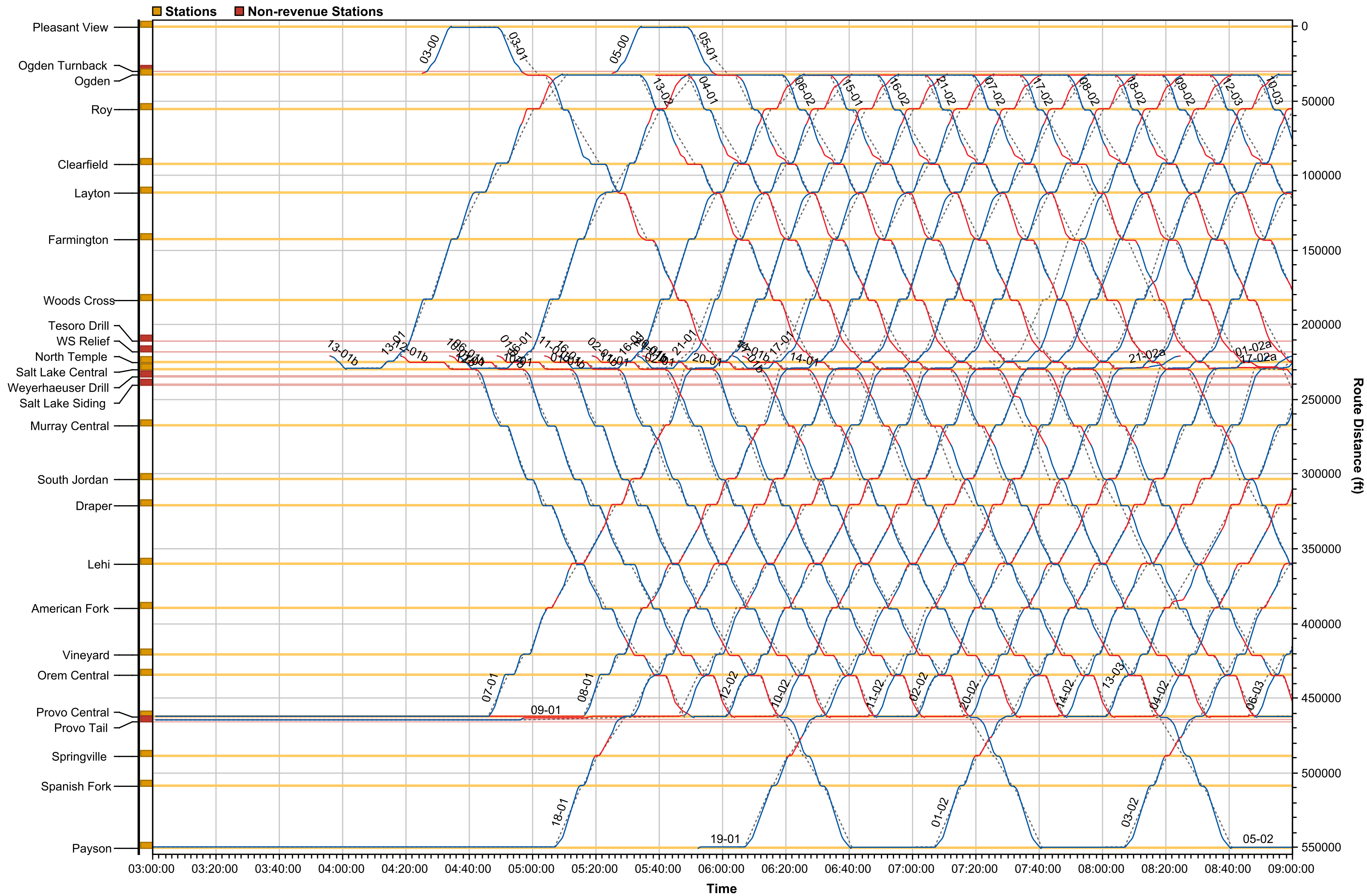


Figure 23-13: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario Day 1 Simulation Results with Perturbations

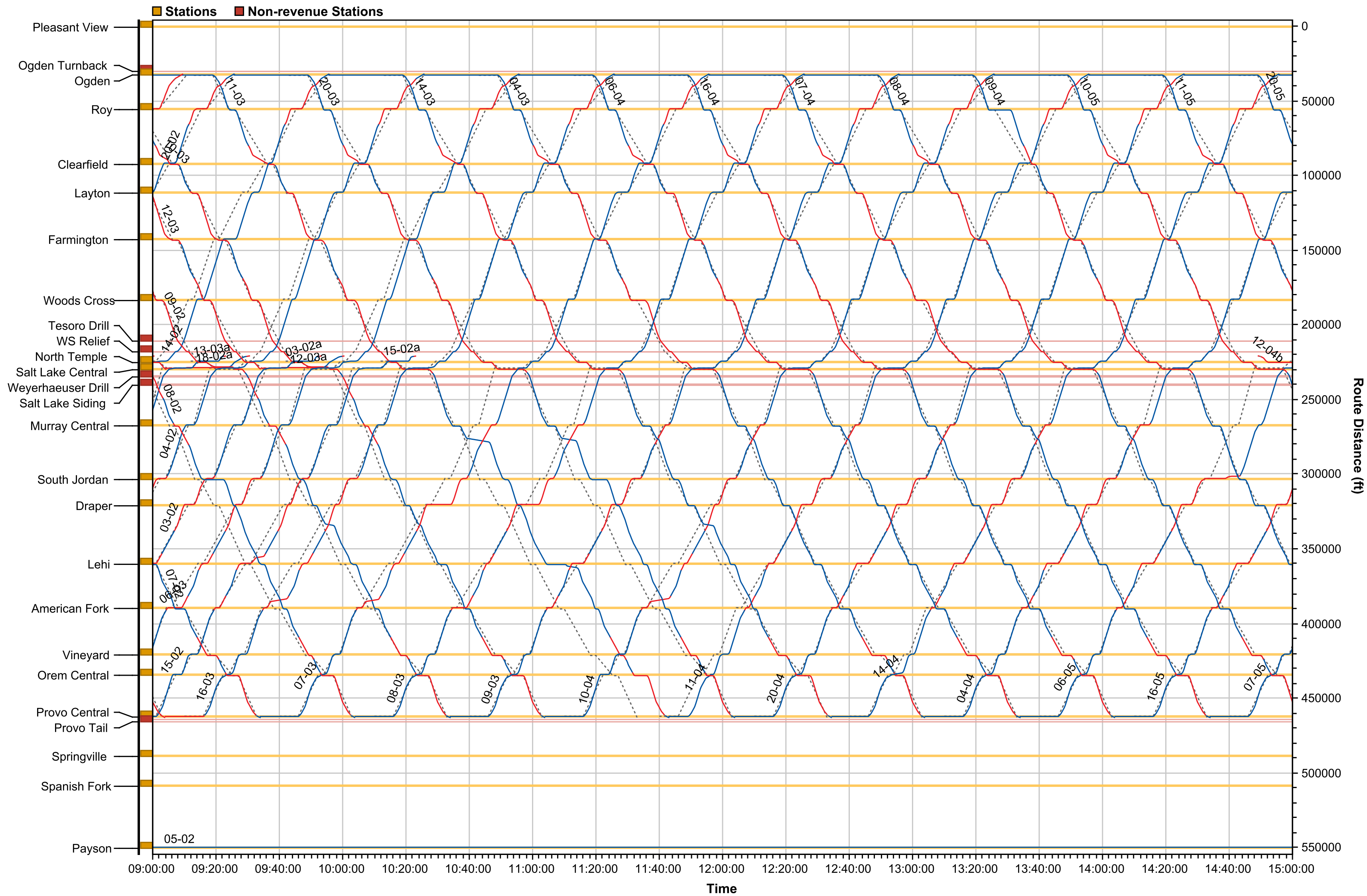


Figure 23-14: Time-Distance ("String") Chart – 9 AM – 3 PM – High Investment Scenario Day 1 Simulation Results with Perturbations

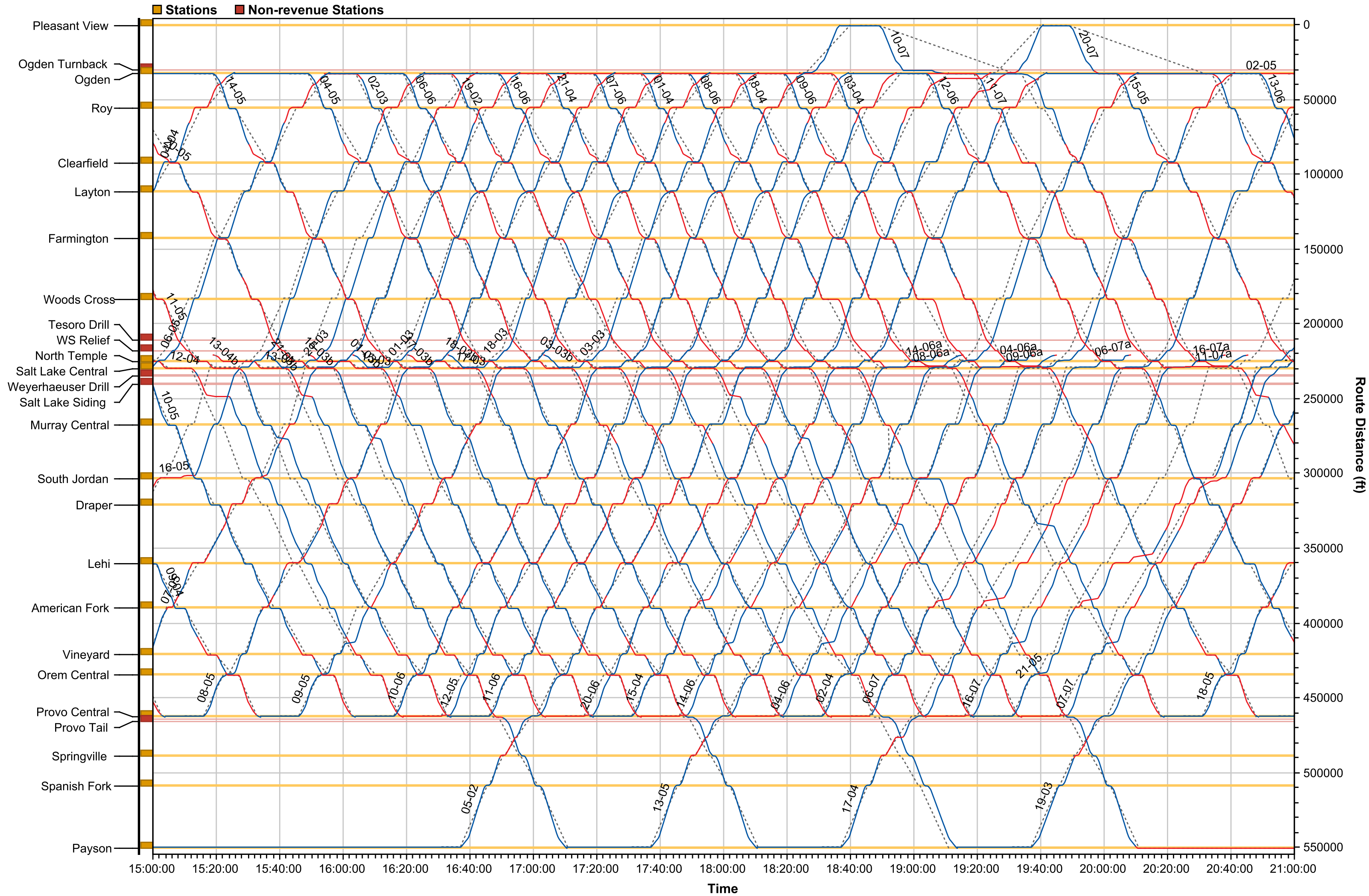


Figure 23-15: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario Day 1 Simulation Results with Perturbations

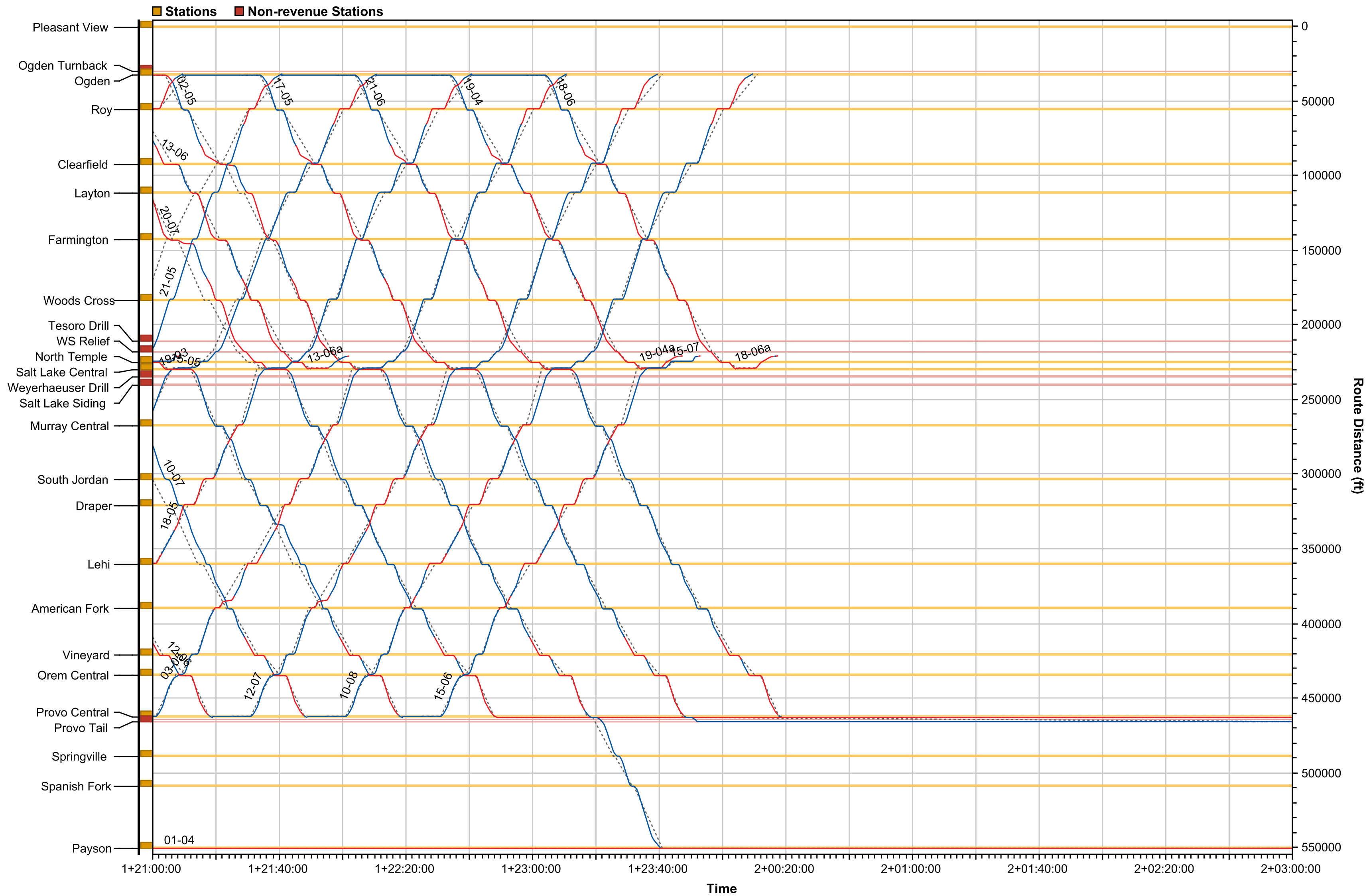


Figure 23-16: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario Day 1 Simulation Results with Perturbations

23.3 Day 2 High Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 2 operating plan perturbations include a 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM due to a crossing failure/broken gate. Day 2 also includes a 5-minute delay for train 20-02 at North Temple due to the need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

23.3.1 Station Occupancy Charts – Salt Lake Central

Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. In both directions, trains stay on schedule with the help of the long dwells at Salt Lake Central Station. Northbound trains arrive and depart late at the end of the afternoon peak period as a result of the crossing failure.

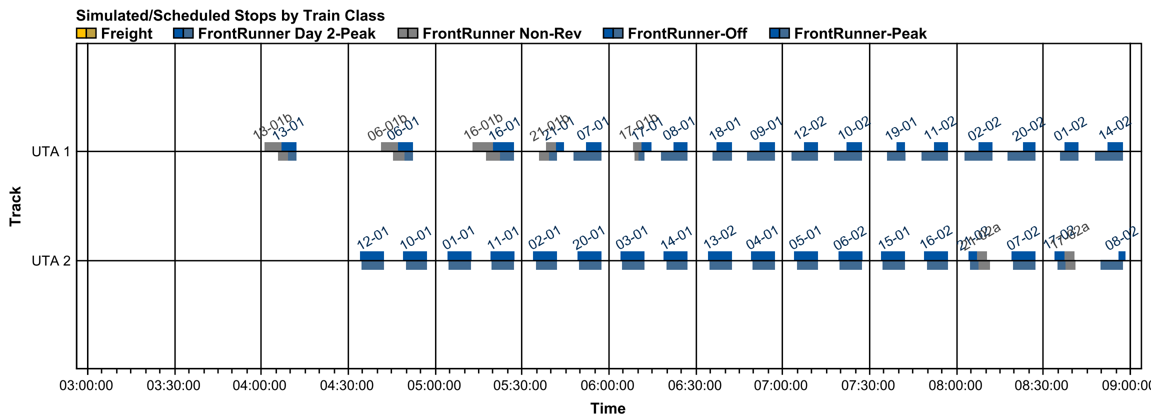


Figure 23-17: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario Day 2 Simulation Results with Perturbations

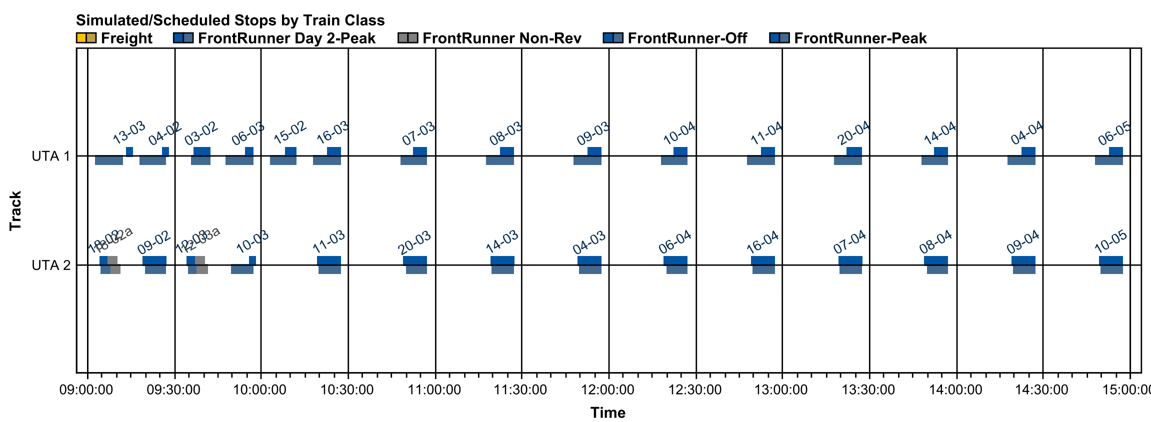


Figure 23-18: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario Day 2 Simulation Results with Perturbations

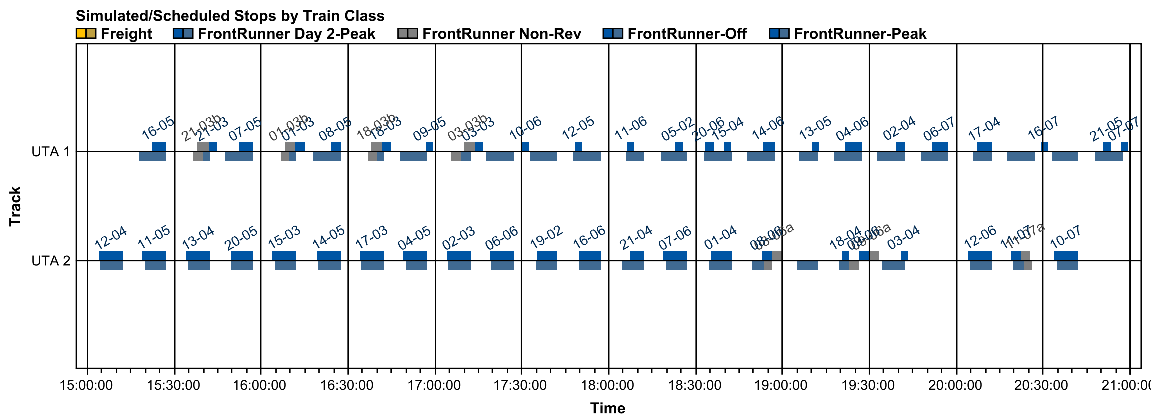


Figure 23-19: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario Day 2 Simulation Results with Perturbations

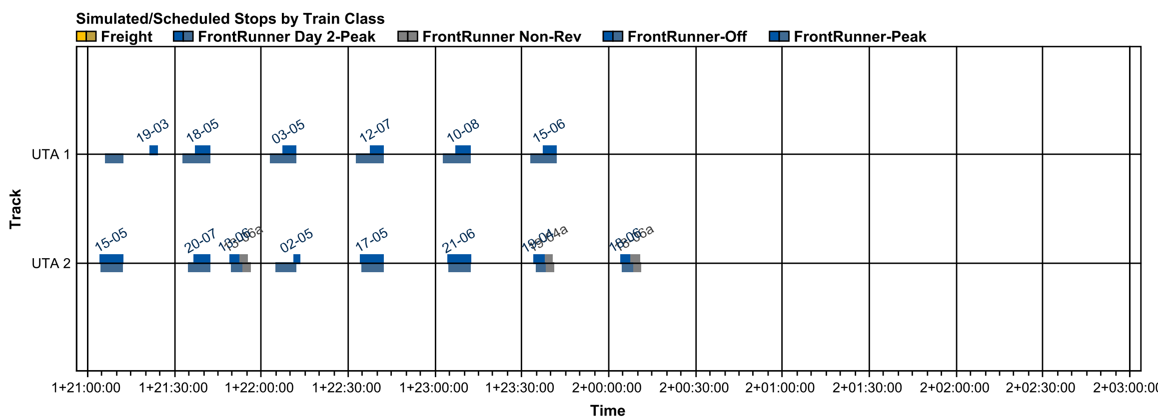


Figure 23-20: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario Day 2 Simulation Results with Perturbations

23.3.2 String Charts

Figure 23-21 shows the randomly-assigned 5-minute delay for train 20-02 at North Temple due to the need to hold for a late TRAX connection. There are very few consequences from this delay and the train is back on schedule by Layton Station.

Figure 23-23 shows the 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM. The lower speed is evident in the more horizontal slopes of the string lines through this period. Due to the high volume of trains through this area in the afternoon peak, combined with the shorter double track segments, severe delays are experienced and trains are not able to return to normal operations until late in the evening, about 10:00 PM.

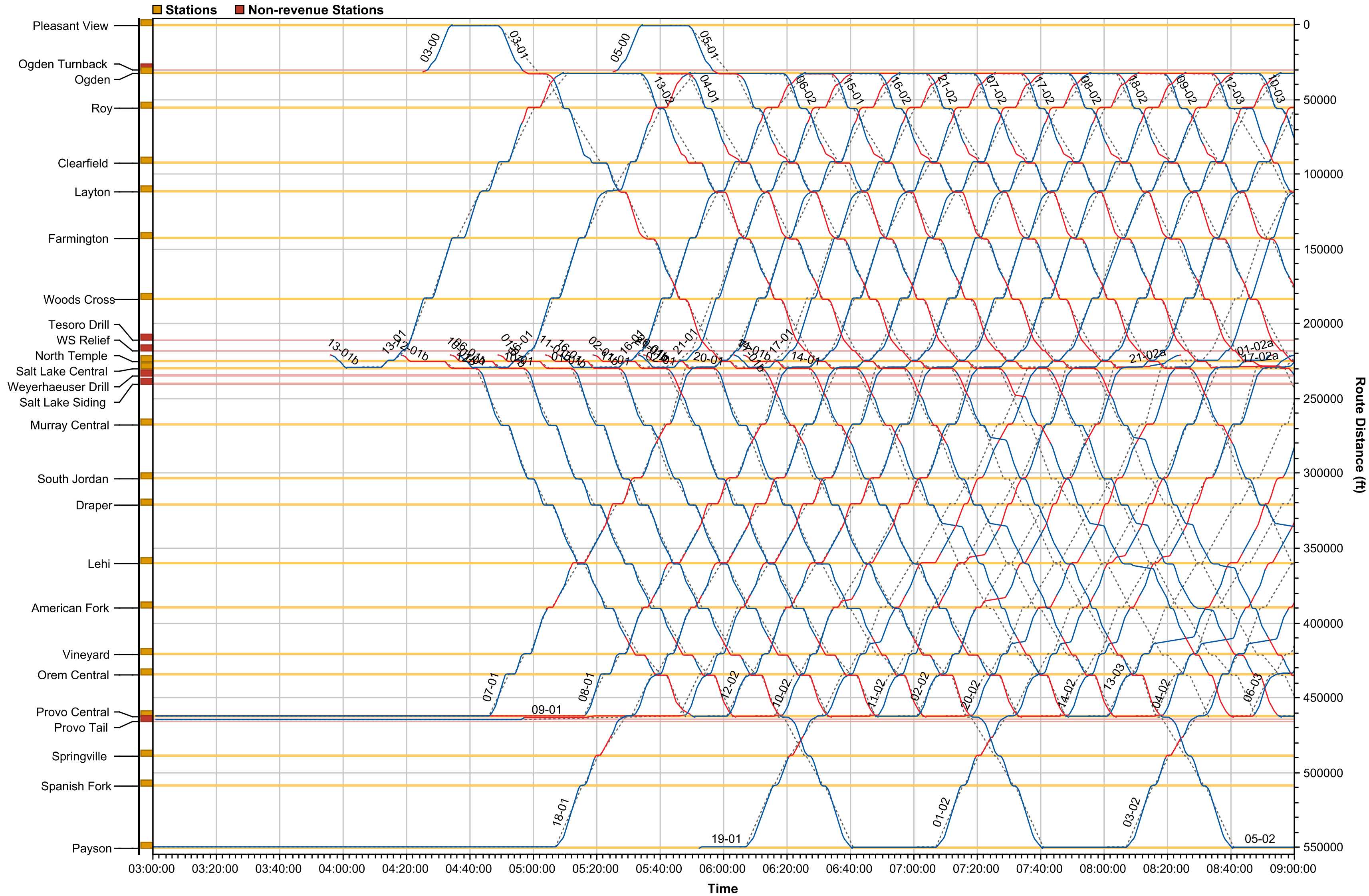


Figure 23-21: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario Day 2 Simulation Results with Perturbations

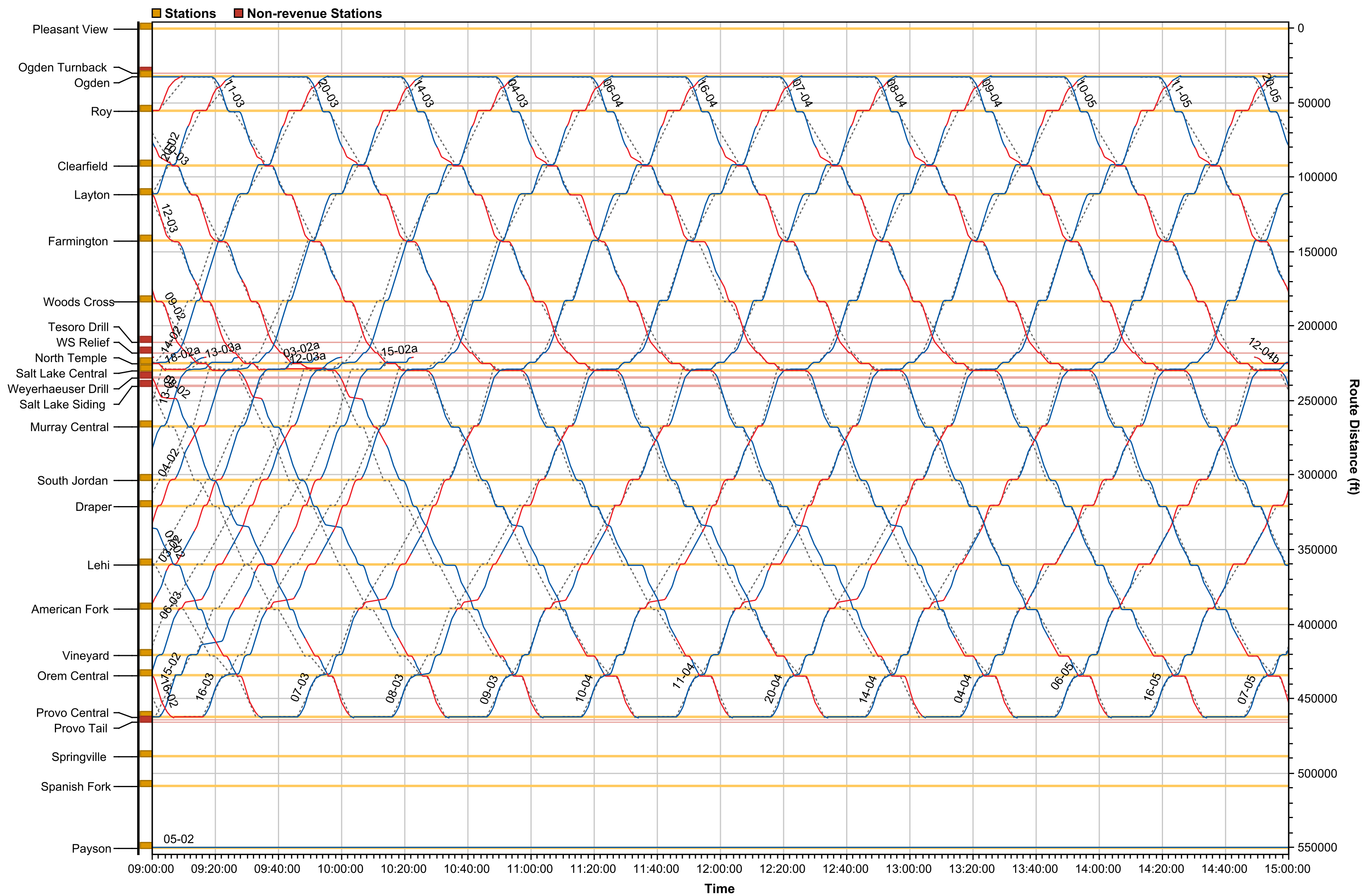


Figure 23-22: Time-Distance ("String") Chart – 9 AM – 3 PM – High Investment Scenario Day 2 Simulation Results with Perturbations

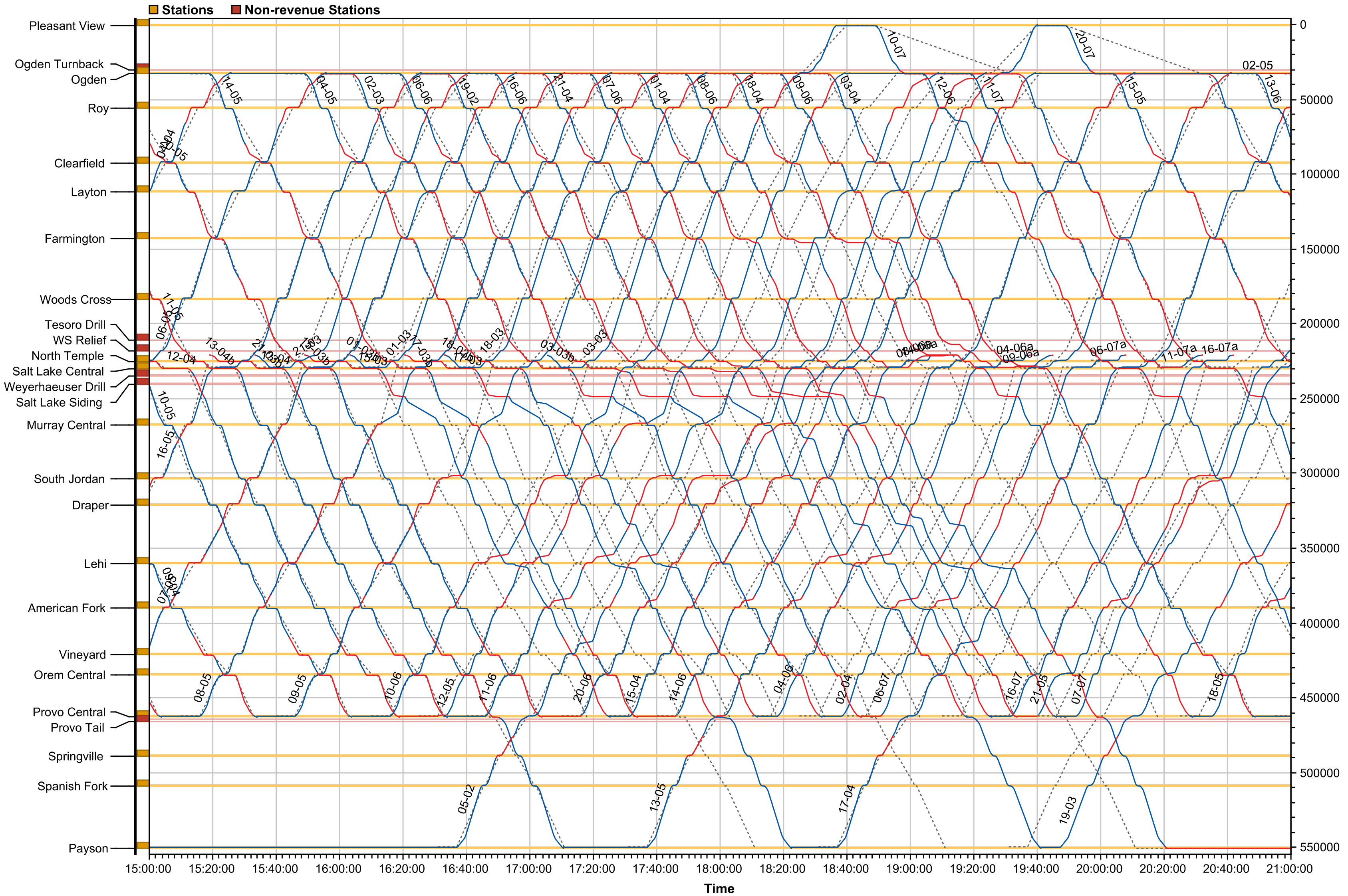


Figure 23-23: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario Day 2 Simulation Results with Perturbations

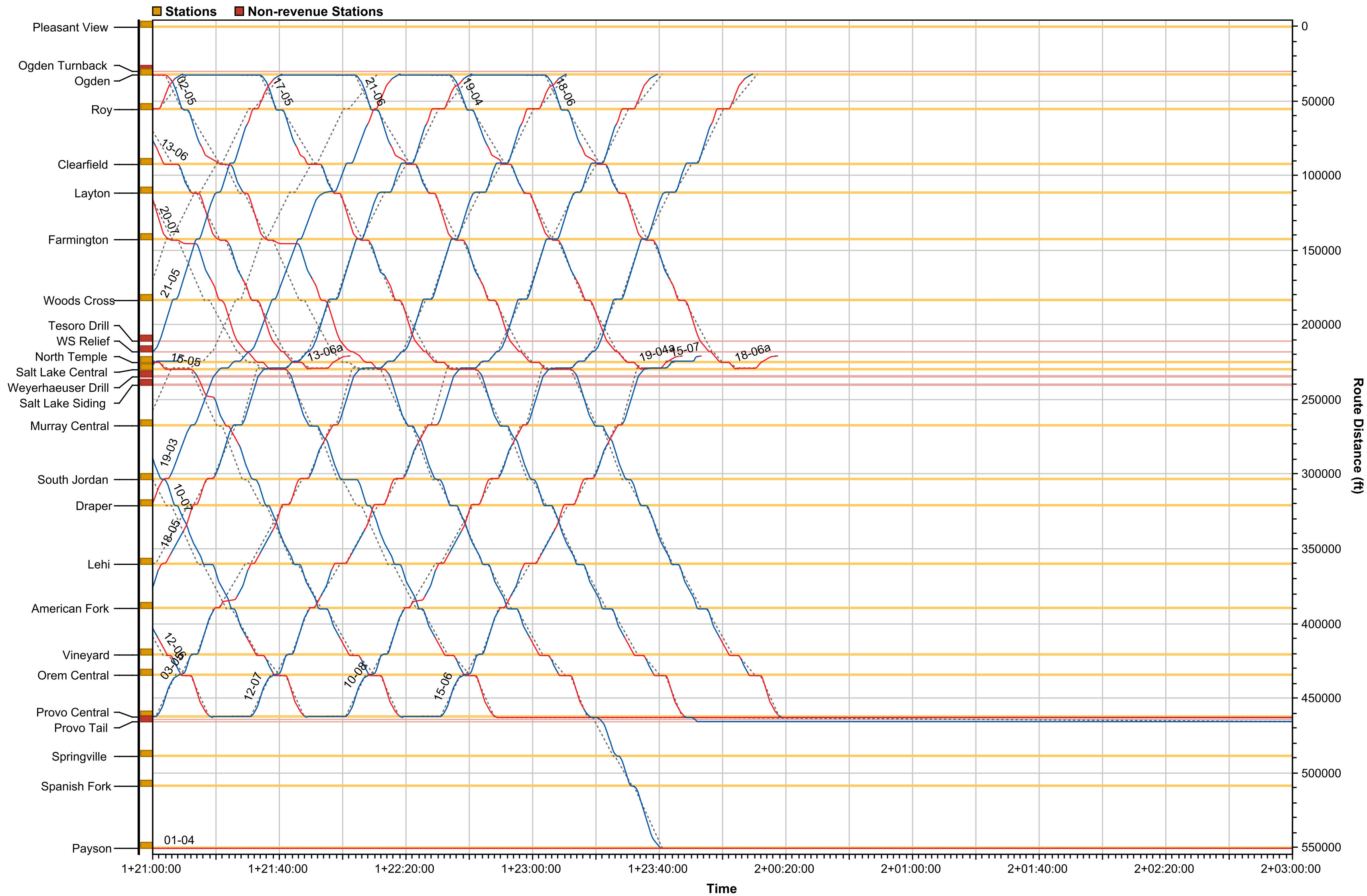


Figure 23-24: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario Day 2 Simulation Results with Perturbations

23.4 Day 3 High Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 3 operating plan includes a locomotive failure on train 10-03 between Layton station and Clearfield station causing the train to stop for 10-minutes while the locomotive is reset. Day 3 also includes a door failure for train 6-03 at Woods Cross Station. This causes an assumed 7-minute extended dwell while the door is cut out and removed from service. Station occupancy charts and string charts are included in the following sections.

23.4.1 Station Occupancy Charts – Salt Lake Central

Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. In both directions, trains stay on schedule with the help of the long dwells at Salt Lake Central Station.

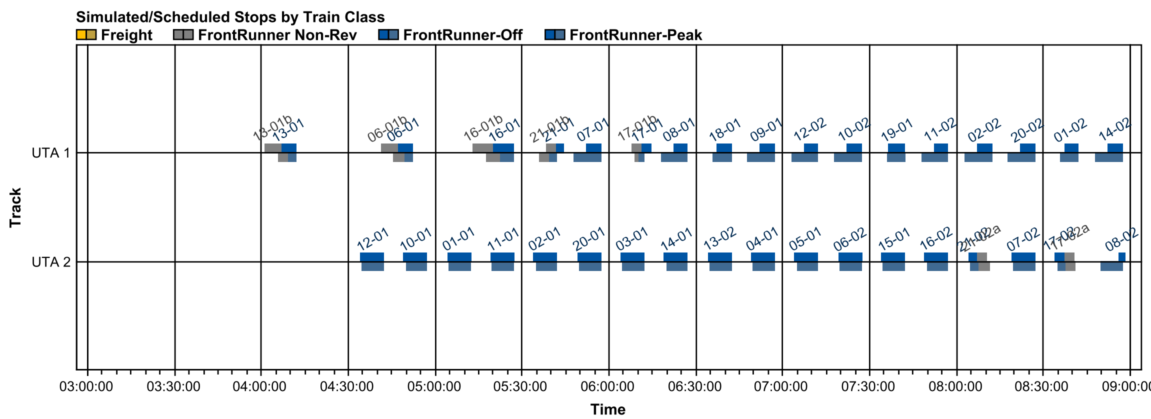


Figure 23-25: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario Day 3 Simulation Results with Perturbations

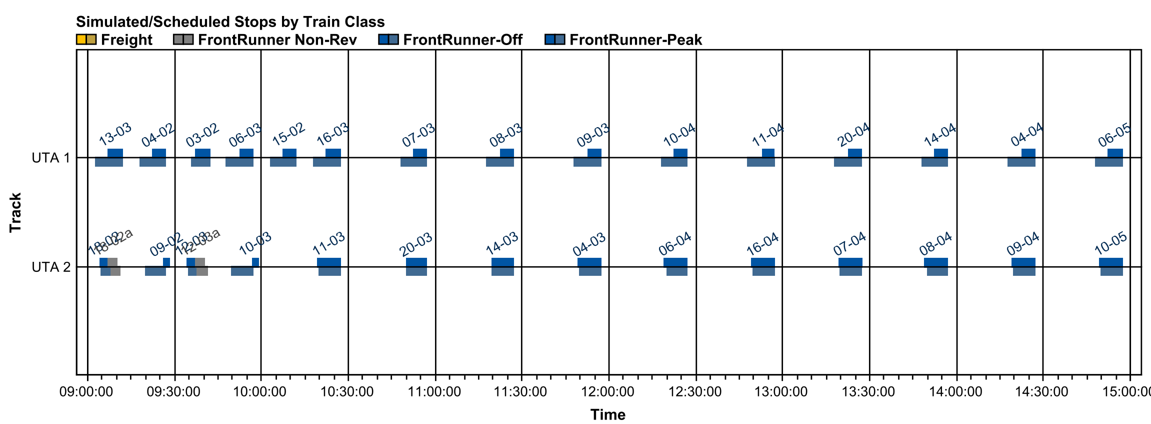


Figure 23-26: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario Day 3 Simulation Results with Perturbations

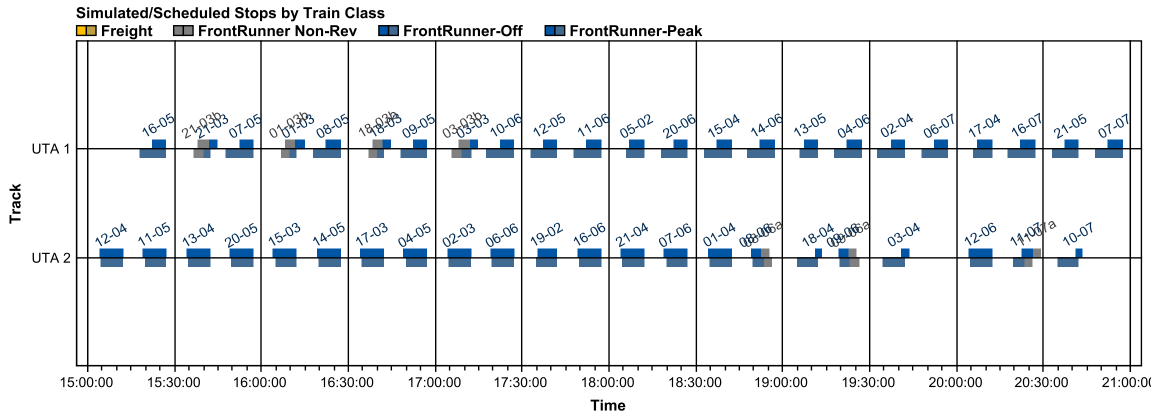


Figure 23-27: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario Day 3 Simulation Results with Perturbations

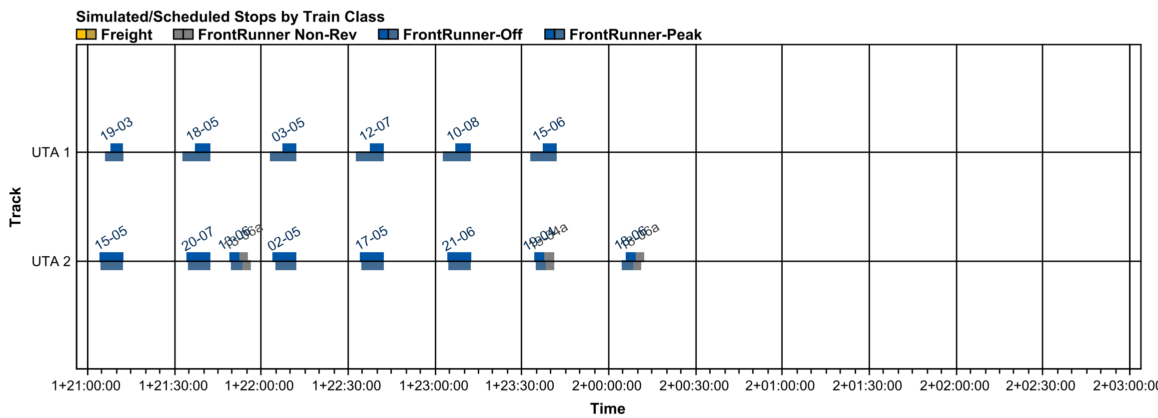


Figure 23-28: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario Day 3 Simulation Results with Perturbations

23.4.2 String Charts

The Day 3 perturbation of train 10-03 experiencing a 10-minute delay in between Clearfield station and Layton station is shown in Figure 23-29 and Figure 23-30. Because of the longer double track sections, there are no serious impacts to northbound trains and train 10-03 is able to get back on schedule with the help of the dwell time at Salt Lake Central Station.

The door failure delay to northbound train 6-03 at Woods Cross station is shown in Figure 23-30. Again, there is minimal disruption to southbound trains due to the longer double track sections and train 6-03 is on time by Roy Station.

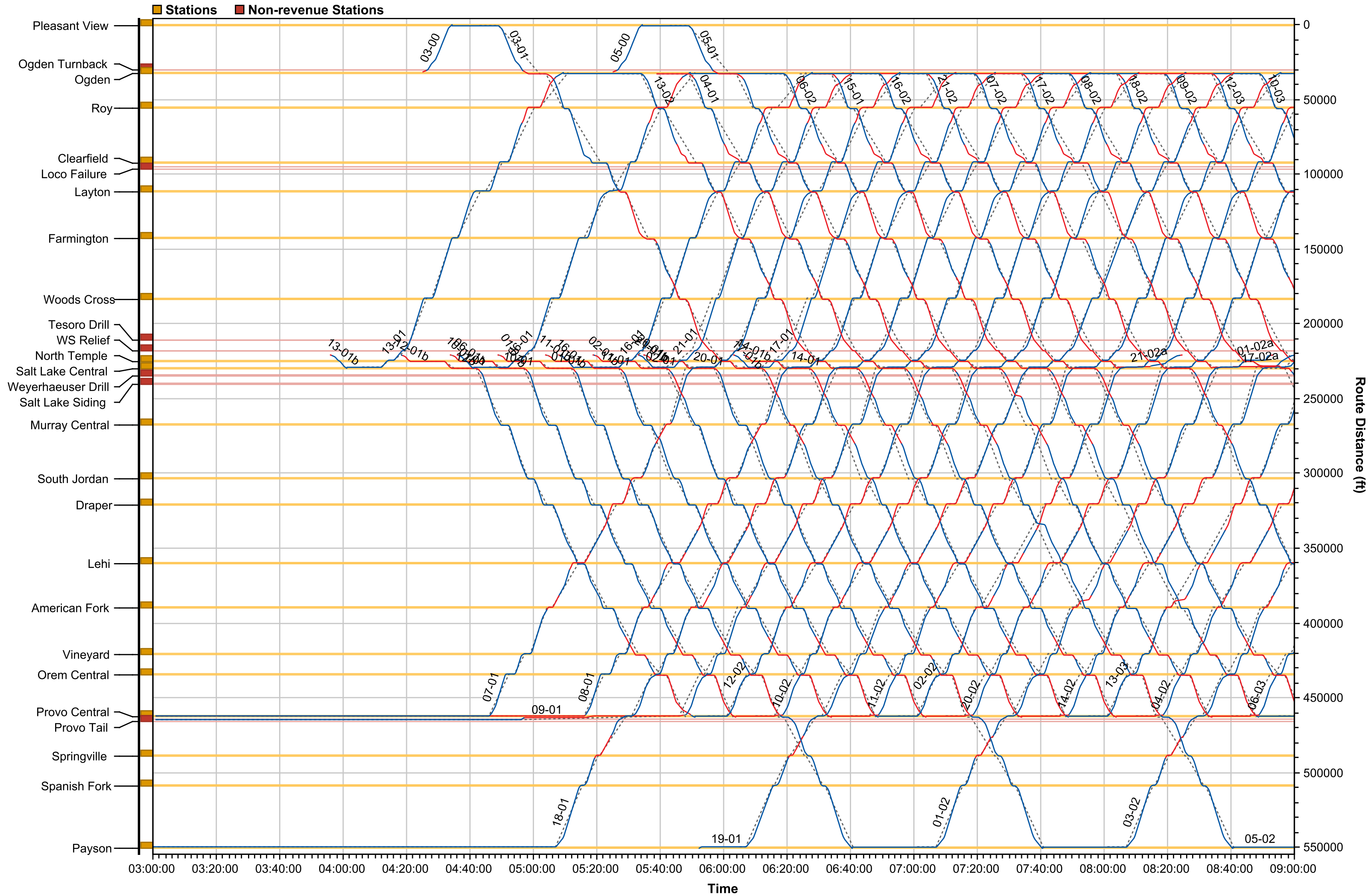


Figure 23-29: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario Day 3 Simulation Results with Perturbations

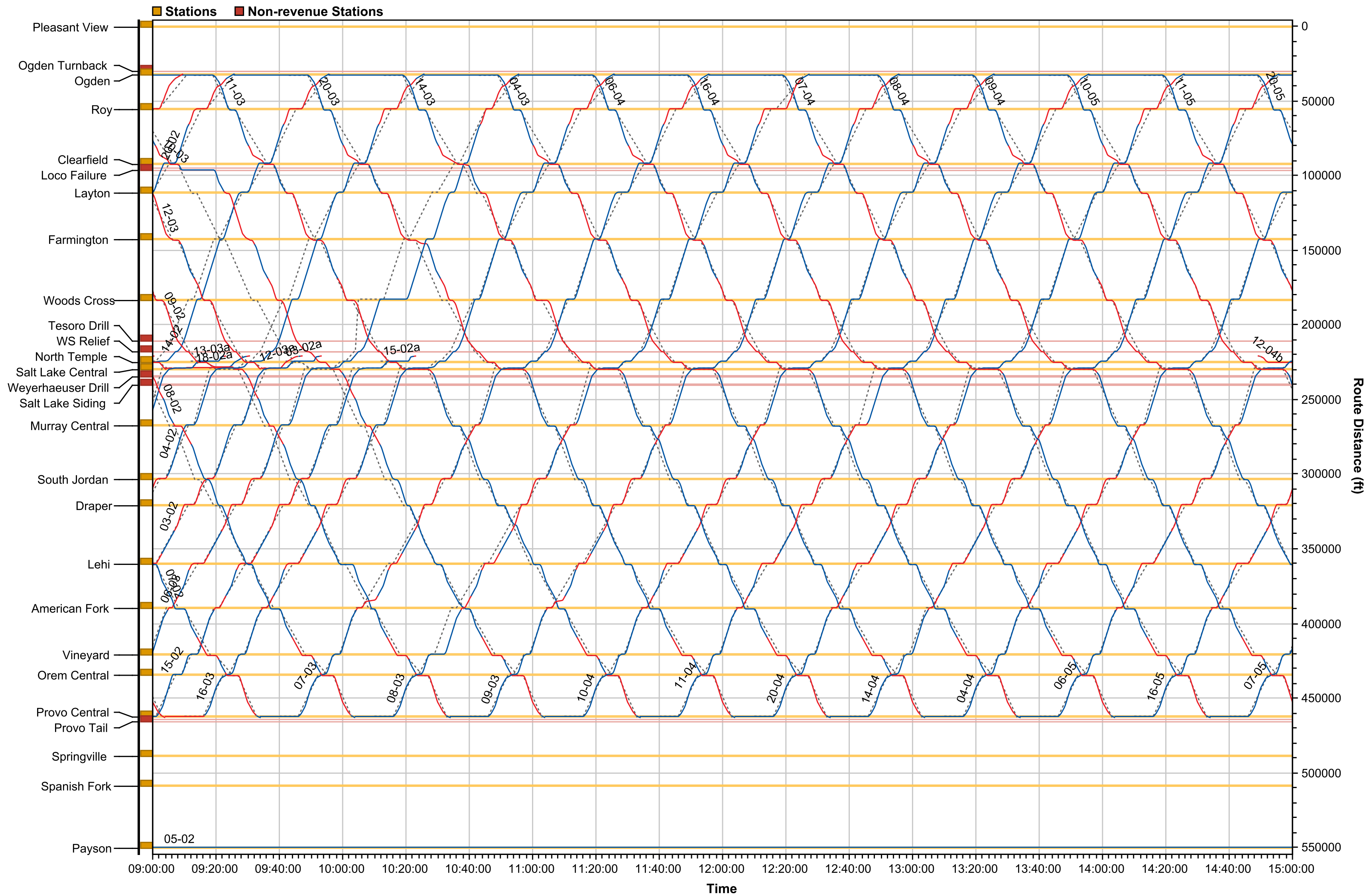


Figure 23-30: Time-Distance ("String") Chart – 9 AM – 3 PM – High Investment Scenario Day 3 Simulation Results with Perturbations

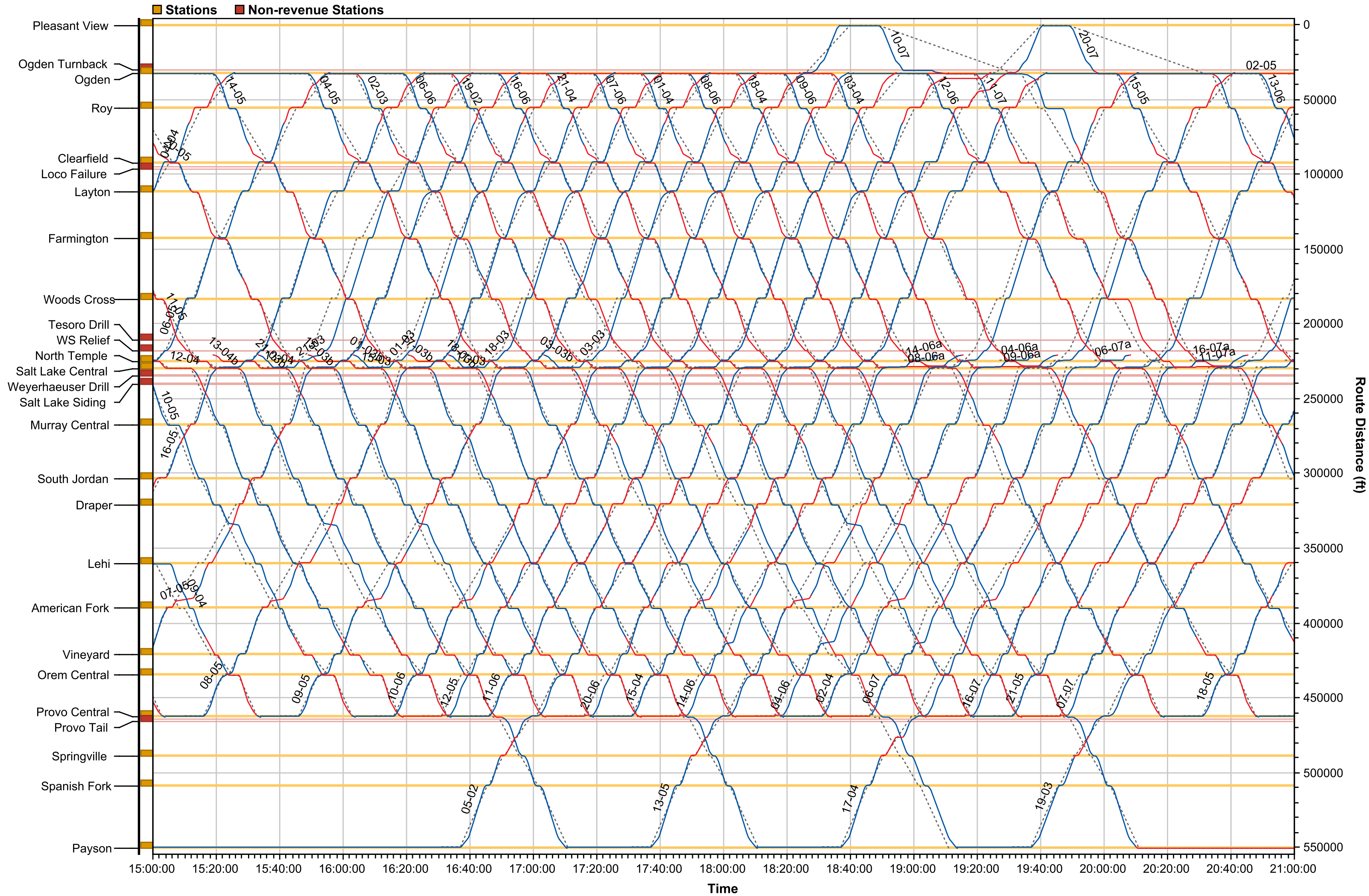


Figure 23-31: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario Day 3 Simulation Results with Perturbations

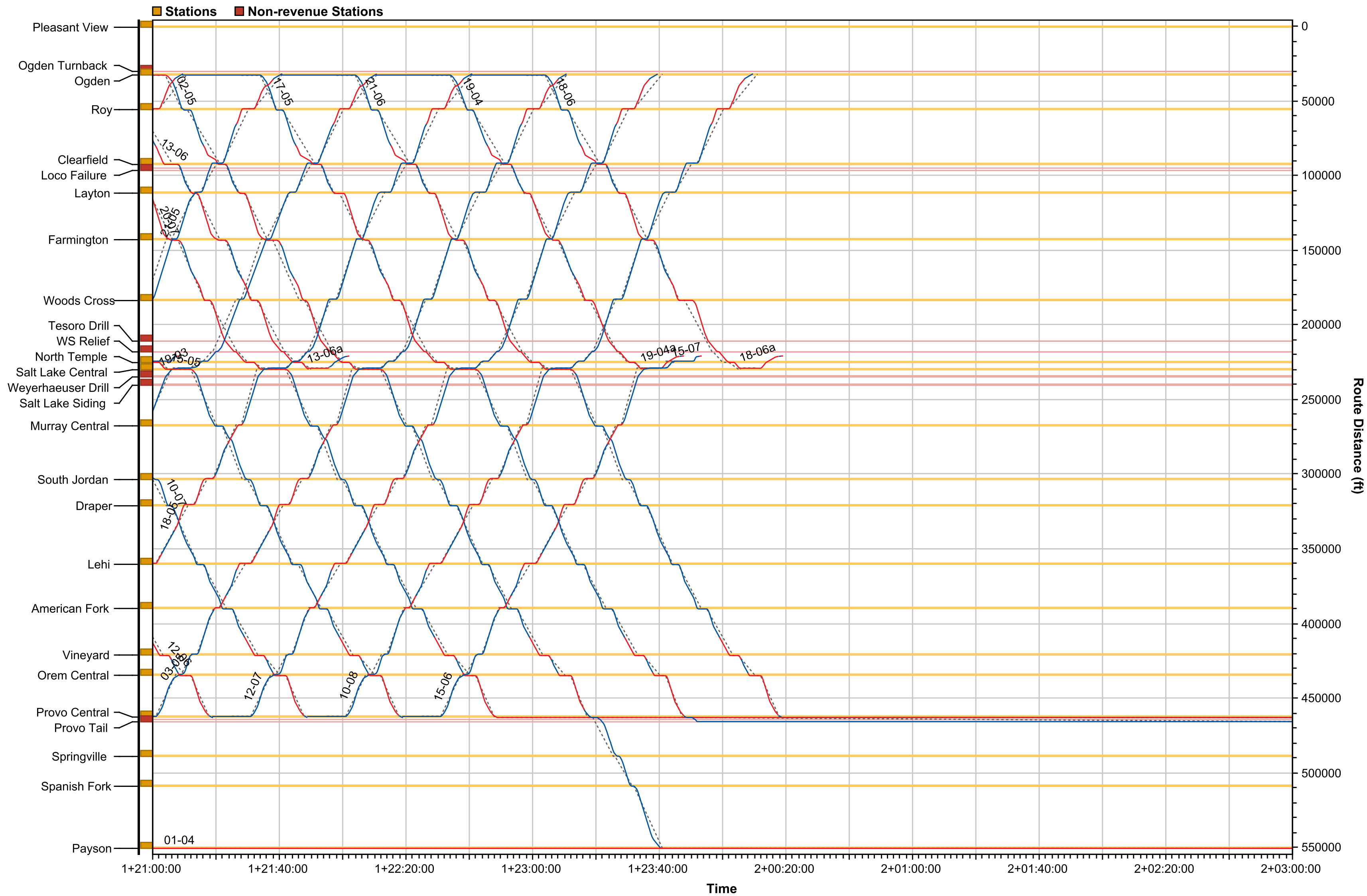


Figure 23-32: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario Day 3 Simulation Results with Perturbations

23.5 Day 4 High Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 4 operating plan includes a door failure for train 16-03 at Orem Station. This causes an assumed 7-minute extended dwell while the door failure is resolved. Day 4 also includes a 15 MPH speed restriction through 9400 South Grade Crossing (North of South Jordan) from 6:30 AM through 8:30 AM due to a crossing failure/broken gate. Salt Lake Central station occupancy charts and full network string charts are included in the following sections.

23.5.1 Station Occupancy Charts – Salt Lake Central

Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. There are severe delays to northbound trains in the morning peak period as a result of the crossing failure and minimal delays to northbound trains at the end of the afternoon peak due a random delay to train 13-05.

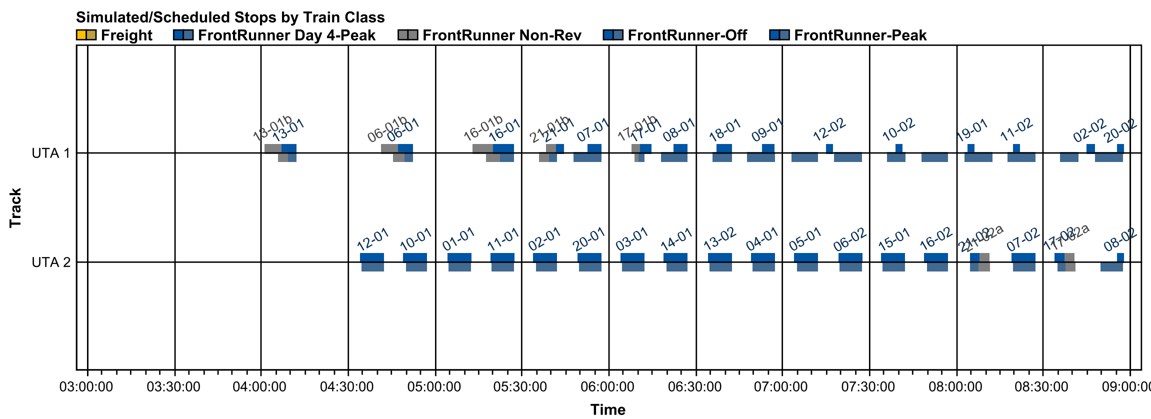


Figure 23-33: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario Day 4 Simulation Results with Perturbations

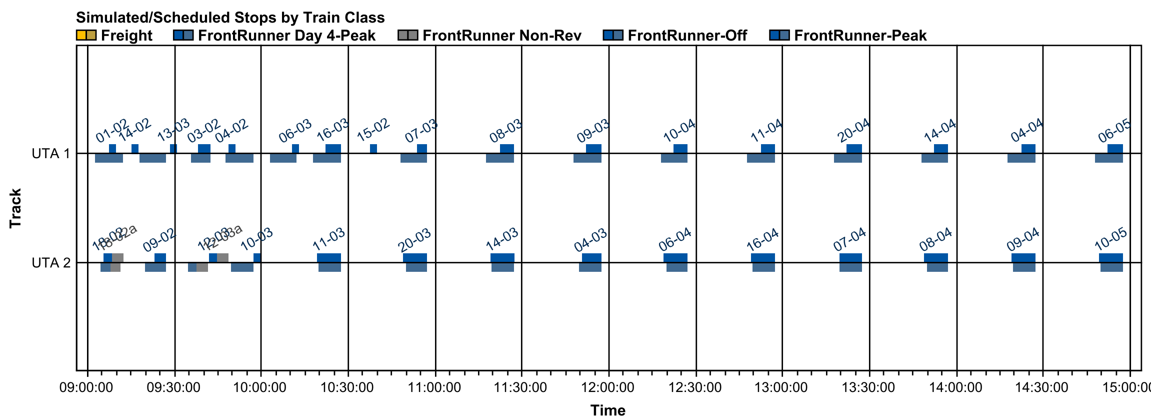


Figure 23-34: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario Day 4 Simulation Results with Perturbations

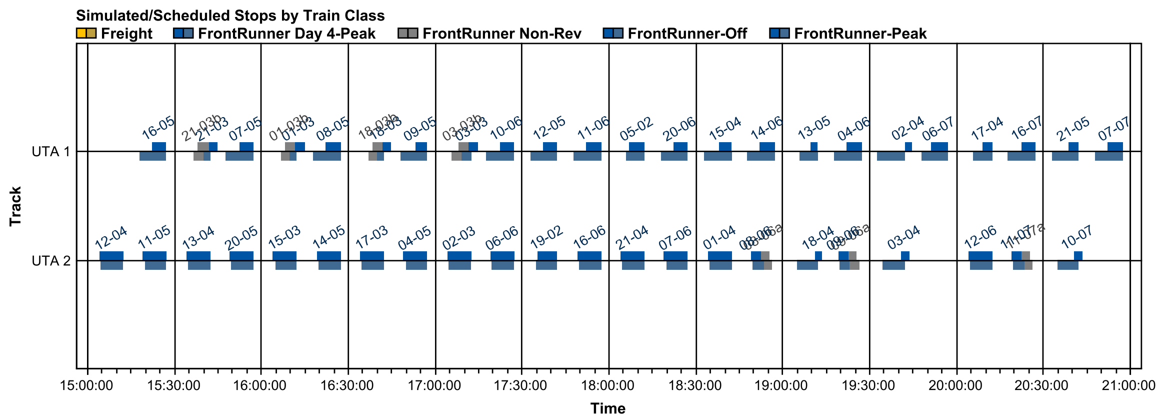


Figure 23-35: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario Day 4 Simulation Results with Perturbations

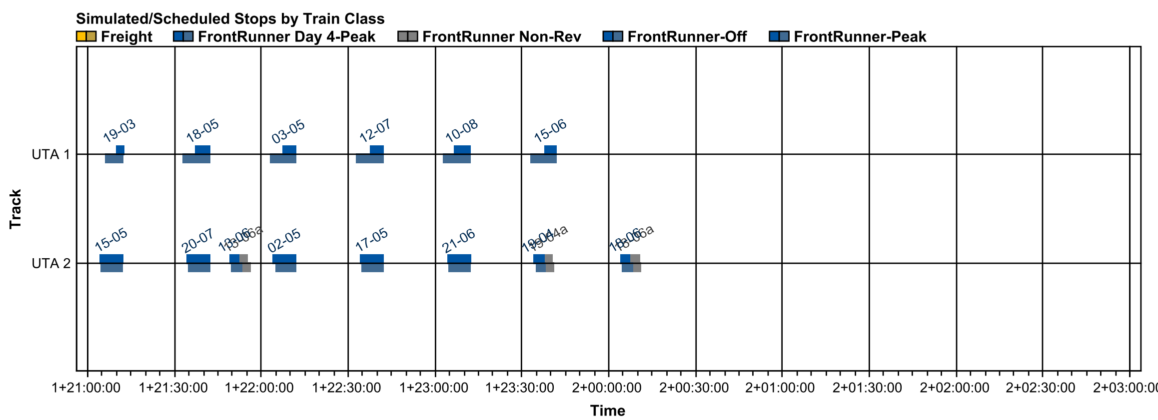


Figure 23-36: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario Day 4 Simulation Results with Perturbations

23.5.2 String Charts

The Day 4 perturbation of a 15 MPH speed restriction through a grade crossing just north of South Jordan is shown in Figure 23-37. This causes cascading delays to the trains throughout the morning peak period and the disruption is made even more severe due to trains running through the location every 15 minutes, which hurts the chances for recovery until the off-peak period. Trains are able to get back on schedule by 12:00 noon.

Figure 23-38 shows the door failure for train 16-03 at Orem Station. This assumed 7-minute extended dwell while the door is disabled causes train 16-03 to run late until it can recover by Salt Lake Central Station, with help from the dwell time at Salt Lake Central station. This train follows very late trains that are caused by the crossing failure.

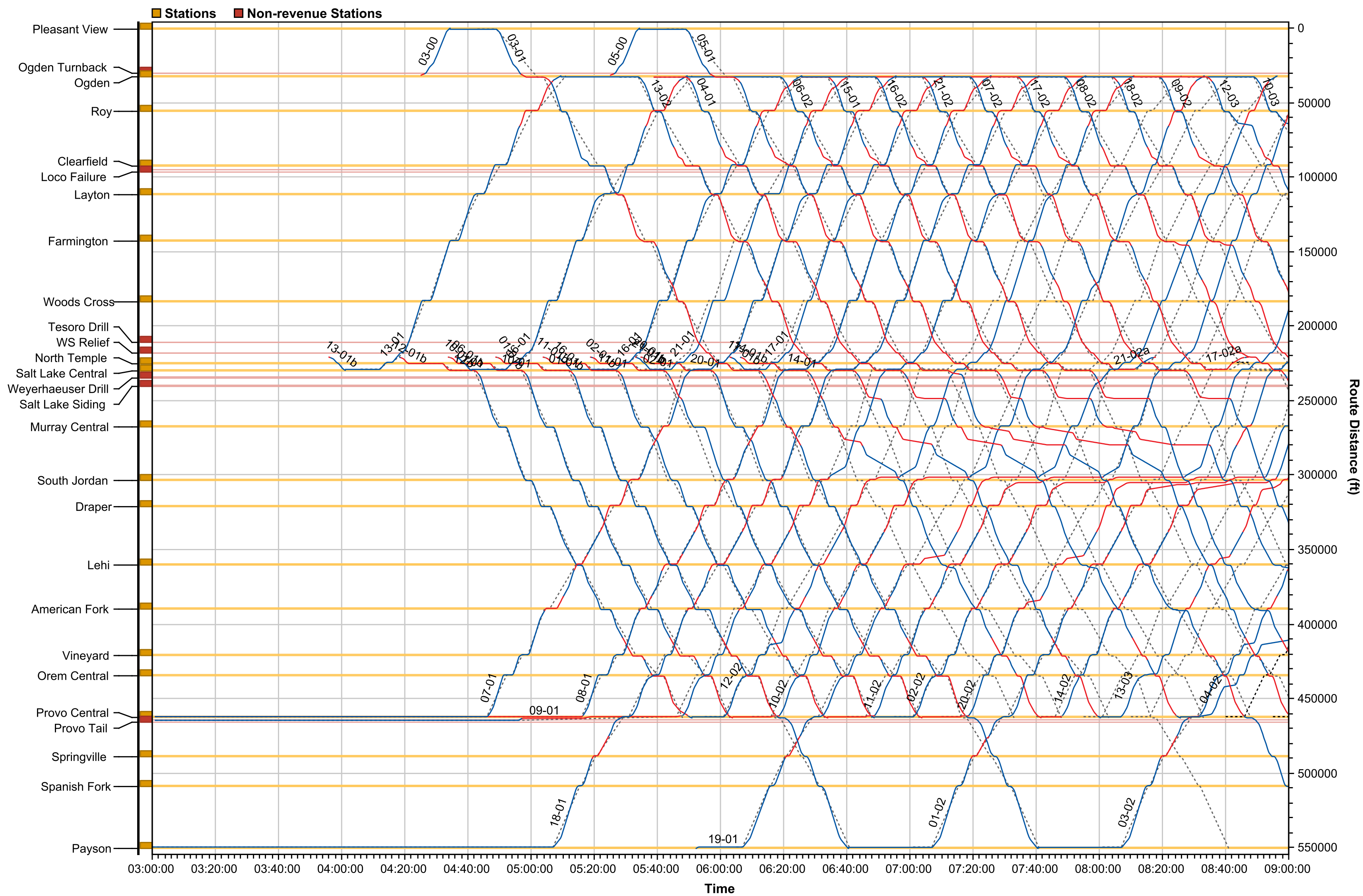


Figure 23-37: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario Day 4 Simulation Results with Perturbations

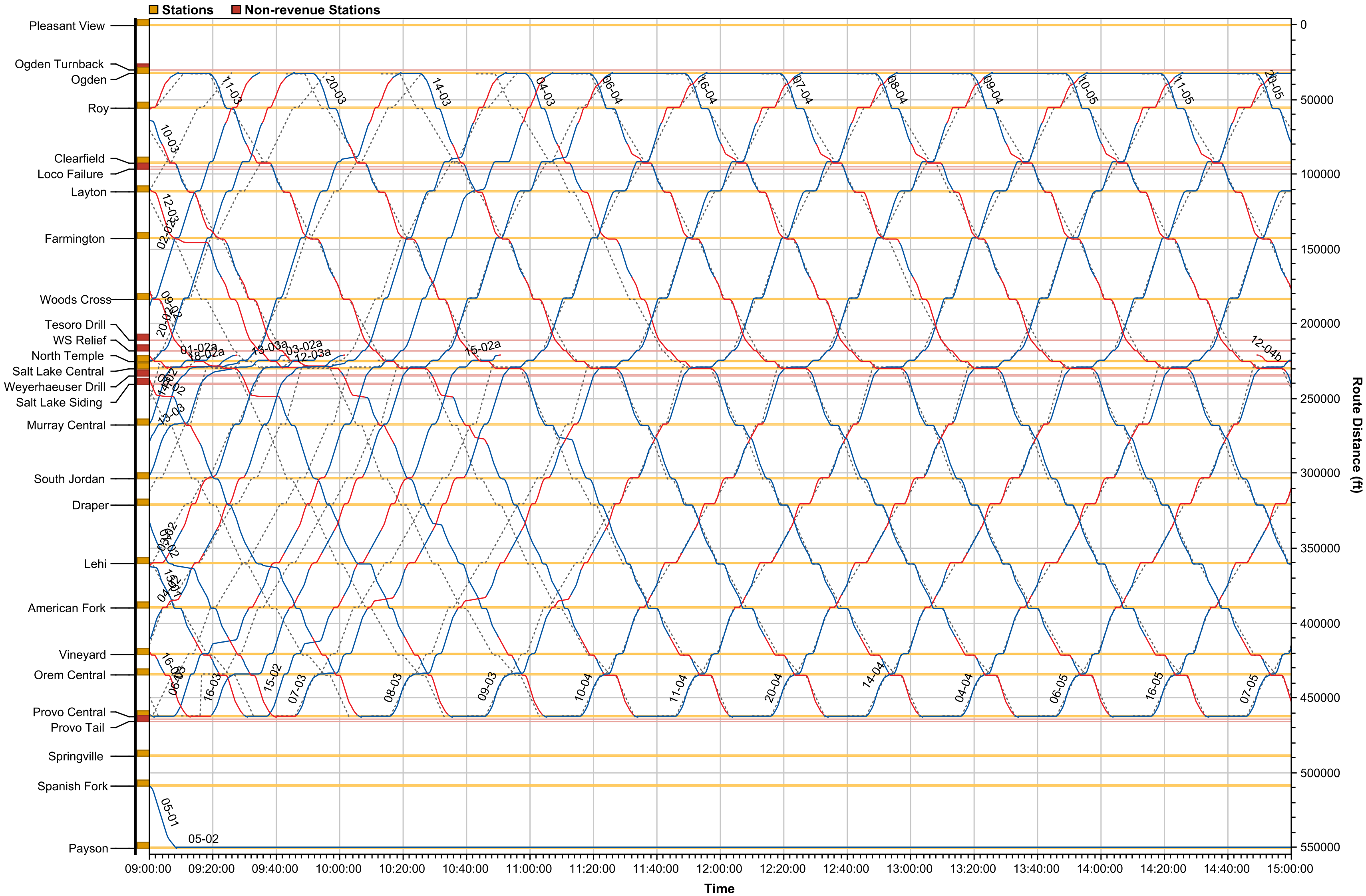


Figure 23-38: Time-Distance ("String") Chart – 9 AM – 3 PM – High Investment Scenario Day 4 Simulation Results with Perturbations

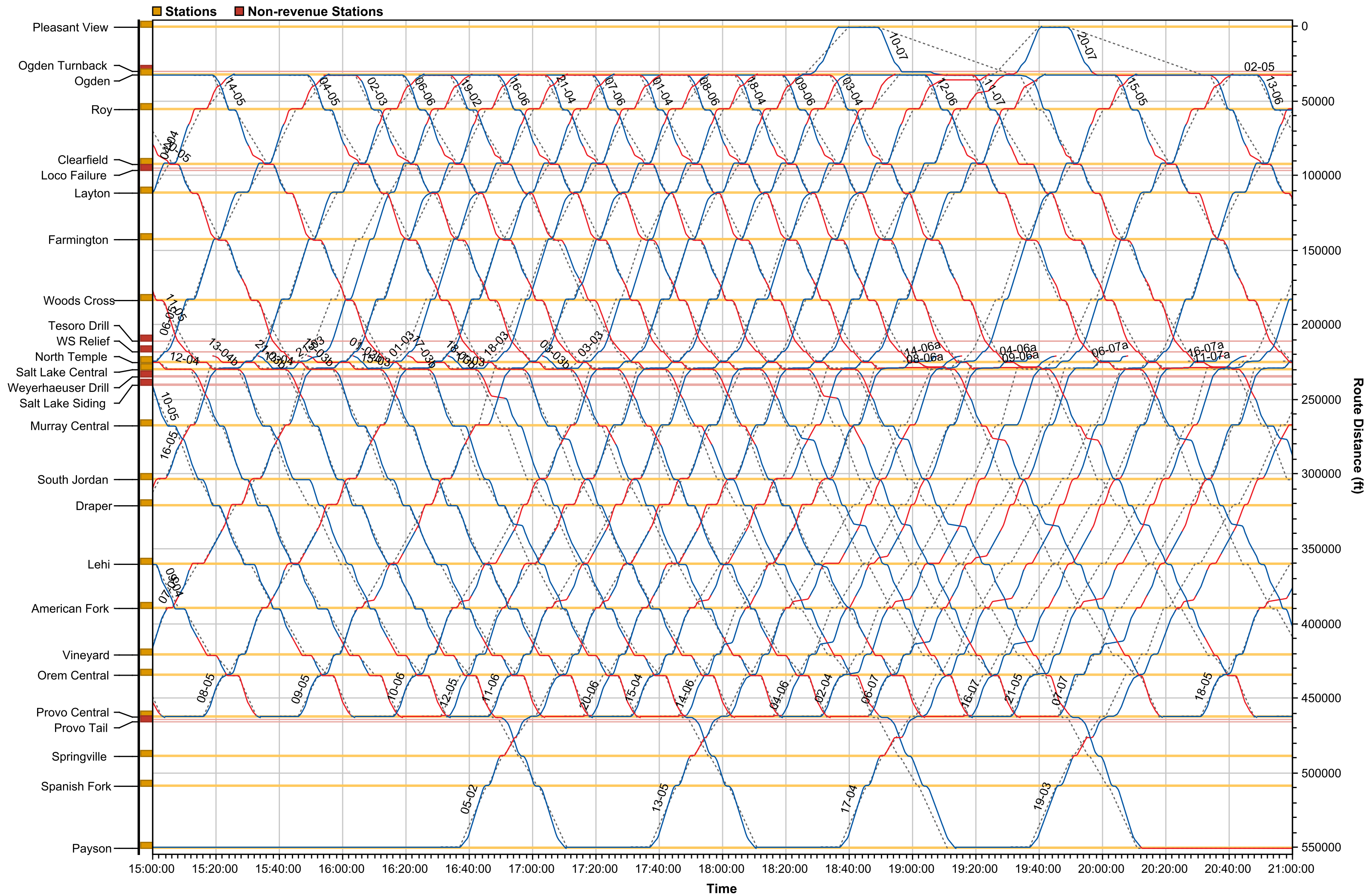


Figure 23-39: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario Day 4 Simulation Results with Perturbations

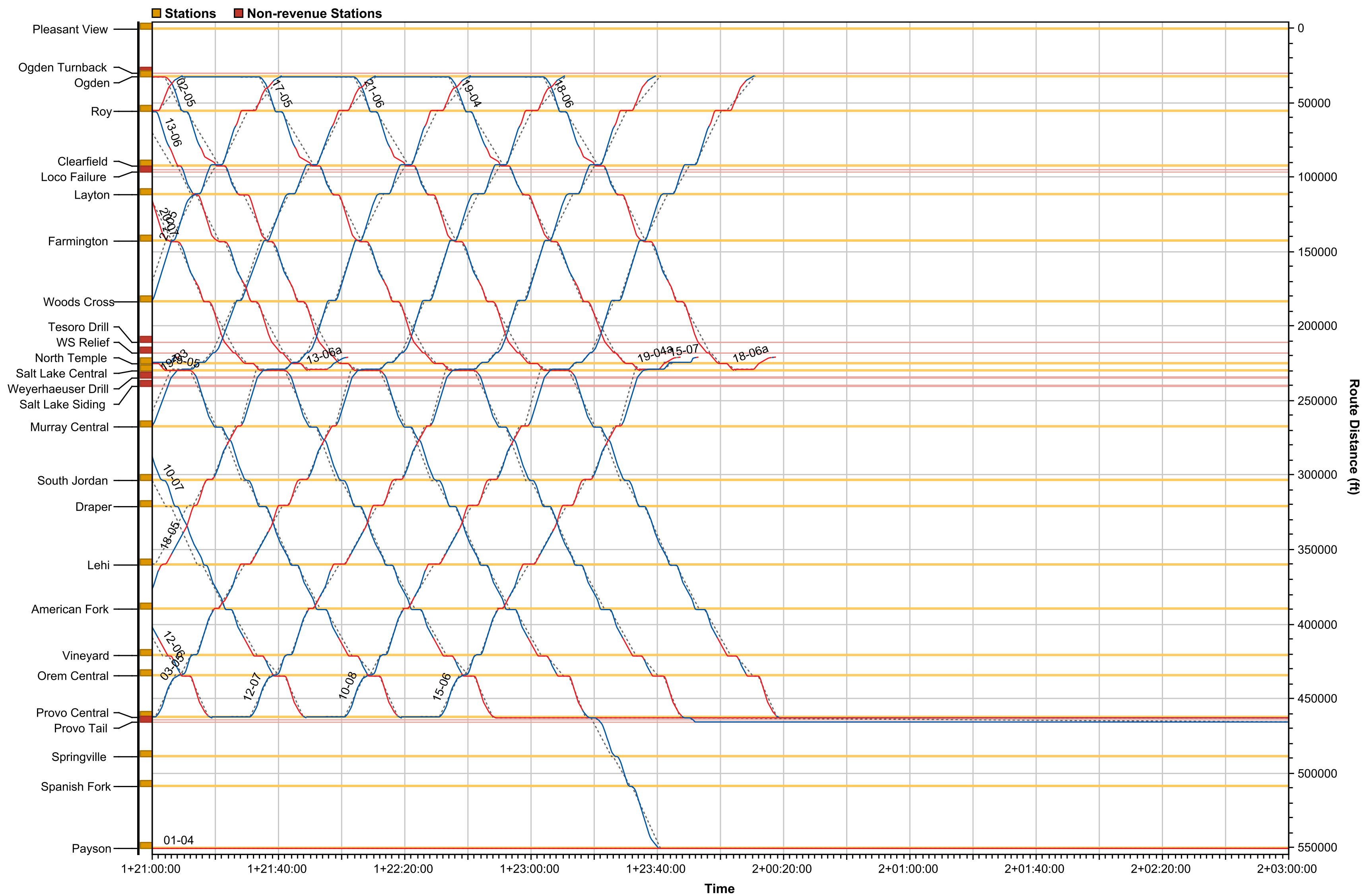


Figure 23-40: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario Day 4 Simulation Results with Perturbations

23.6 Day 5 High Investment Scenario Simulation Results with Perturbations

The FrontRunner - Day 5 operating plan includes a 5-minute delay for train 19-01 at North Temple due to assumed need to hold for a late connecting TRAX train. Day 5 also includes a locomotive failure on train 14-06 between Lehi station and American Fork station causing the train to stop for 10-minutes while the locomotive is reset. Station occupancy charts and string charts are included in the following sections.

23.6.1 Station Occupancy Charts – Salt Lake Central

Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. There are delays to northbound trains as a result of the cascading delays from the locomotive failure on train 14-06.

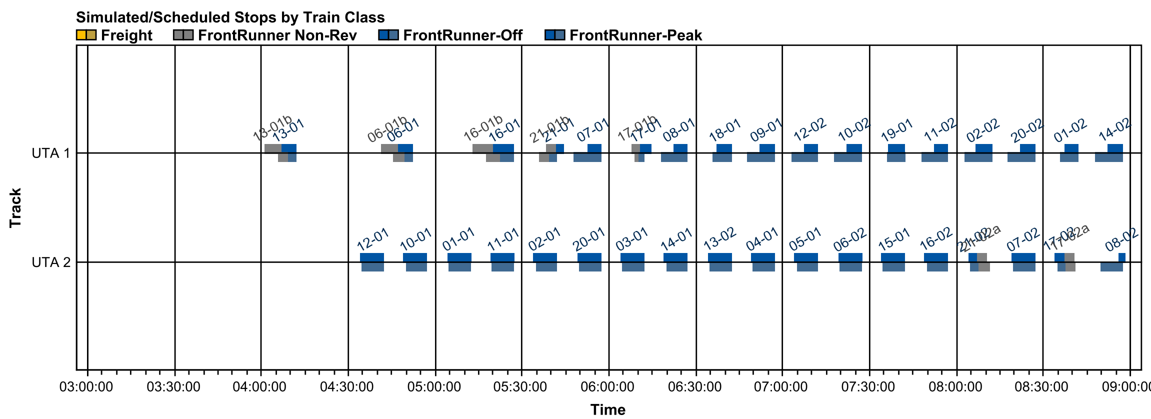


Figure 23-41: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario Day 5 Simulation Results with Perturbations

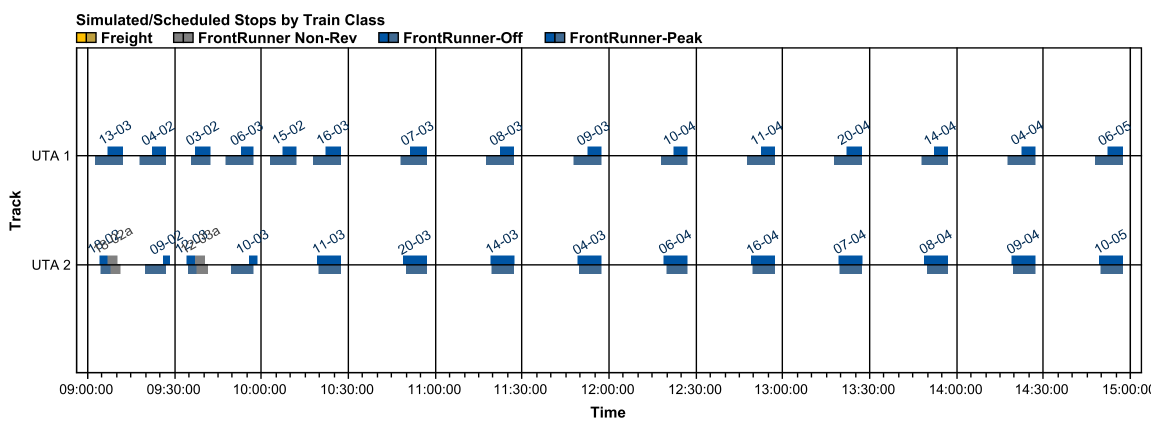


Figure 23-42: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario Day 5 Simulation Results with Perturbations

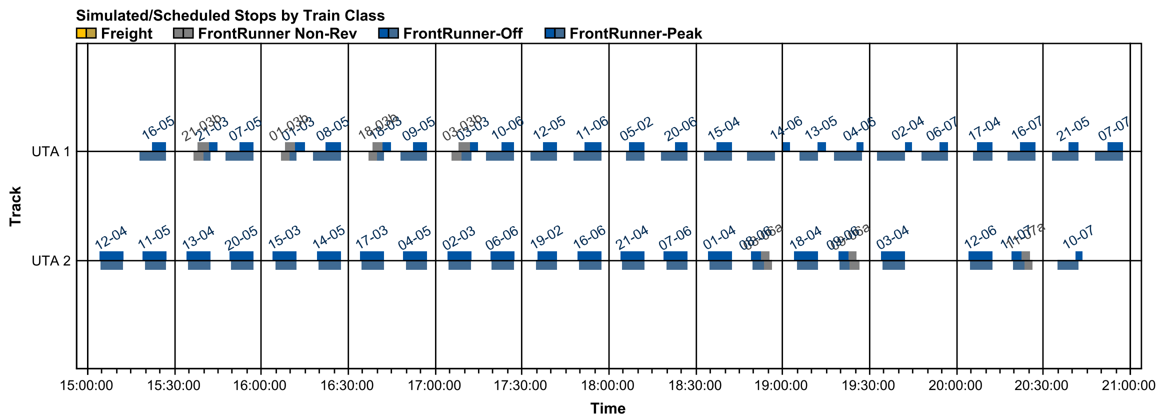


Figure 23-43: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario Day 5 Simulation Results with Perturbations

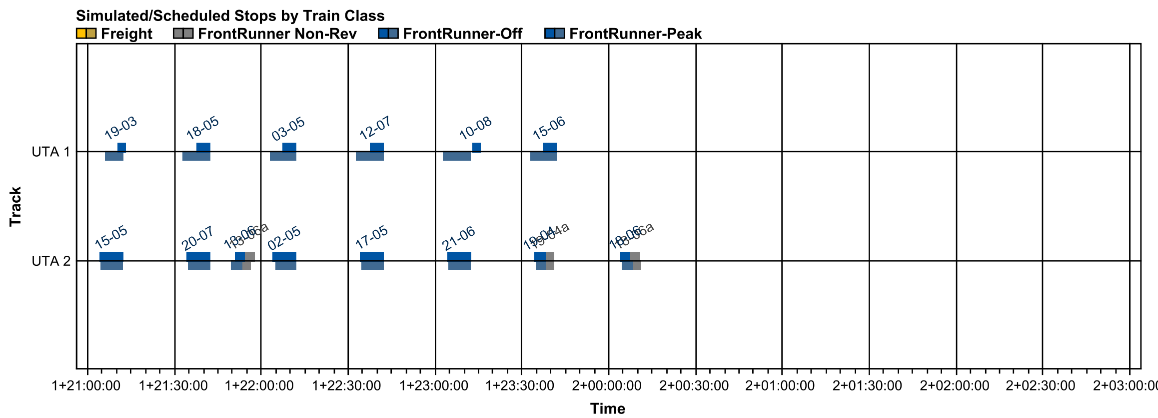


Figure 23-44: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario Day 5 Simulation Results with Perturbations

23.6.2 String Charts

Figure 23-45 shows that train 19-01 has been randomly assigned the 5-minute delay perturbation at North Temple station. With the extended double track sidings, the train is does not cause delays to southbound trains and it makes up the time by Clearfield Station.

Under the Day 5 perturbations, train 14-06 is randomly assigned a locomotive failure and stops for 10 minutes between Lehi station and American Fork station as shown in Figure 23-47. This causes some cascading delays to trains in both directions and the system is not able to fully recover until after the peak period, about 9:00 PM.

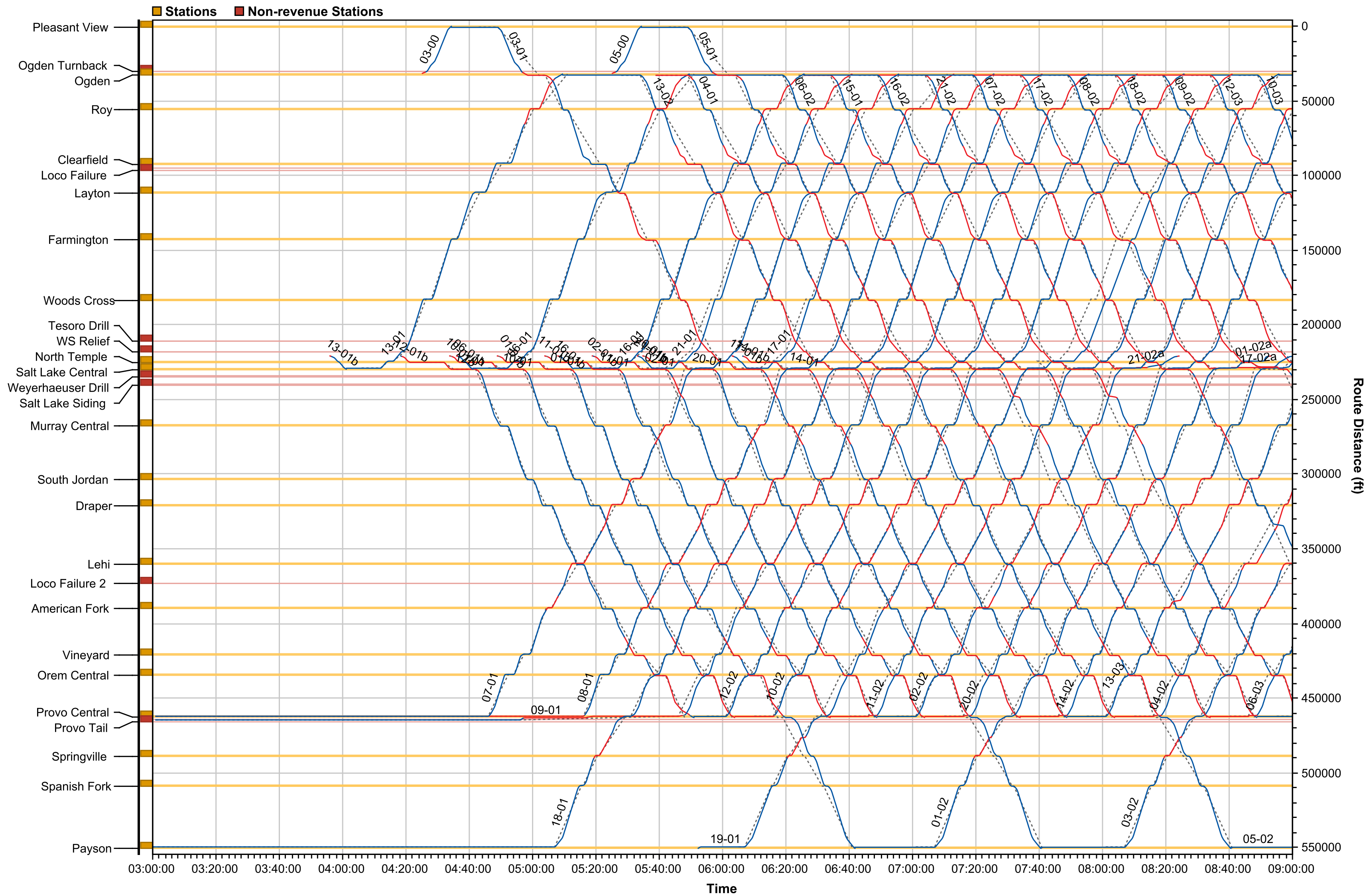


Figure 23-45: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario Day 5 Simulation Results with Perturbations

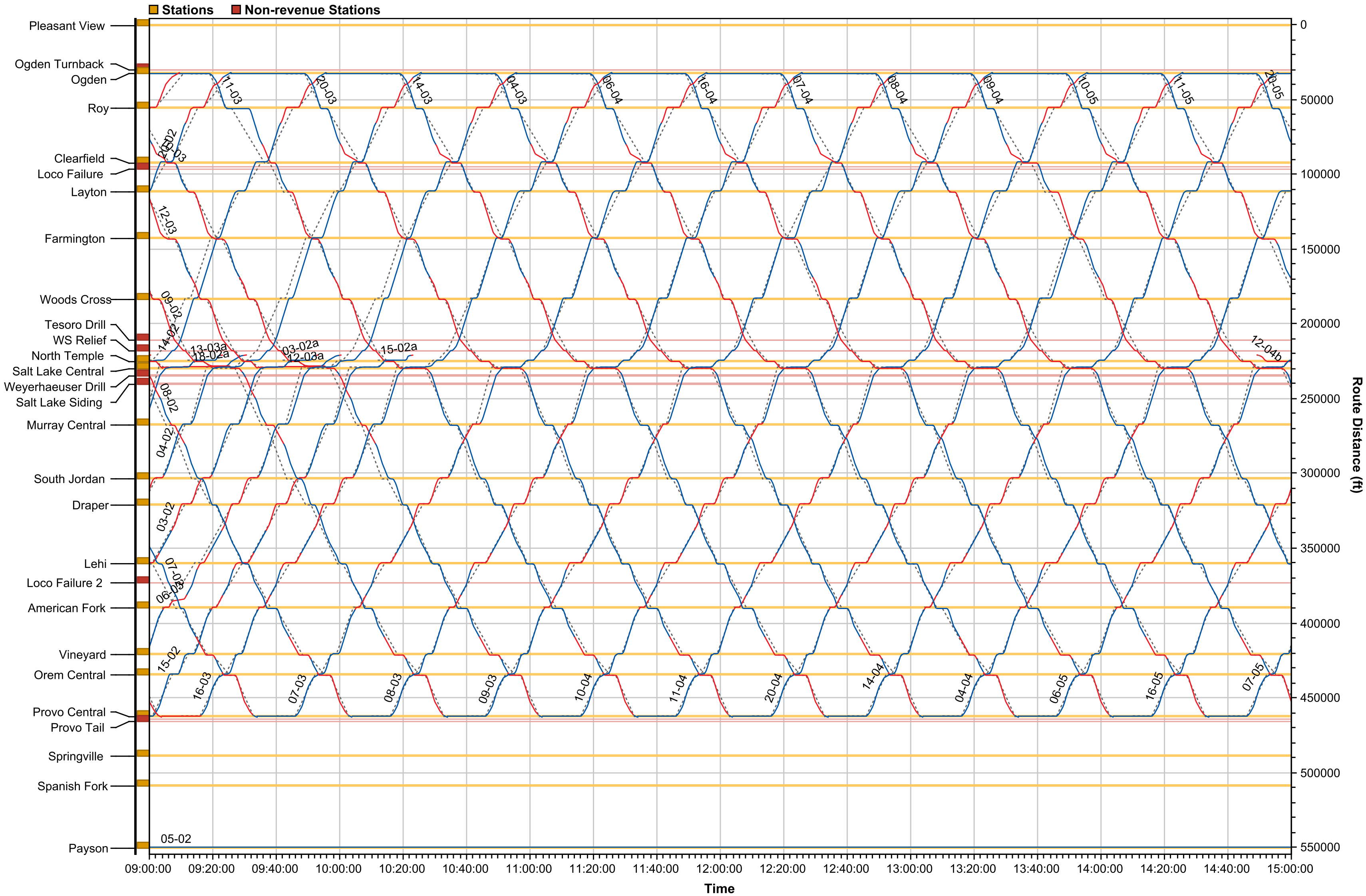


Figure 23-46: Time-Distance ("String") Chart – 9 AM – 3 PM – High Investment Scenario Day 5 Simulation Results with Perturbations

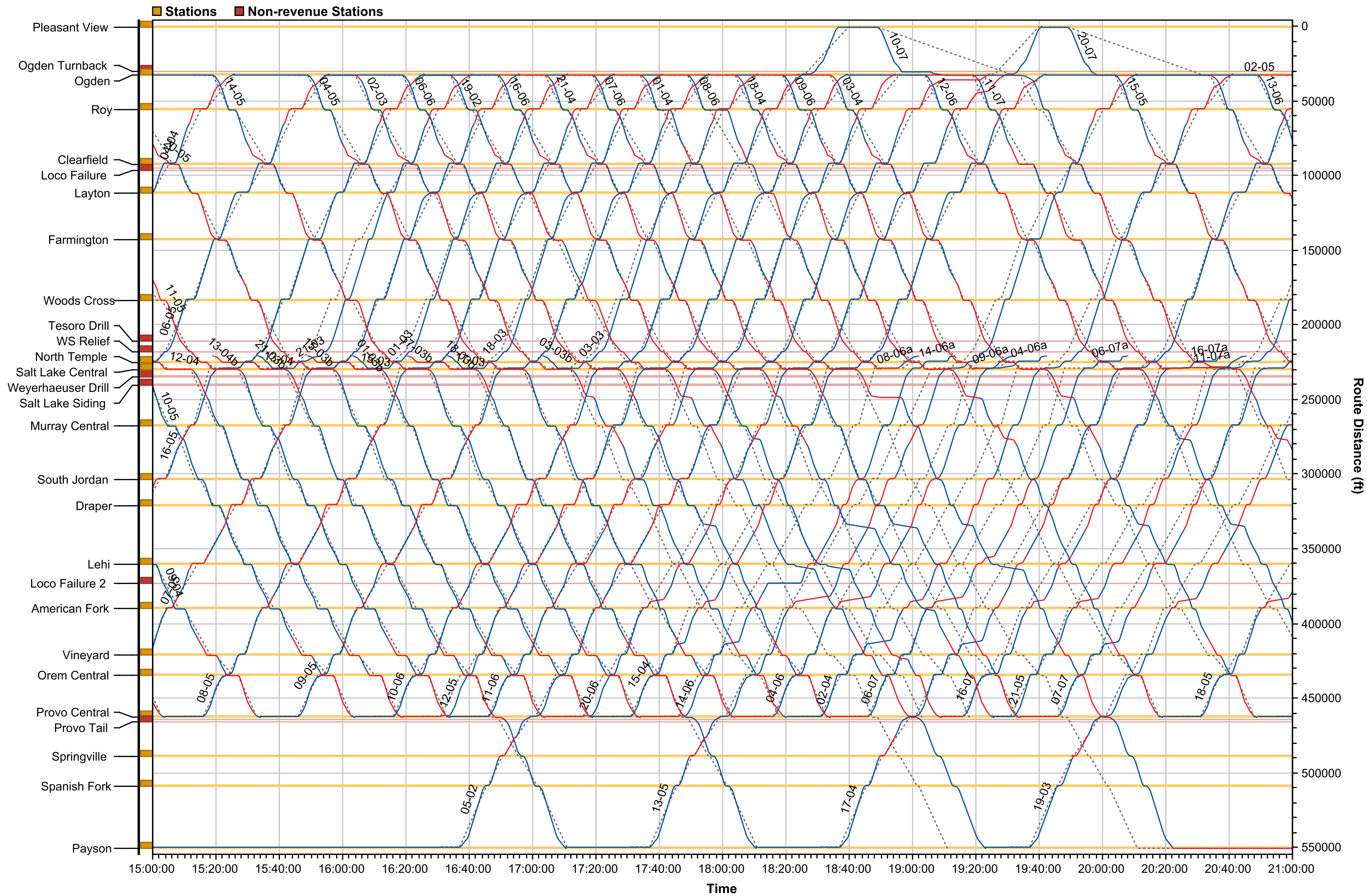


Figure 23-47: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario Day 5 Simulation Results with Perturbations

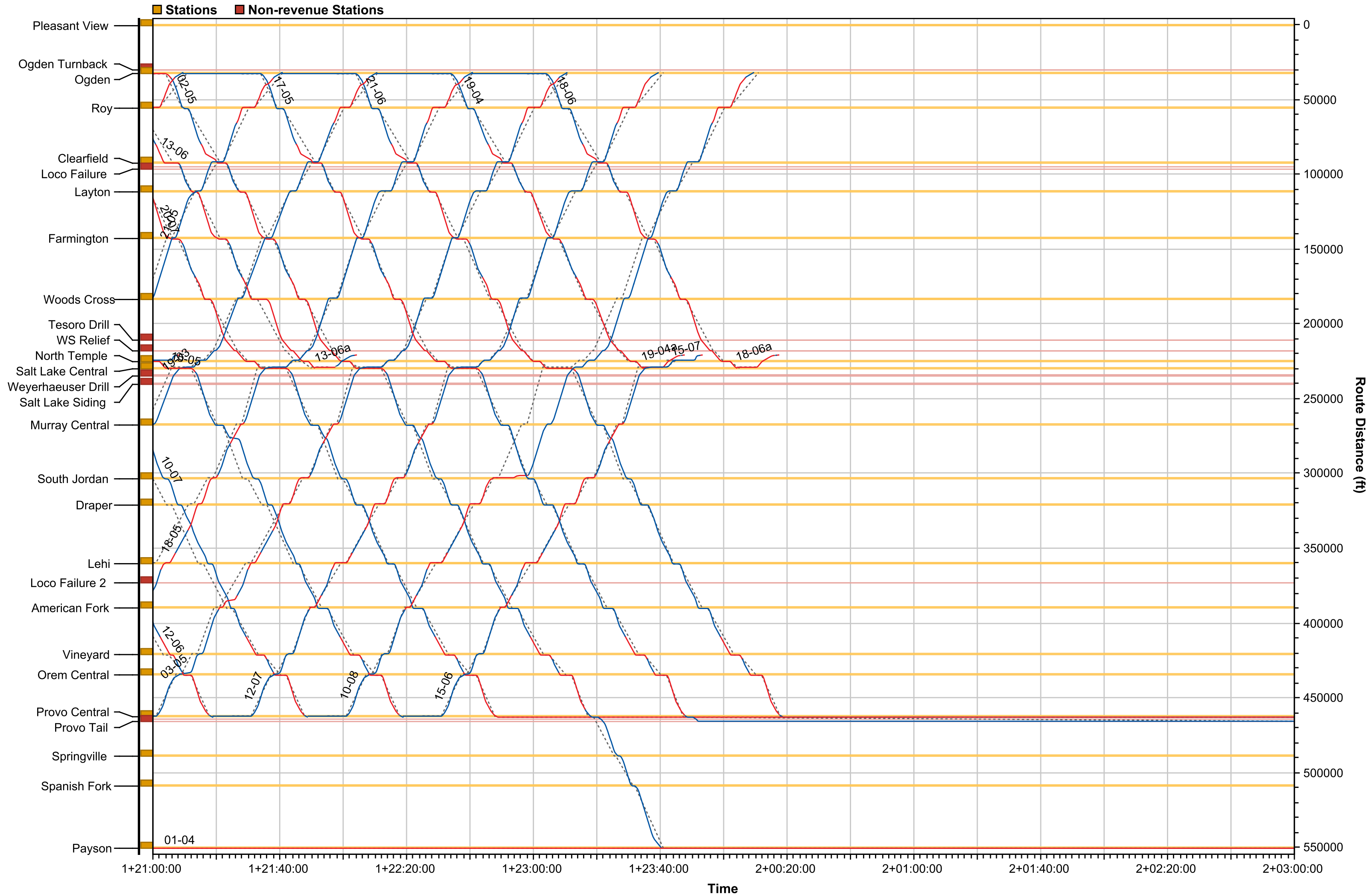


Figure 23-48: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario Day 5 Simulation Results with Perturbations

24 Appendix I High Investment with Infill Stations Scenario Time-Distance (“String”) Charts and Station Occupancy Charts

24.1 High Investment Scenario with Infill Stations Simulation Results without Perturbations (Ideal Day)

24.1.1 Station Occupancy Charts – Salt Lake Central

Northbound trains are shown on UTA1 with southbound trains on UTA2. Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. In both directions, trains stay on schedule with the help of the long dwells at Salt Lake Central Station. The EMU consists also help keep trains on schedule through this station with the ability to accelerate and decelerate faster through interlockings.

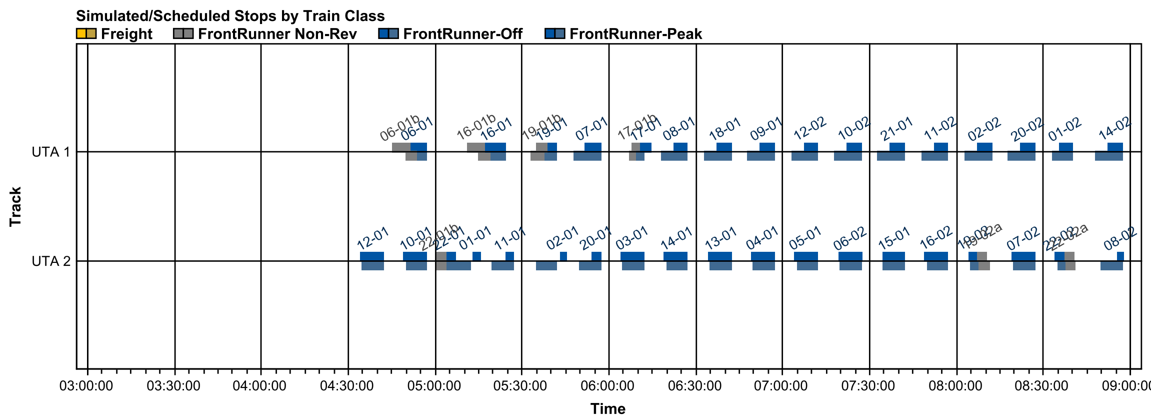


Figure 24-1: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario with Infill Stations No Added Perturbations

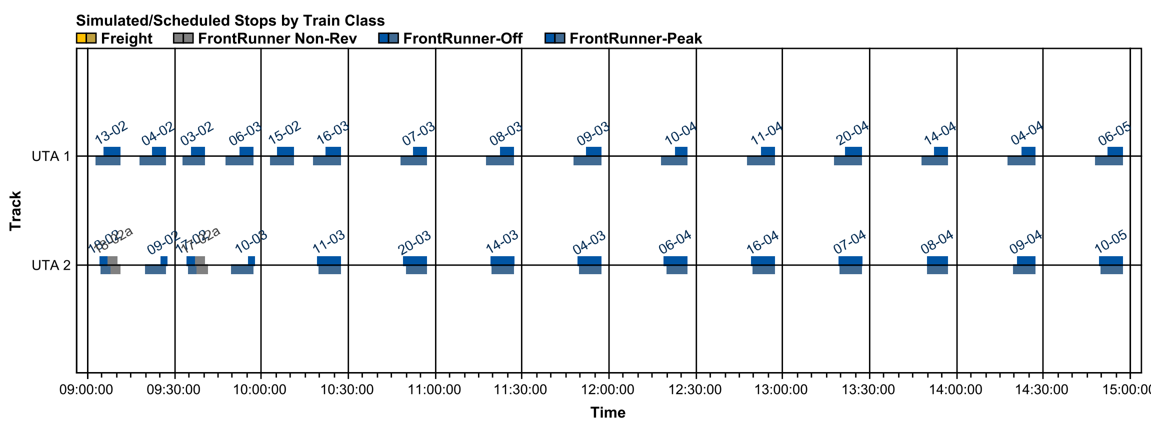


Figure 24-2: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario with Infill Stations No Added Perturbations

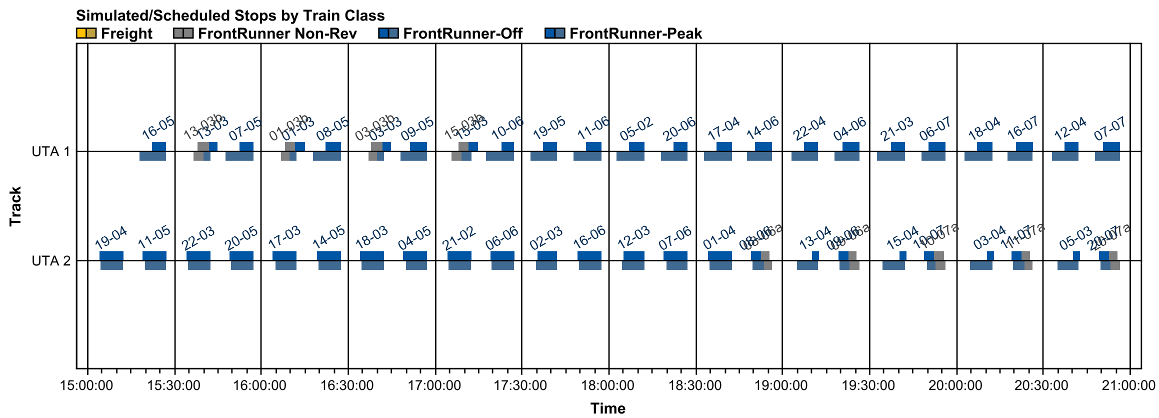


Figure 24-3: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario with Infill Stations No Added Perturbations

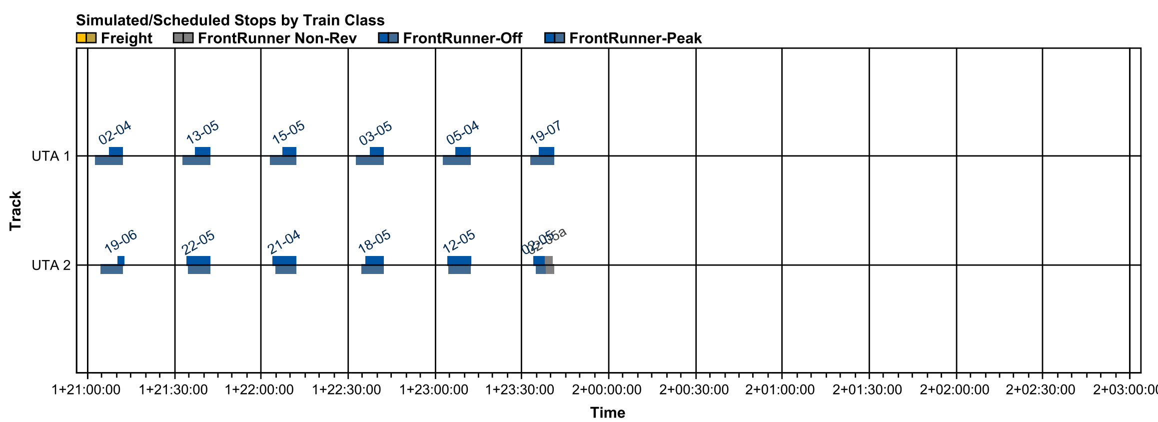


Figure 24-4: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario with Infill Stations No Added Perturbations

24.1.2 String Charts

Delays can be observed when comparing the dashed scheduled train trip lines to the solid simulated ones. The trains run very close to on-time in the No Added Perturbations run. Similar to the High Investment Scenario, there are no cascading delays, even with the addition of three infill stations between Provo and Ogden without any compensating additional double track. This is due to the faster acceleration and deceleration, and the ability to stay at a higher speed longer, with the EMU consists.

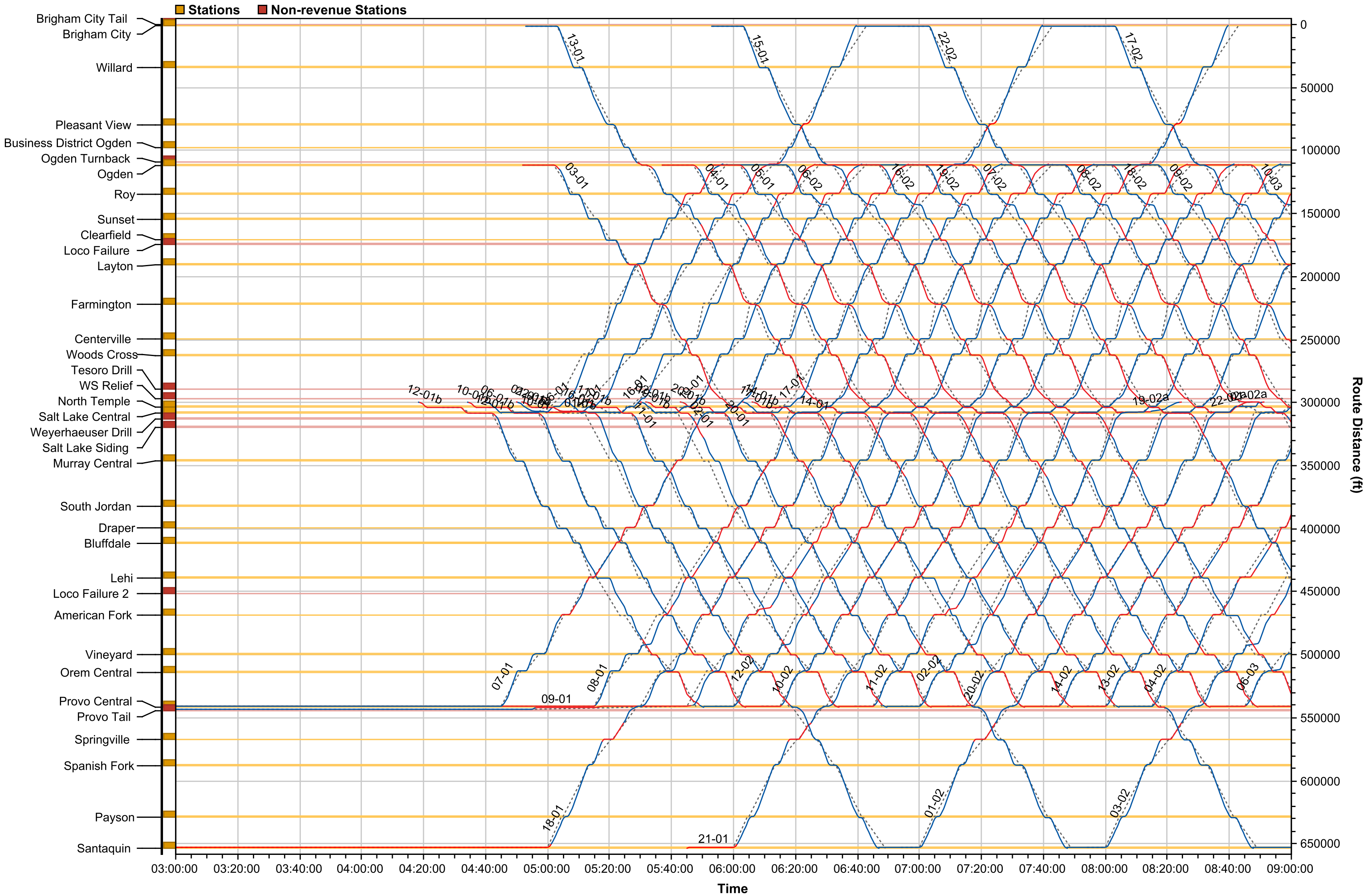


Figure 24-5: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario with Infill Stations No Added Perturbations

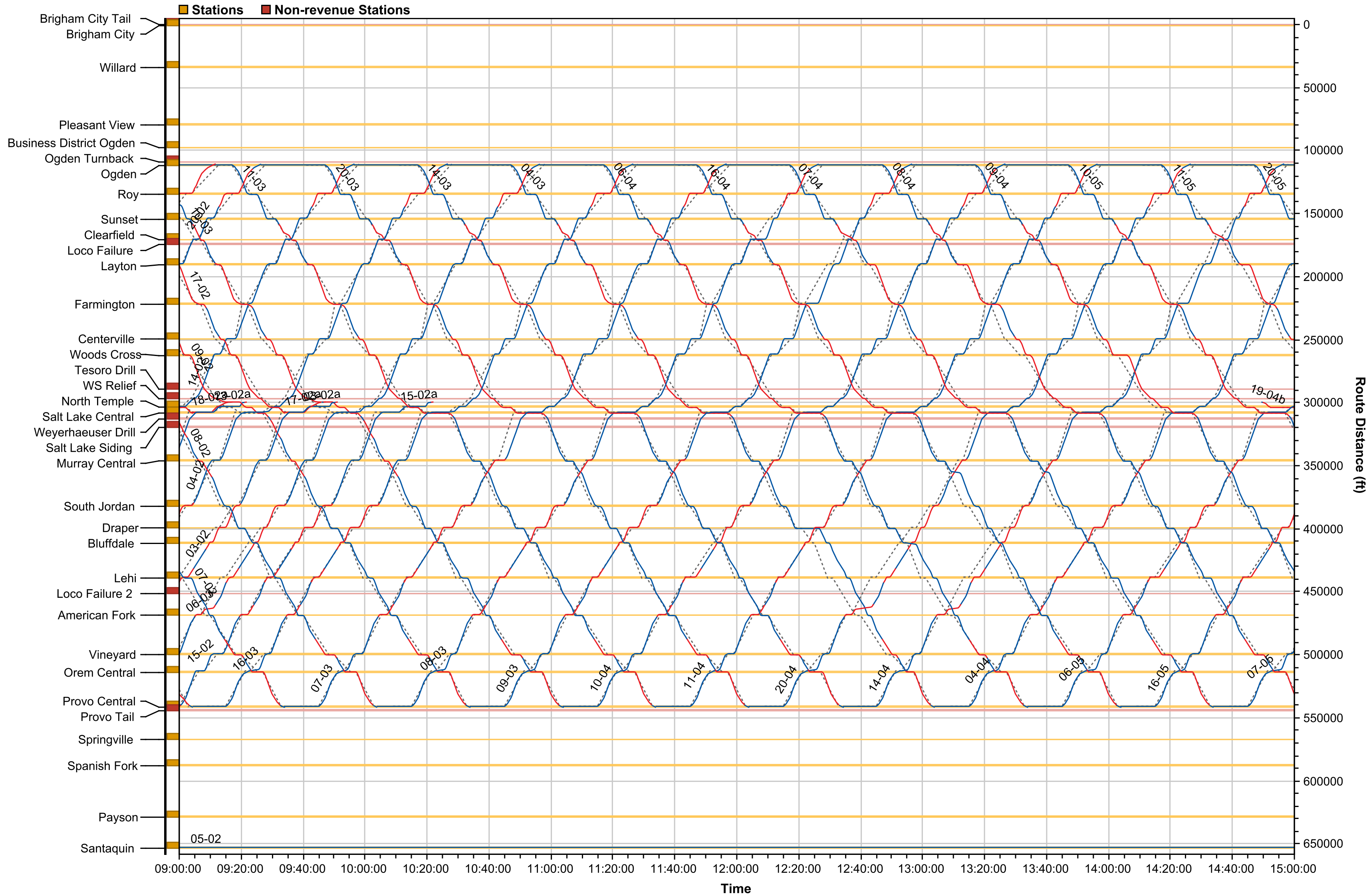


Figure 24-6: Time-Distance ("String") Chart – 9 AM – 3 PM – High Investment Scenario with Infill Stations No Added Perturbations

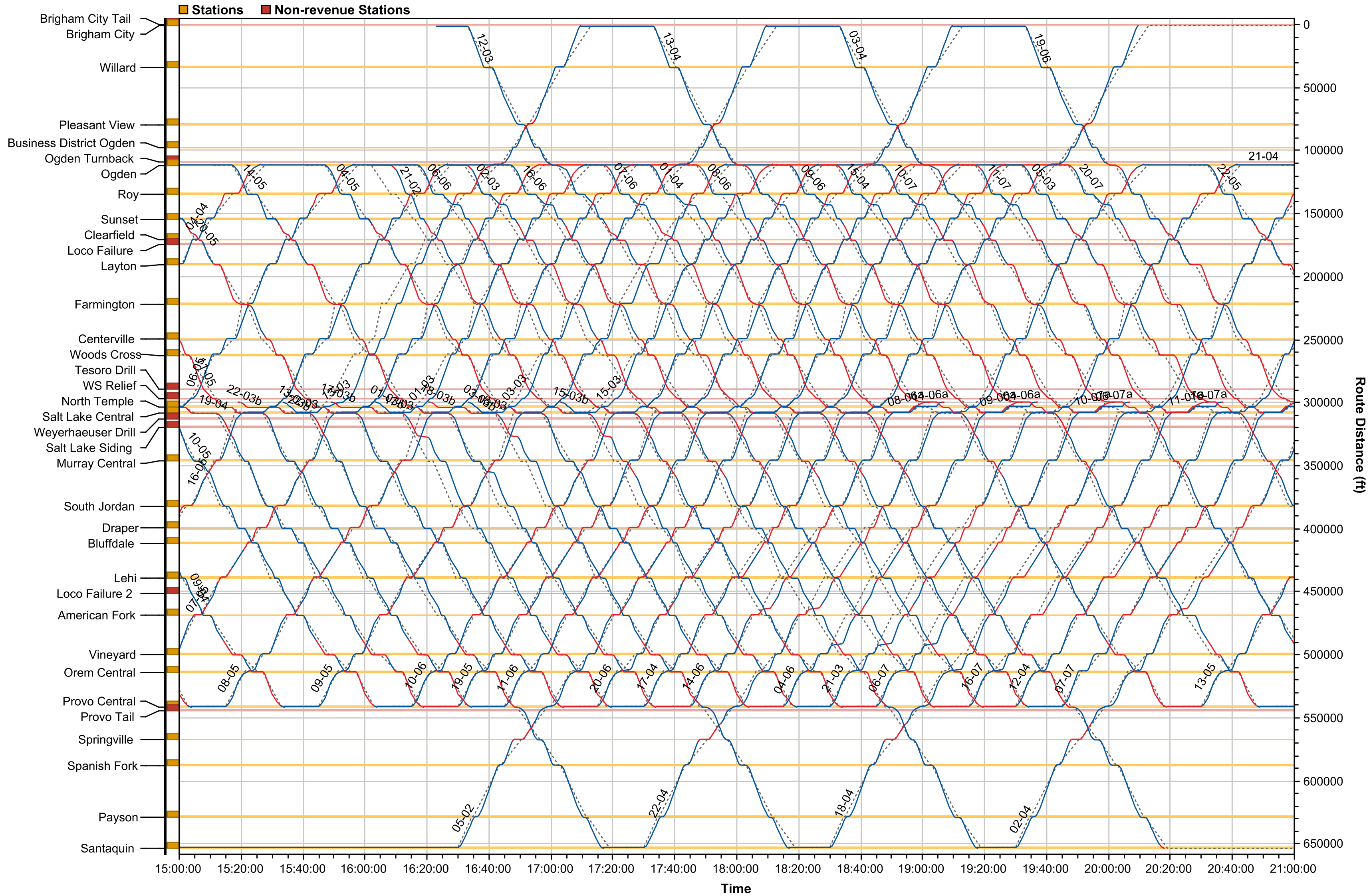


Figure 24-7: Time-Distance (“String”) Chart – 3 PM – 9 PM – High Investment Scenario with Infill Stations No Added Perturbations

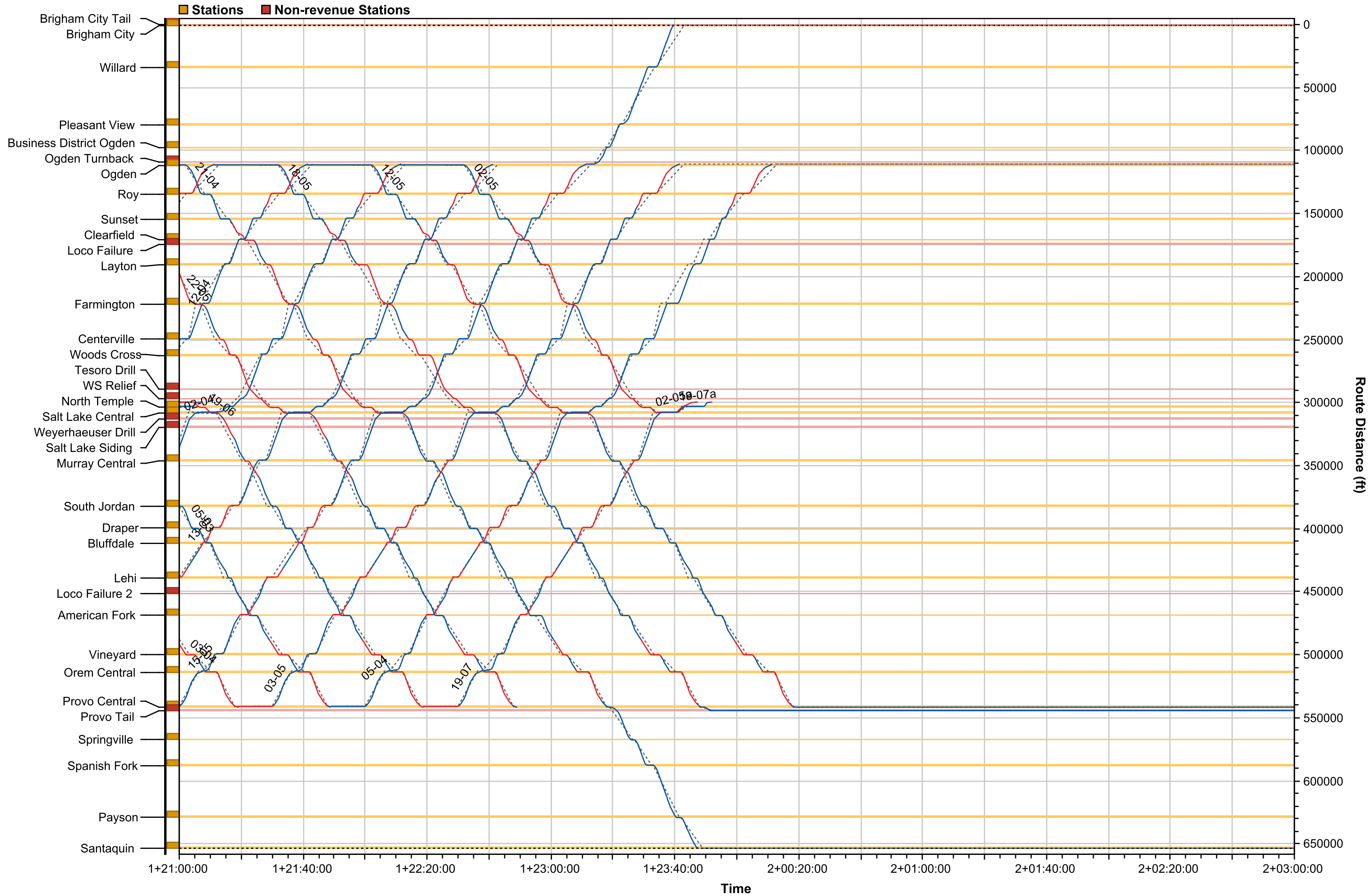


Figure 24-8: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario with Infill Stations No Added Perturbations

24.2 Day 1 High Investment Scenario with Infill Stations Simulation Results with Perturbations

The FrontRunner - Day 1 operating plan includes a randomly-assigned door failure for train 1-04 at South Jordan station. This causes a 7-minute extended dwell. Day 1 also includes a 5-minute delay for train 10-01 at North Temple due to the randomly-assigned need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

24.2.1 Station Occupancy Charts – Salt Lake Central

Northbound trains are shown on UTA1 with southbound trains on UTA2. Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. Northbound trains arrive later at the end of the afternoon peak due to the door failure on train 1-04.

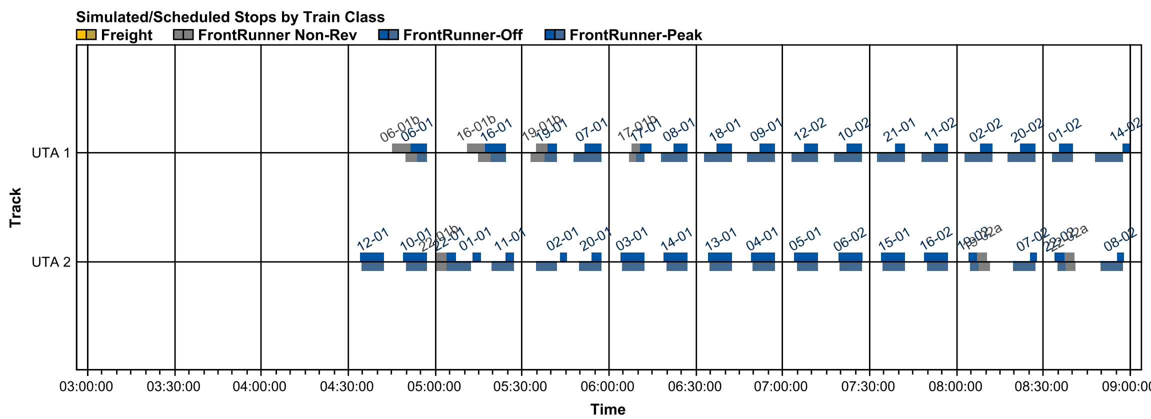


Figure 24-9: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario with Infill Stations Day 1 Simulation Results with Perturbations

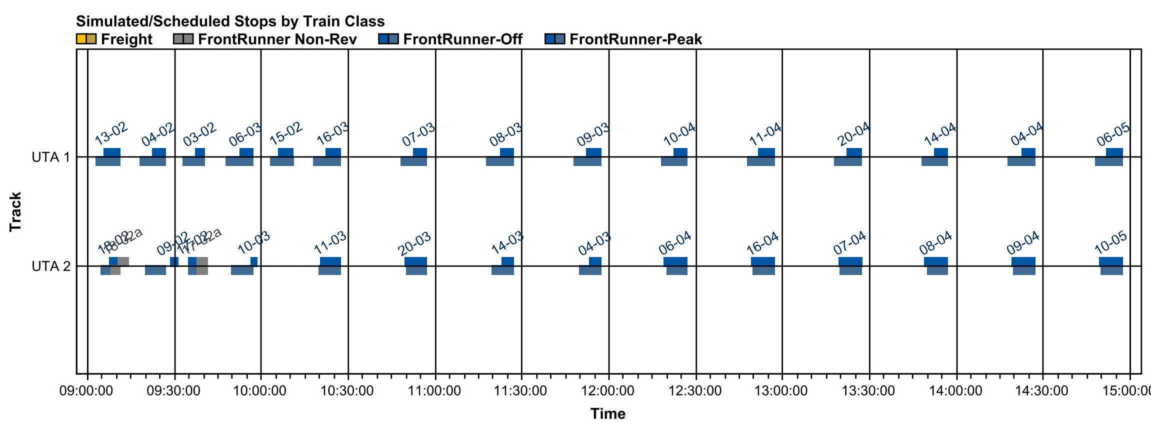


Figure 24-10: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario with Infill Stations Day 1 Simulation Results with Perturbations

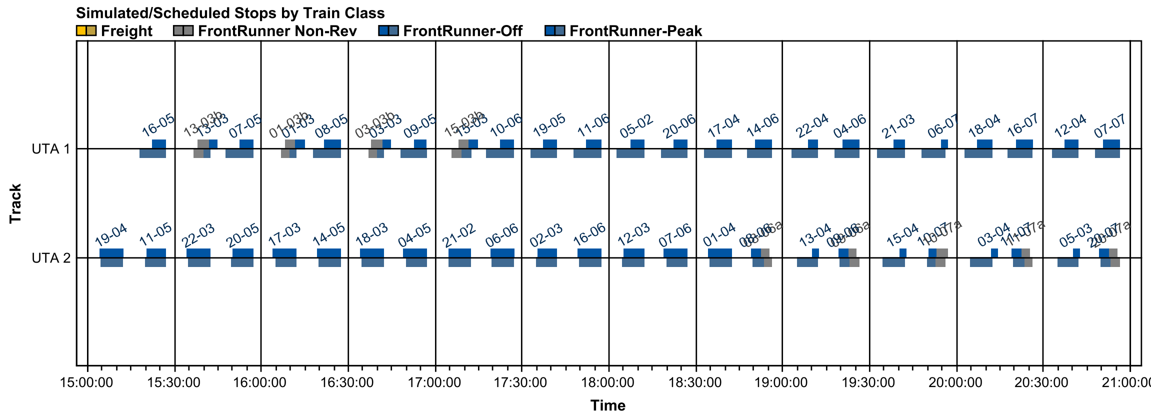


Figure 24-11: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario with Infill Stations Day 1 Simulation Results with Perturbations

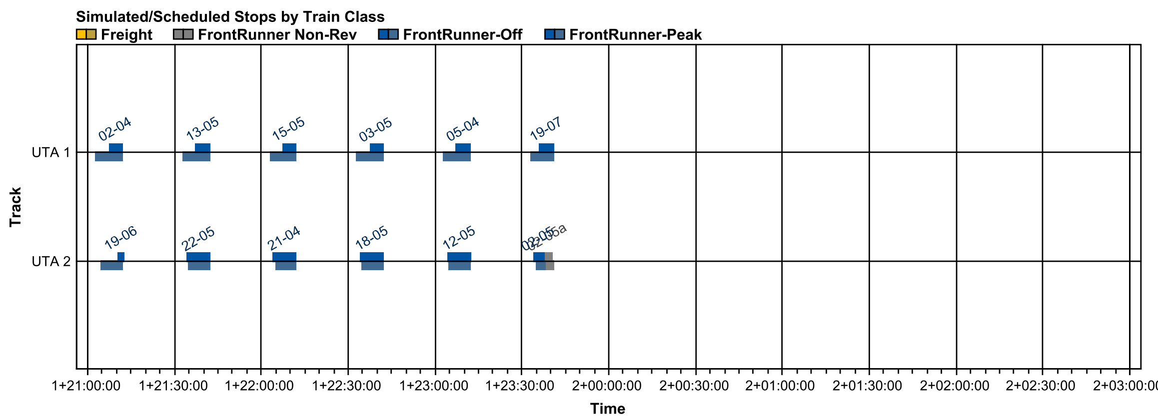


Figure 24-12: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario with Infill Stations Day 1 Simulation Results with Perturbations

24.2.2 String Charts

Figure 24-13 shows the randomly-assigned 5-minute delay for train 10-02 at North Temple due to the need to hold for a late TRAX connection. With the help of the extended sidings, train 10-02 is on schedule by Clearfield Station and has minimal delays to the northbound trains that meet it.

Figure 24-15 shows the 7-minute extended dwell perturbation to train 1-04. This causes minimal delays to northbound trains that are able to quickly rectify themselves with the help of the long dwell at Salt Lake Central Station.

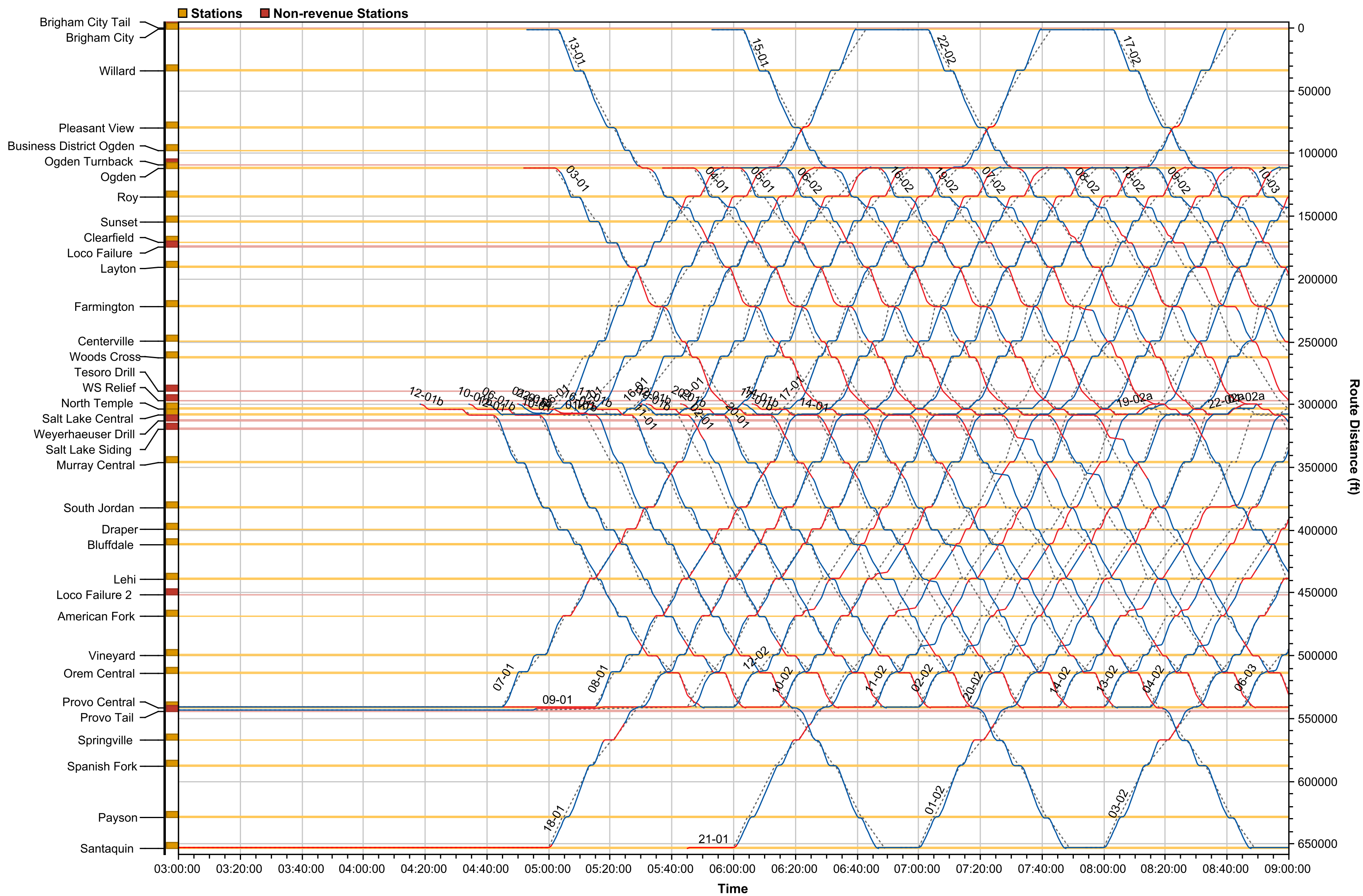


Figure 24-13: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario with Infill Stations Day 1 Simulation Results with Perturbations

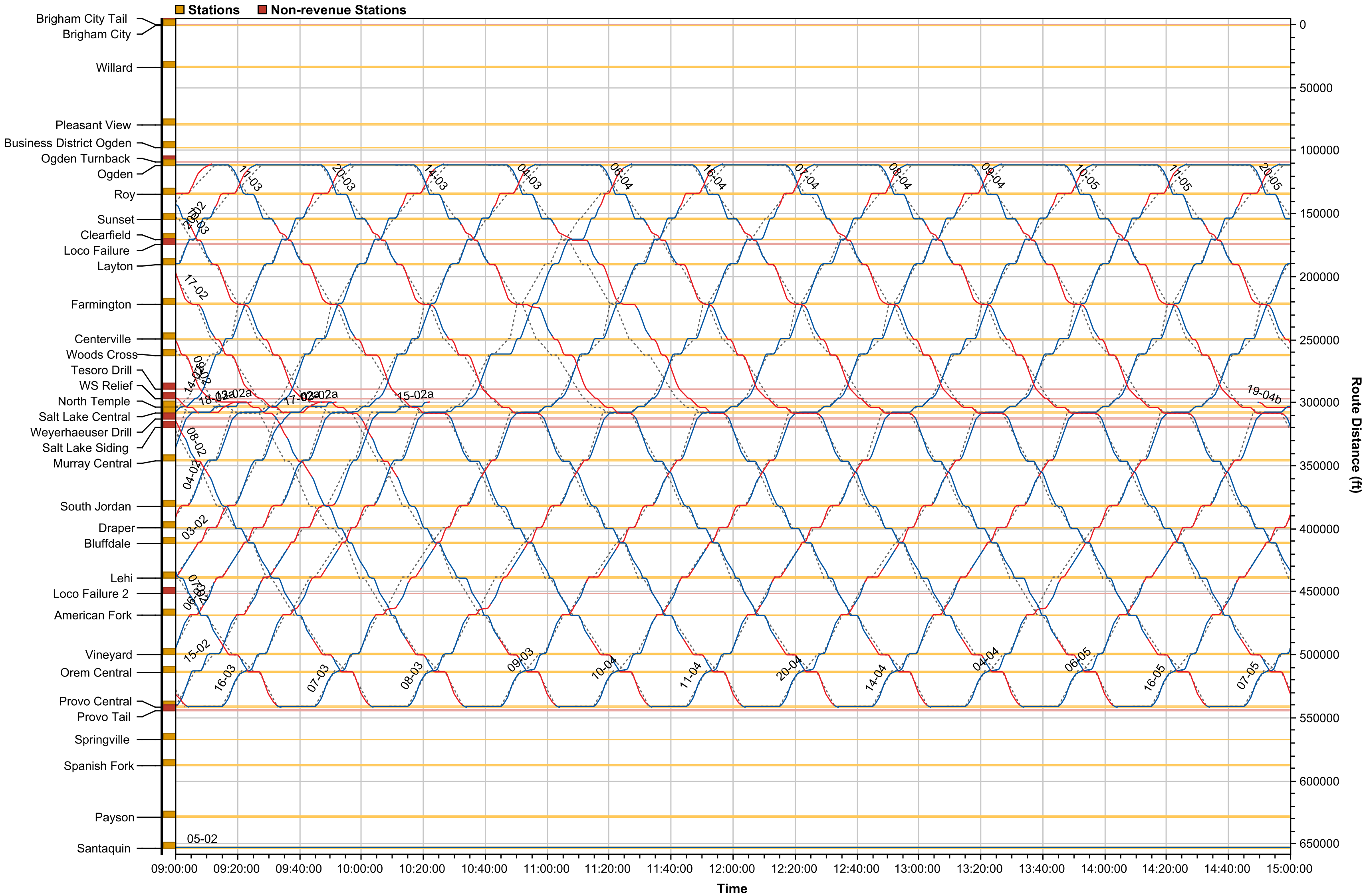


Figure 24-14: Time-Distance (“String”) Chart – 9 AM – 3 PM – High Investment Scenario with Infill Stations Day 1 Simulation Results with Perturbations

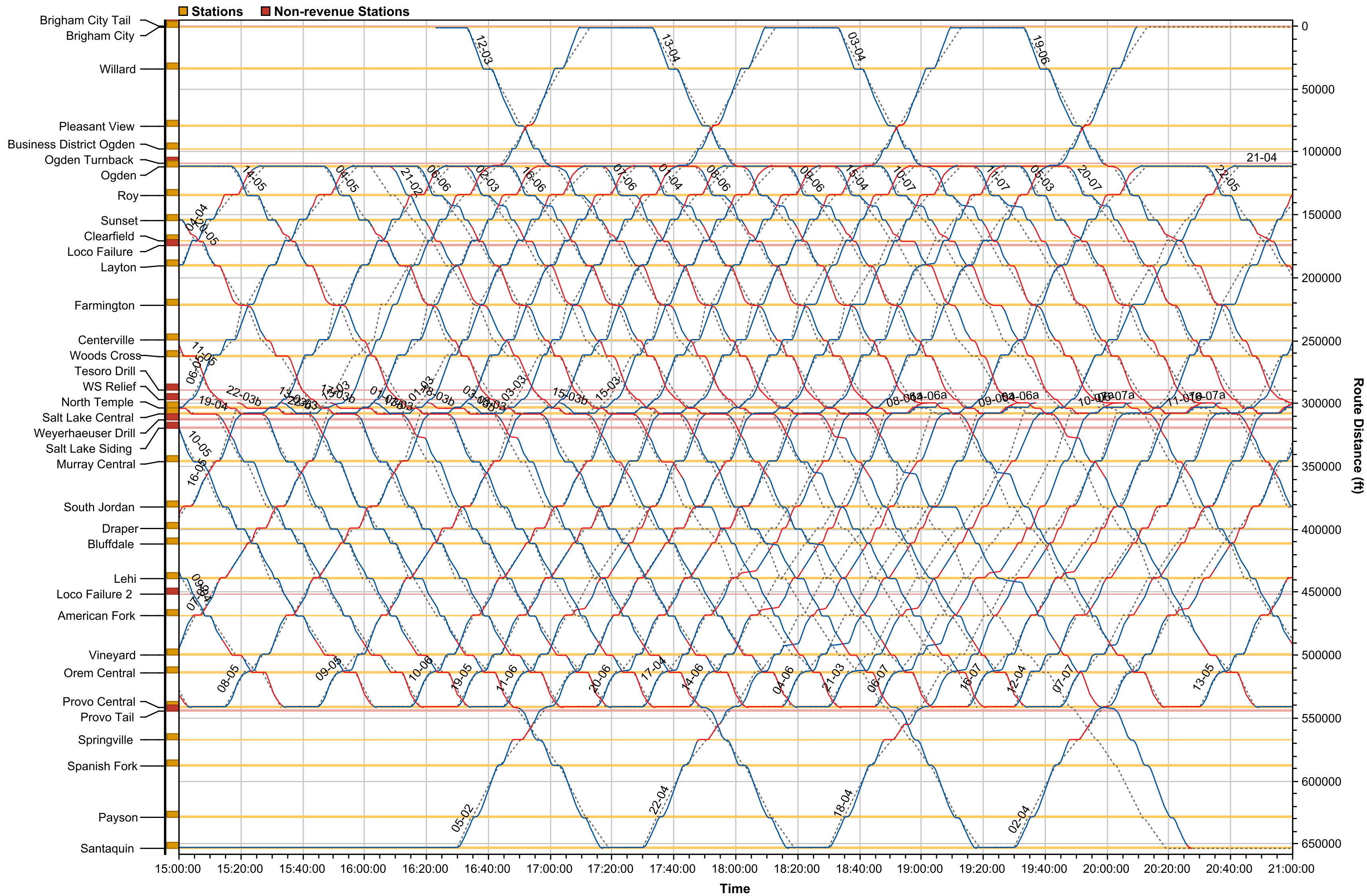


Figure 24-15: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario with Infill Stations Day 1 Simulation Results with Perturbations

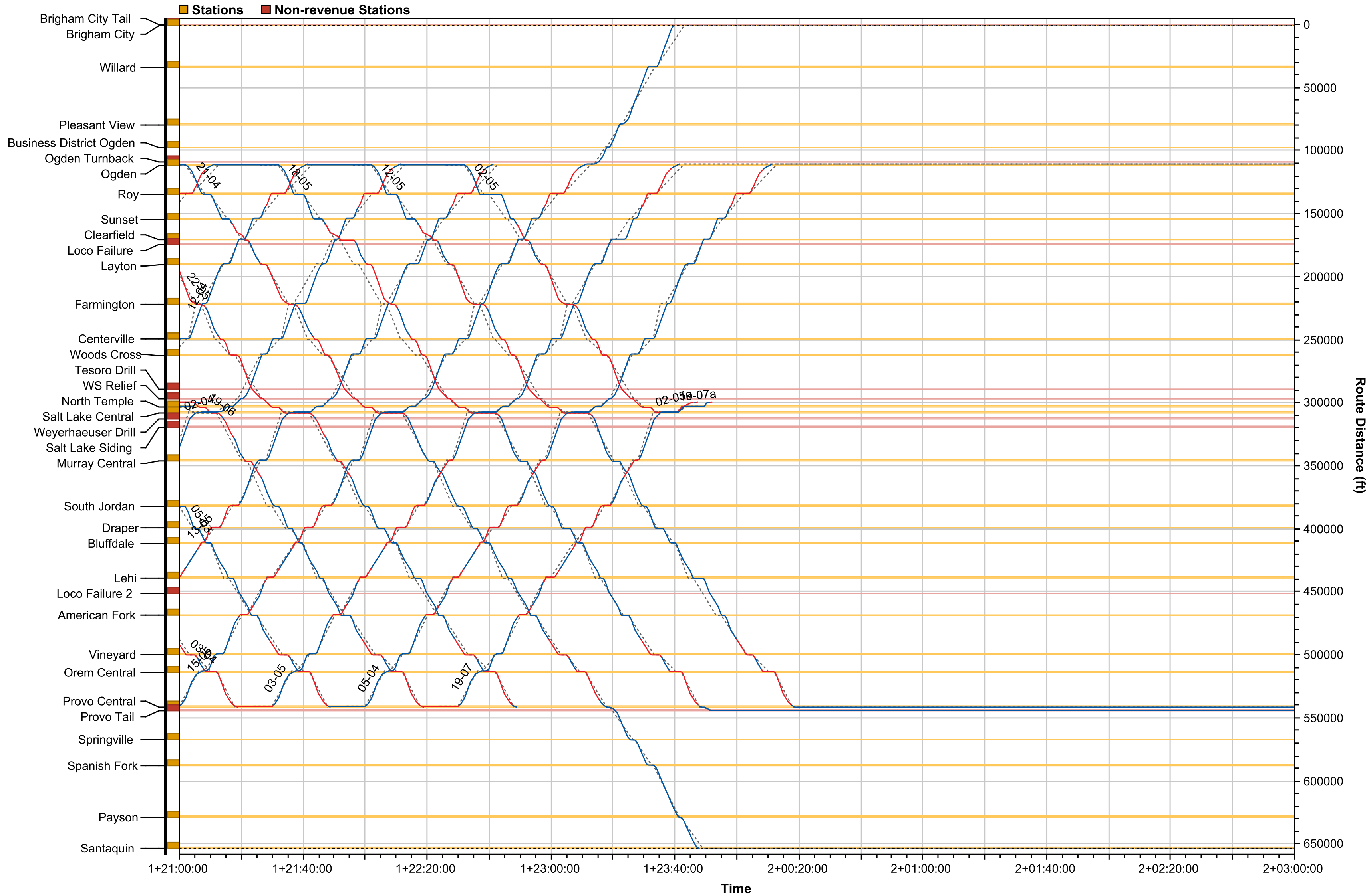


Figure 24-16: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario with Infill Stations Day 1 Simulation Results with Perturbations

24.3 Day 2 High Investment Scenario with Infill Stations Simulation Results with Perturbations

The FrontRunner - Day 2 operating plan perturbations include a 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM due to a crossing failure/broken gate. Day 2 also includes a 5-minute delay for train 20-02 at North Temple due to the need to hold for a late TRAX connection. Station occupancy charts and string charts are included in the following sections.

24.3.1 Station Occupancy Charts – Salt Lake Central

Northbound trains are shown on UTA1 with southbound trains on UTA2. Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. The crossing failure in the afternoon peak period causes northbound trains to arrive and depart very late.

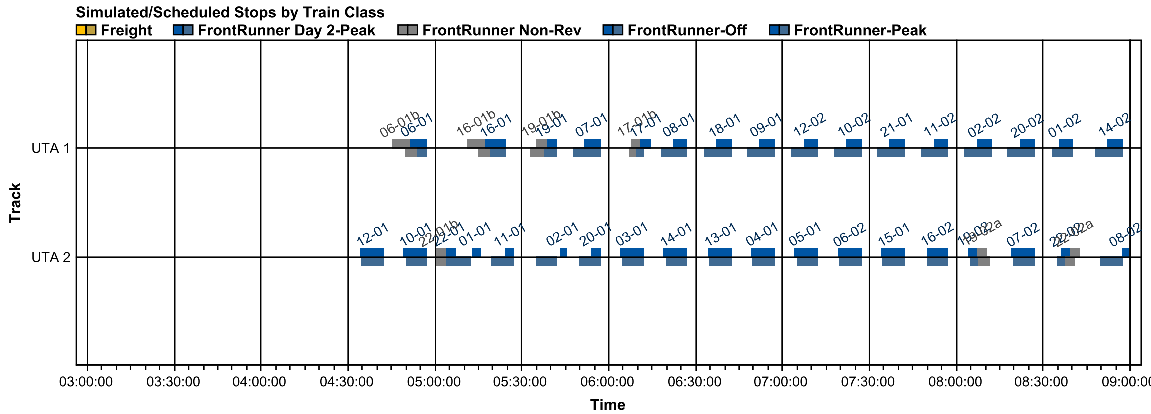


Figure 24-17: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario with Infill Stations Day 2 Simulation Results with Perturbations

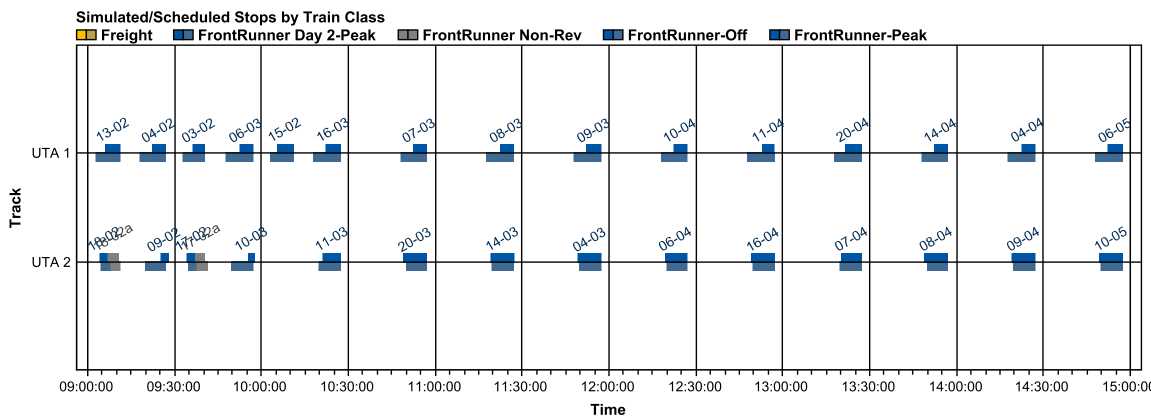


Figure 24-18: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario with Infill Stations Day 2 Simulation Results with Perturbations

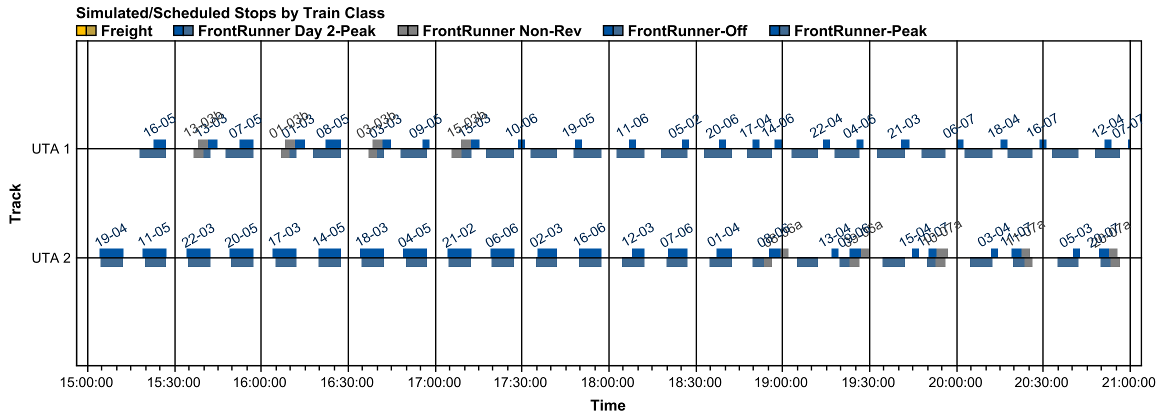


Figure 24-19: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM –
High Investment Scenario with Infill Stations Day 2 Simulation Results with Perturbations

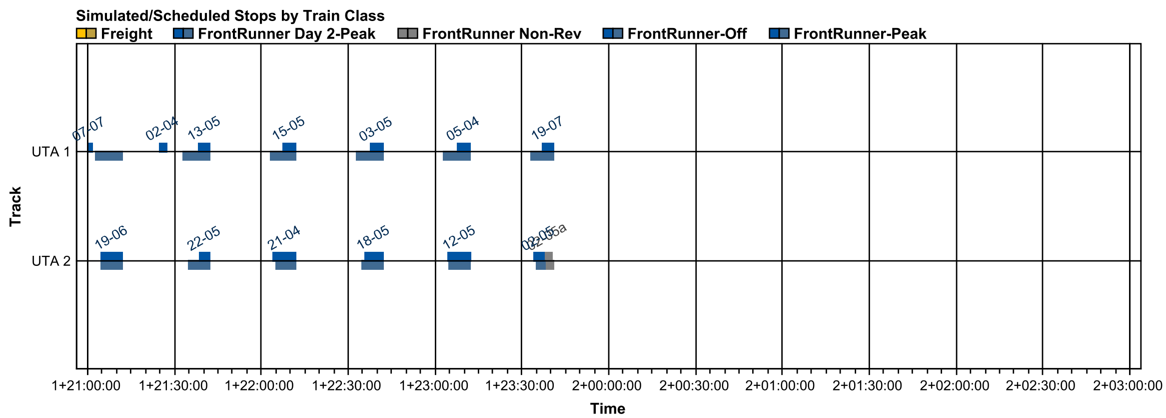


Figure 24-20: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM –
High Investment Scenario with Infill Stations Day 2 Simulation Results with Perturbations

24.3.2 String Charts

Figure 24-21 shows the randomly-assigned 5-minute delay for train 20-02 at North Temple due to the need to hold for a late TRAX connection. There are very few consequences from this delay and the train is back on schedule by Roy Station.

Figure 24-23 shows the 15 MPH speed restriction through 4500 South Grade Crossing (North of Murray) from 4:10 PM through 6:10 PM. The lower speed is evident in the more horizontal slopes of the string lines through this period. The crossing failure causes severe cascading delays and has impacts to trains in both directions until nearly the end of the service day.

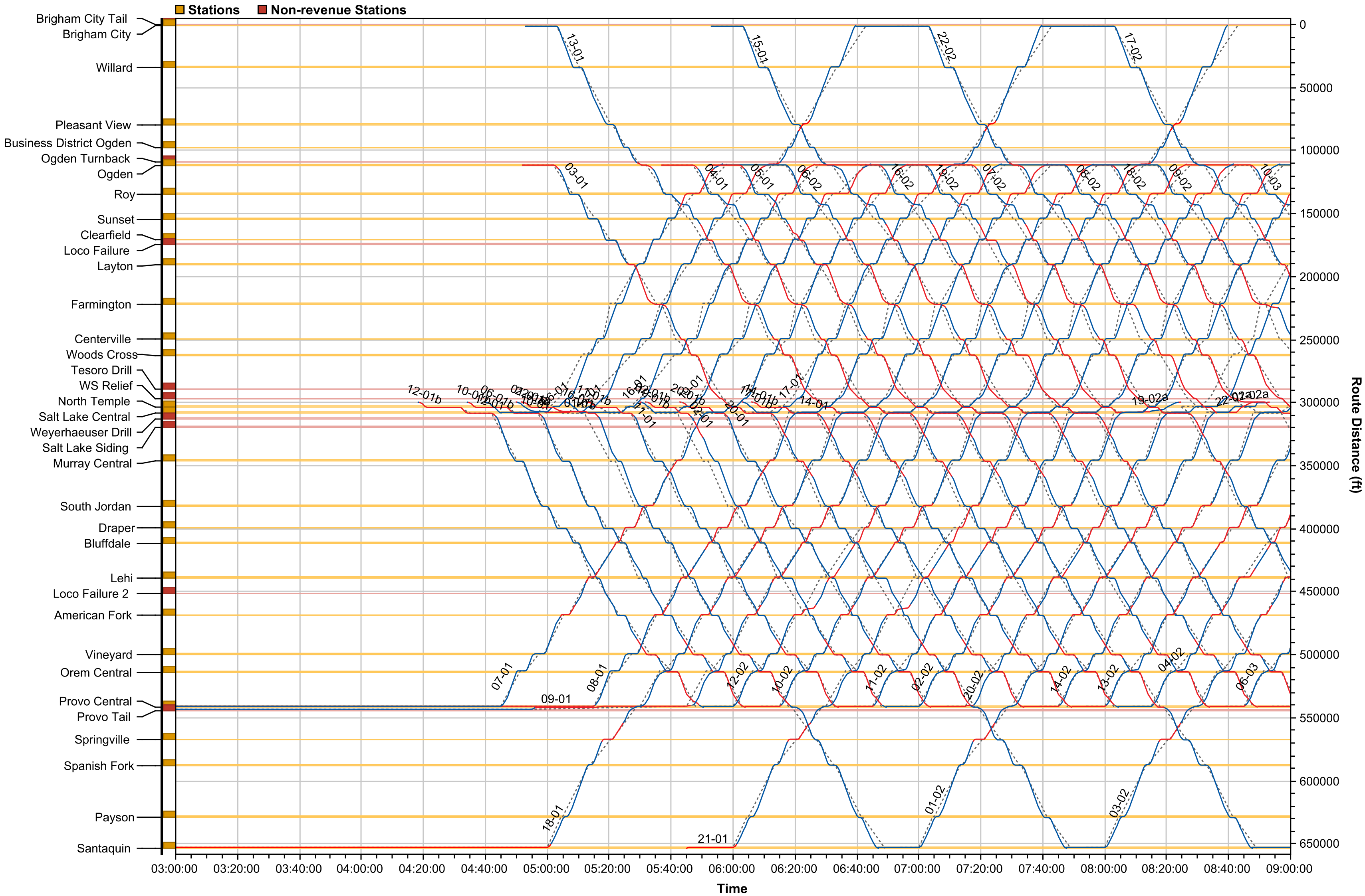


Figure 24-21: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario with Infill Stations Day 2 Simulation Results with Perturbations

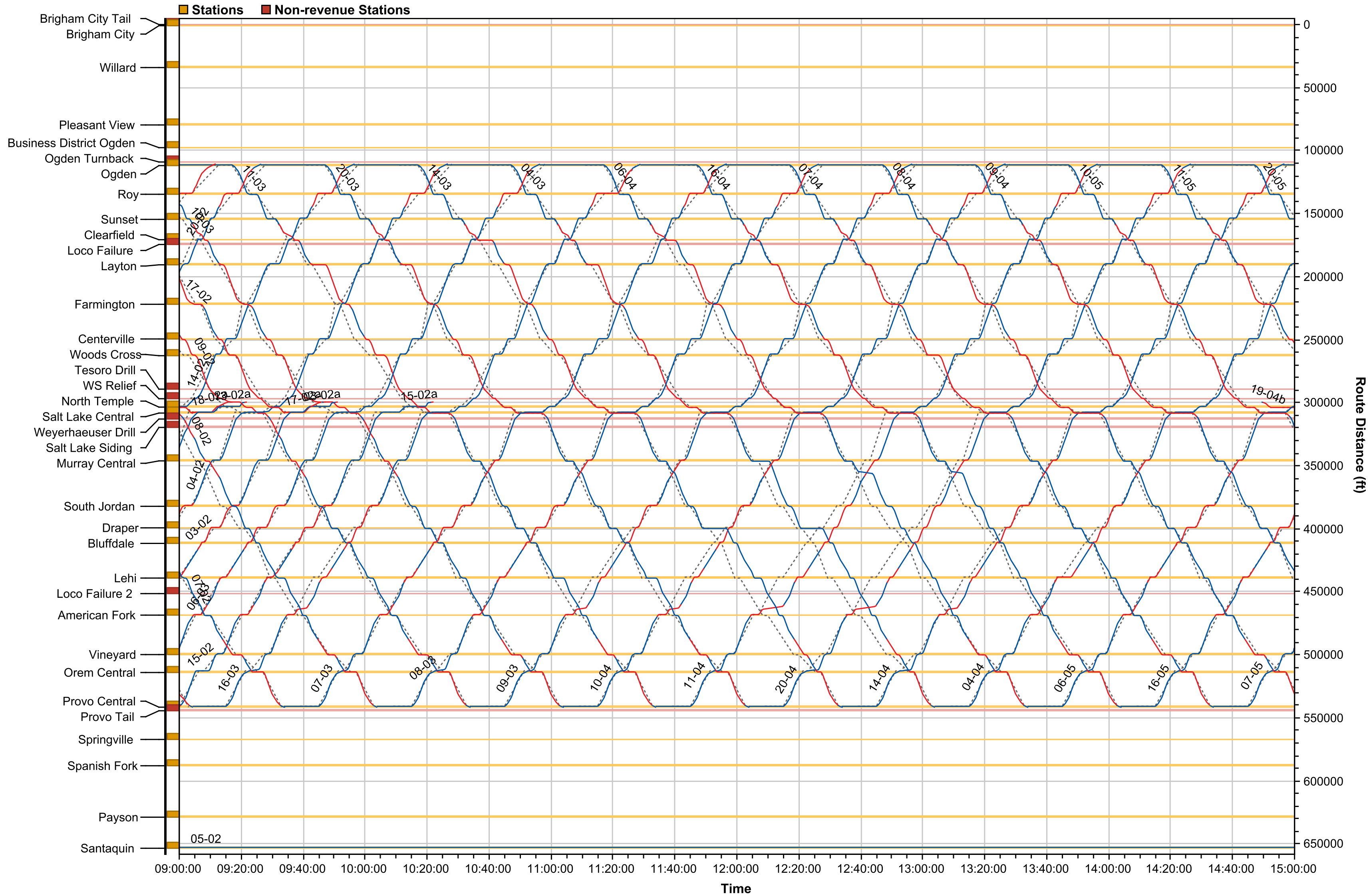


Figure 24-22: Time-Distance ("String") Chart – 9 AM – 3 PM – High Investment Scenario with Infill Stations Day 2 Simulation Results with Perturbations

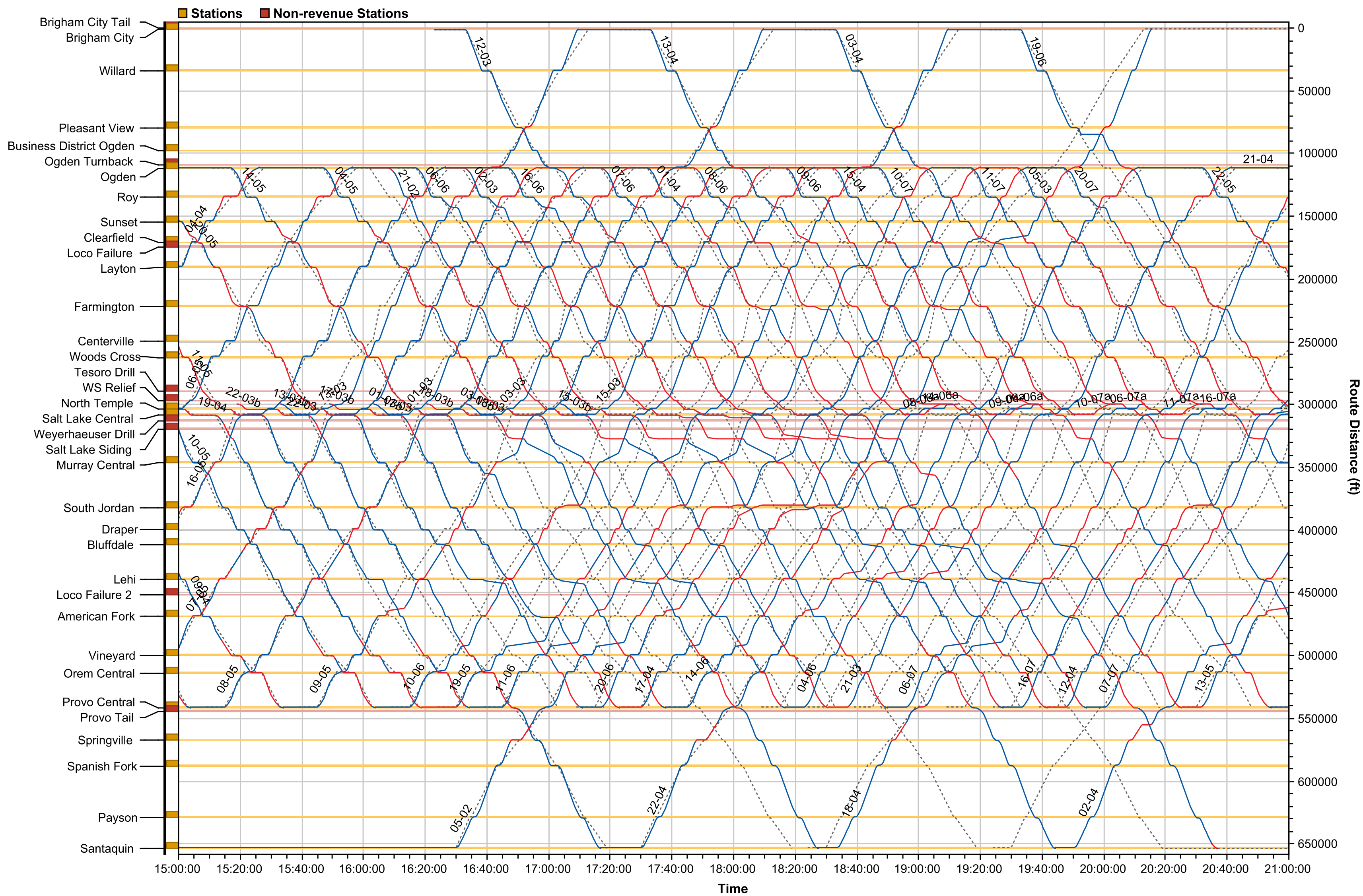


Figure 24-23: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario with Infill Stations Day 2 Simulation Results with Perturbations

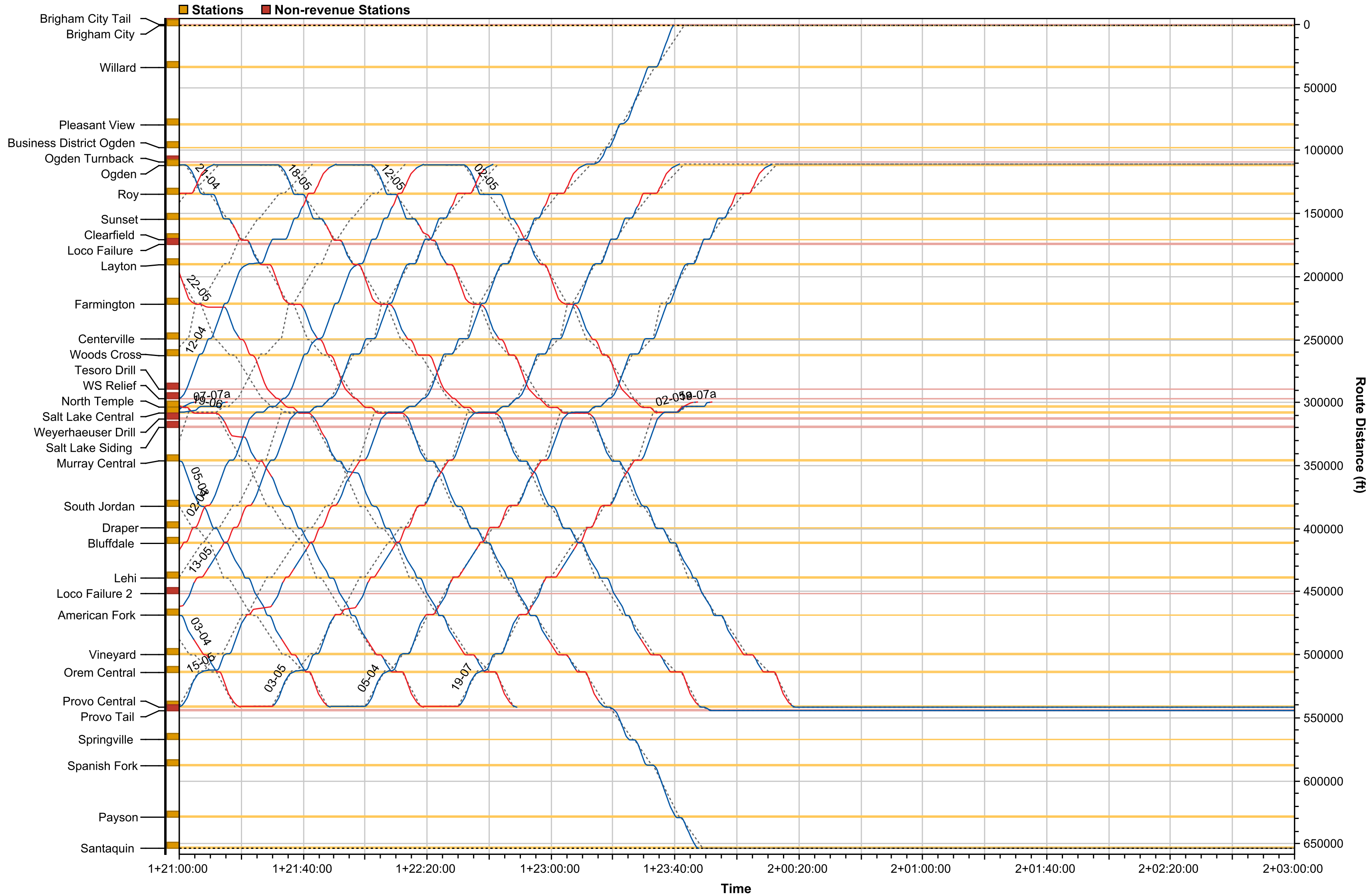


Figure 24-24: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario with Infill Stations Day 2 Simulation Results with Perturbations

24.4 Day 3 High Investment Scenario with Infill Stations Simulation Results with Perturbations

The FrontRunner - Day 3 operating plan includes a locomotive failure on train 10-03 between Layton station and Clearfield station causing the train to stop for 10-minutes while the locomotive is reset. Day 3 also includes a door failure for train 6-03 at Woods Cross Station. This causes an assumed 7-minute extended dwell while the door is cut out and removed from service. Station occupancy charts and string charts are included in the following sections.

24.4.1 Station Occupancy Charts – Salt Lake Central

Northbound trains are shown on UTA1 with southbound trains on UTA2. Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. In both directions, trains stay on schedule with the help of the long dwells at Salt Lake Central Station.

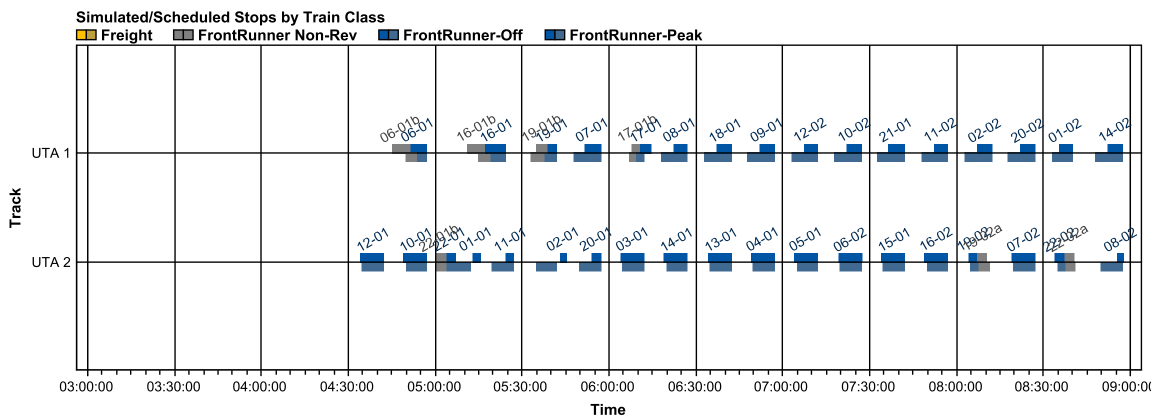


Figure 24-25: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario with Infill Stations Day 3 Simulation Results with Perturbations

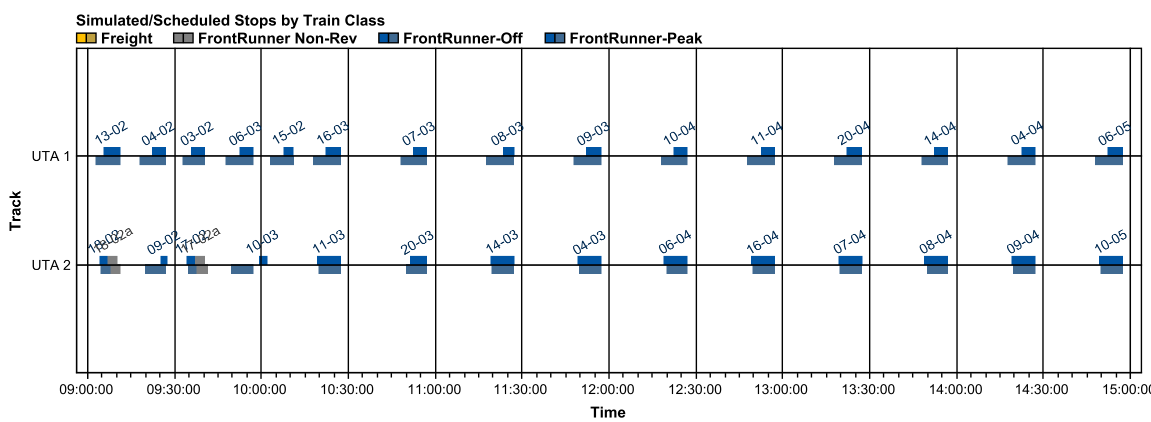


Figure 24-26: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario with Infill Stations Day 3 Simulation Results with Perturbations

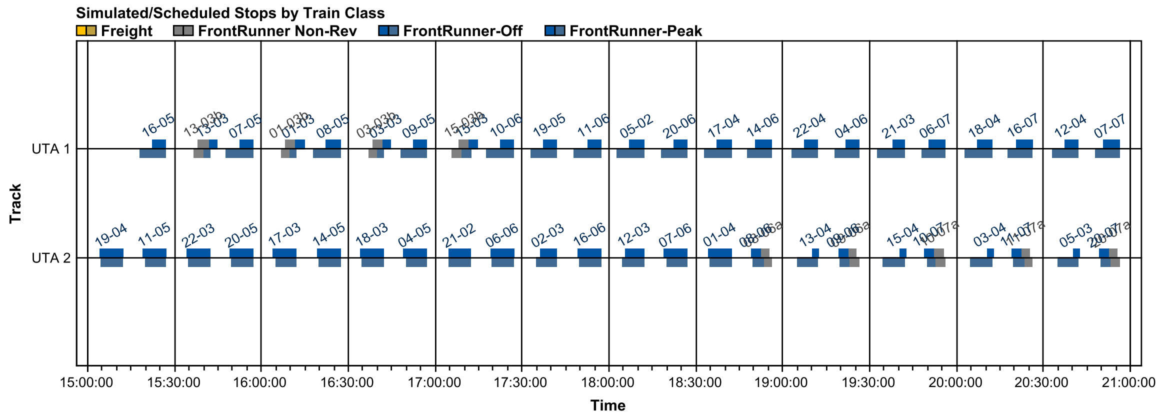


Figure 24-27: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario with Infill Stations Day 3 Simulation Results with Perturbations

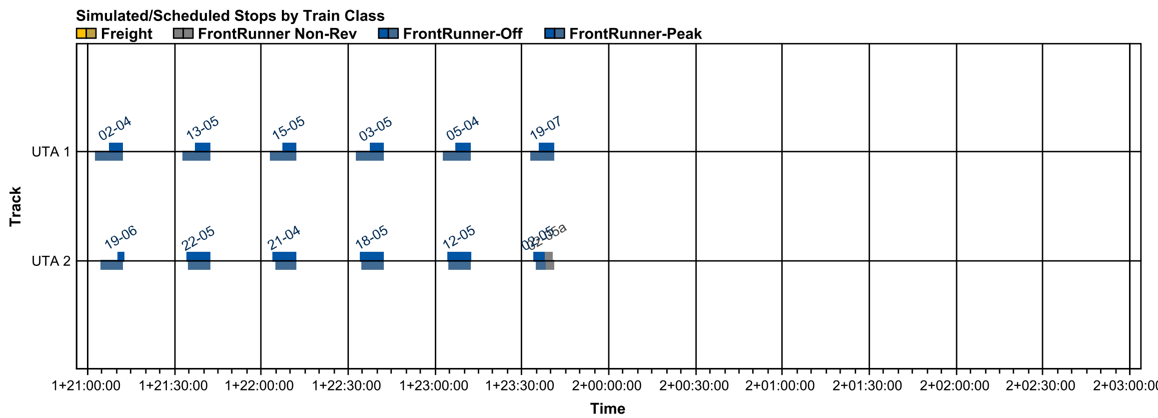


Figure 24-28: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario with Infill Stations Day 3 Simulation Results with Perturbations

24.4.2 String Charts

The Day 3 perturbation of train 10-03 experiencing a 10-minute delay in between Clearfield station and Layton station is shown in Figure 24-29 and Figure 24-30. With the help of extended sidings, train 10-03 causes minimal delays to northbound trains and it is running on time by the Orem Central Station.

The door failure on train 6-03, shown in Figure 24-29 and Figure 24-30 causes minimal disruptions to southbound trains and it arrives Roy Station on time.

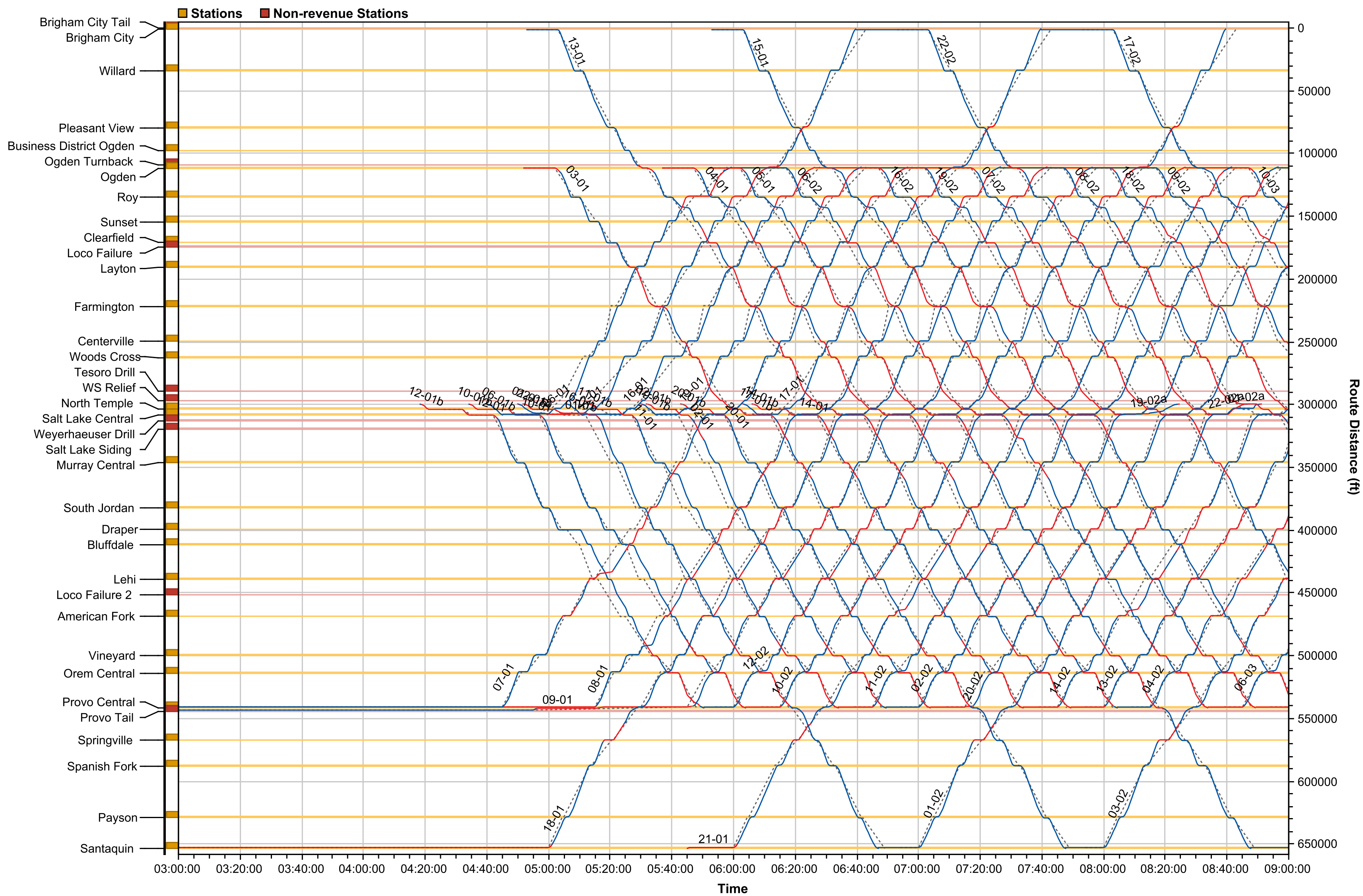


Figure 24-29: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario with Infill Stations Day 3 Simulation Results with Perturbations

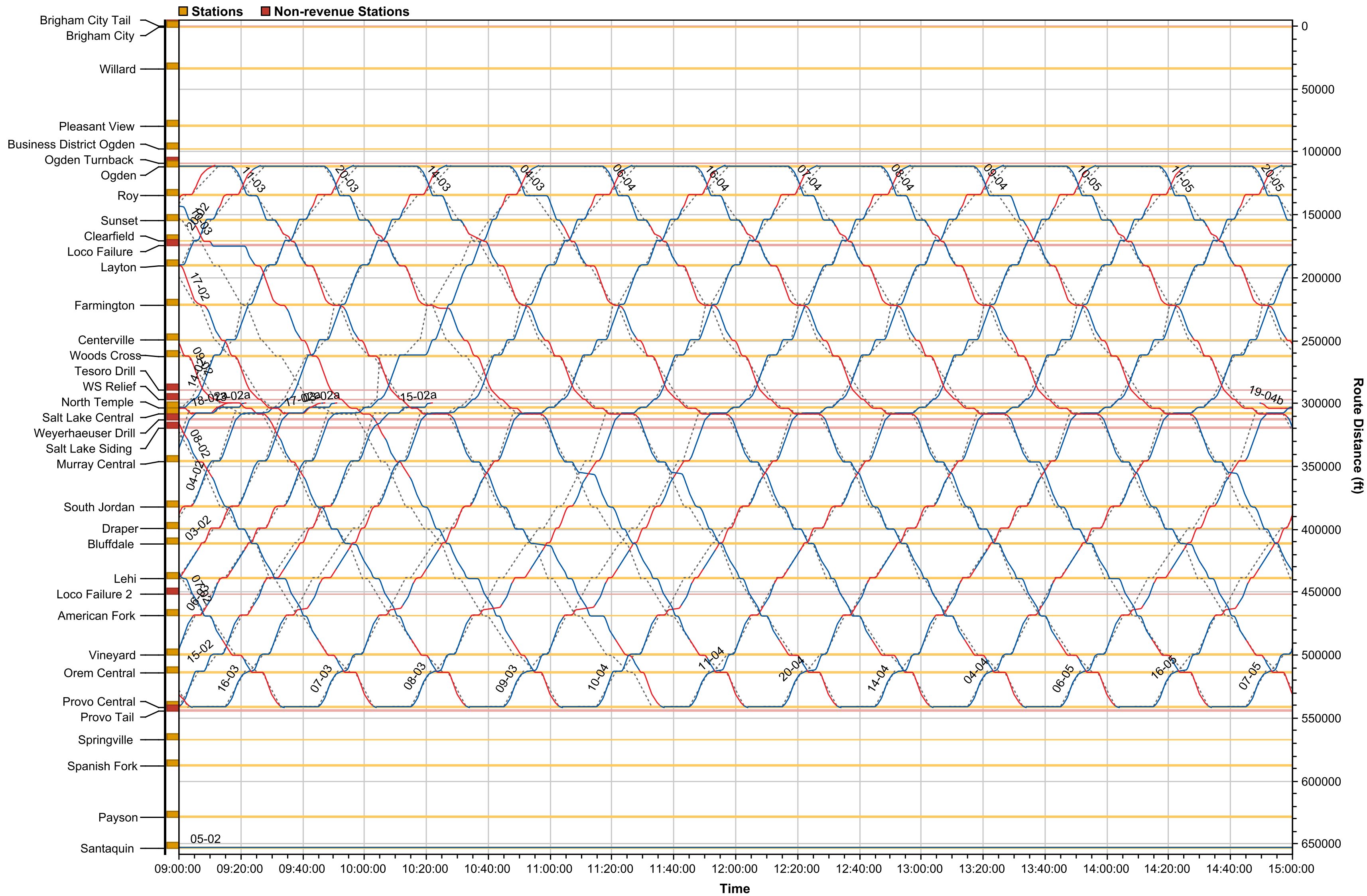


Figure 24-30: Time-Distance ("String") Chart – 9 AM – 3 PM – High Investment Scenario with Infill Stations Day 3 Simulation Results with Perturbations

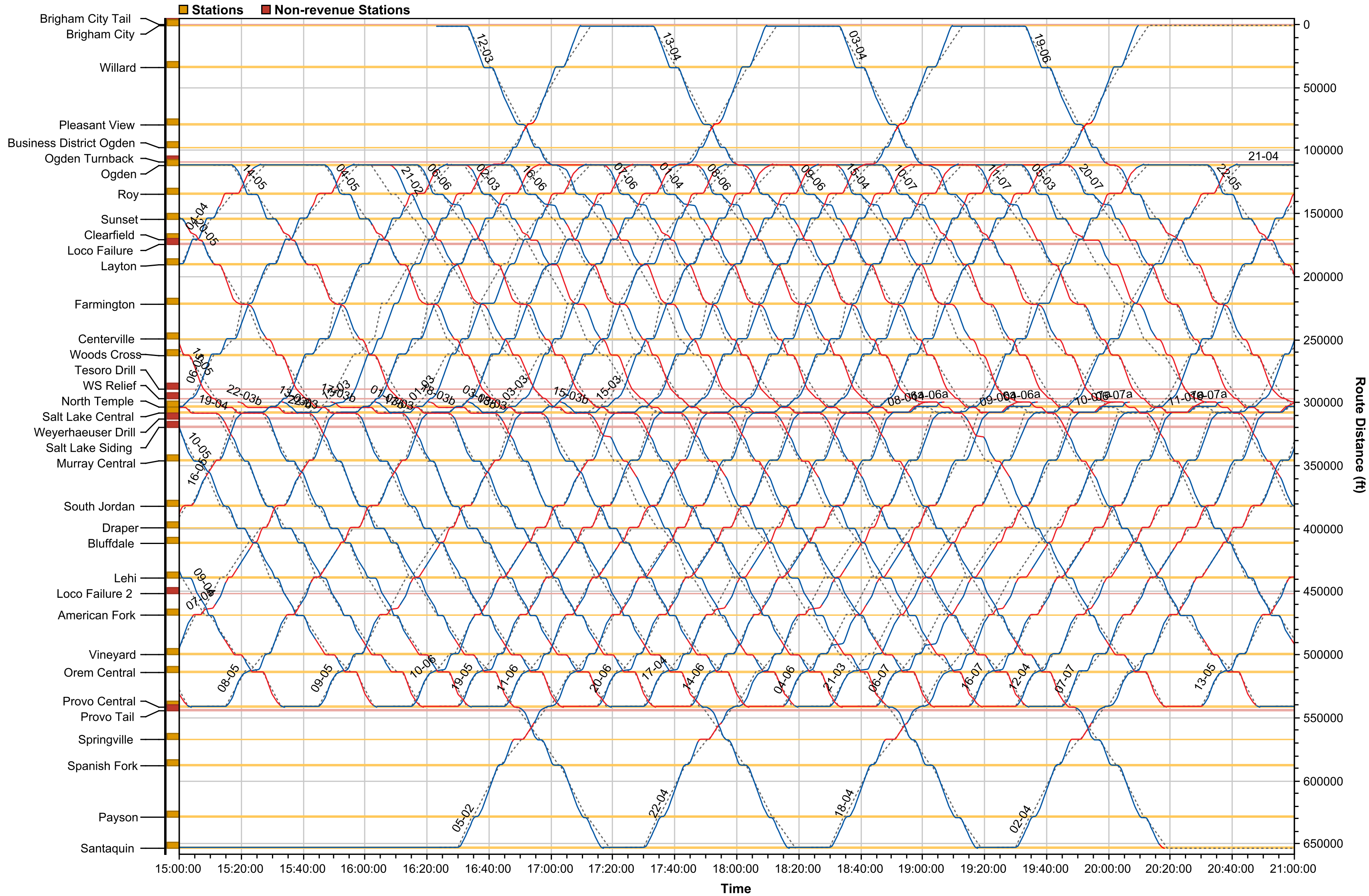


Figure 24-31: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario with Infill Stations Day 3 Simulation Results with Perturbations

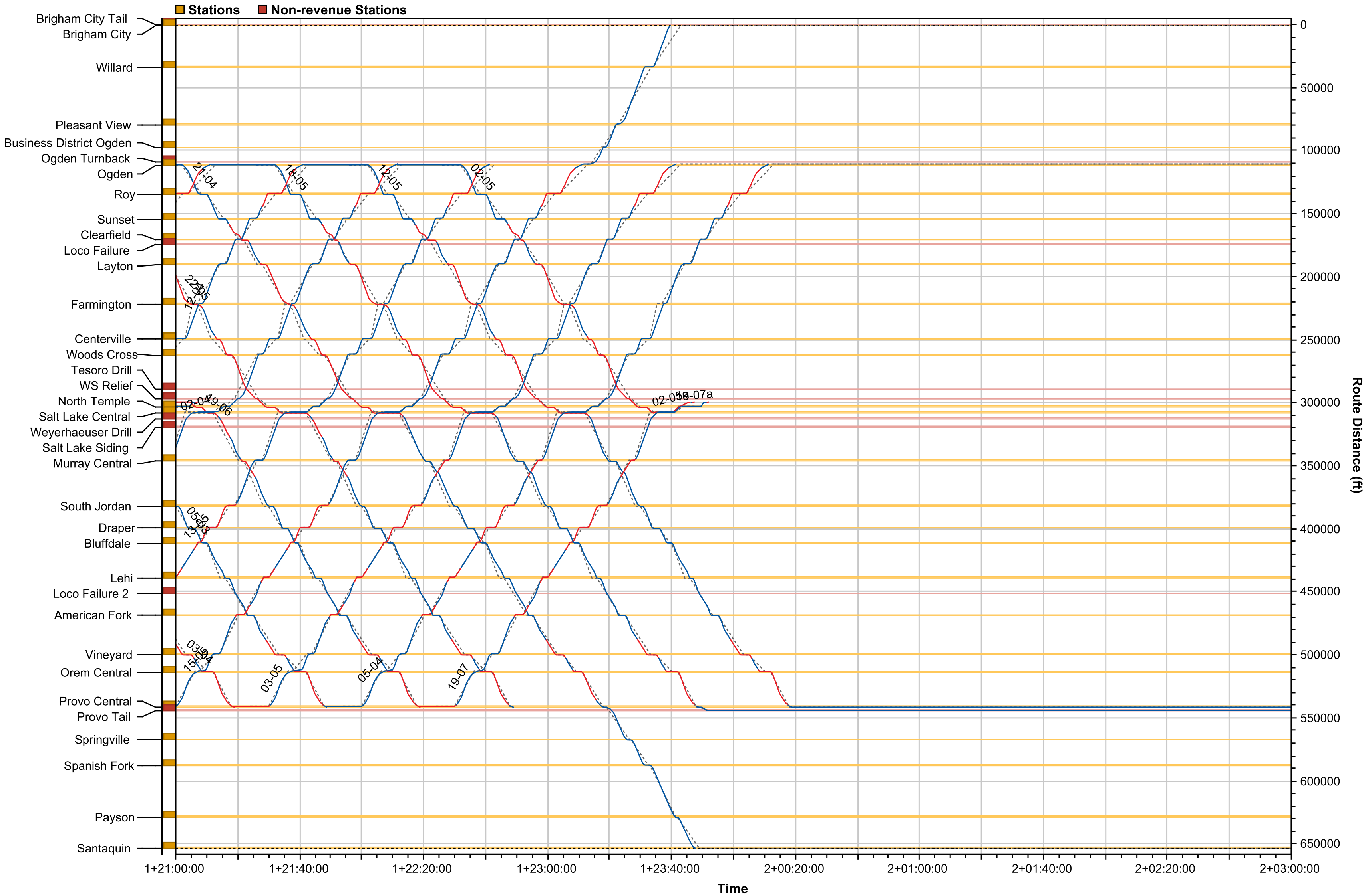


Figure 24-32: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario with Infill Stations Day 3 Simulation Results with Perturbations

24.5 Day 4 High Investment Scenario with Infill Stations Simulation Results with Perturbations

The FrontRunner - Day 4 operating plan includes a door failure for train 16-03 at Orem Station. This causes an assumed 7-minute extended dwell while the door failure is resolved. Day 4 also includes a 15 MPH speed restriction through 9400 South Grade Crossing (North of South Jordan) from 6:30 AM through 8:30 AM due to a crossing failure/broken gate. Salt Lake Central station occupancy charts and full network string charts are included in the following sections.

24.5.1 Station Occupancy Charts – Salt Lake Central

Northbound trains are shown on UTA1 with southbound trains on UTA2. Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. Most northbound trains arrive and depart late in the morning peak period due to the crossing failure.

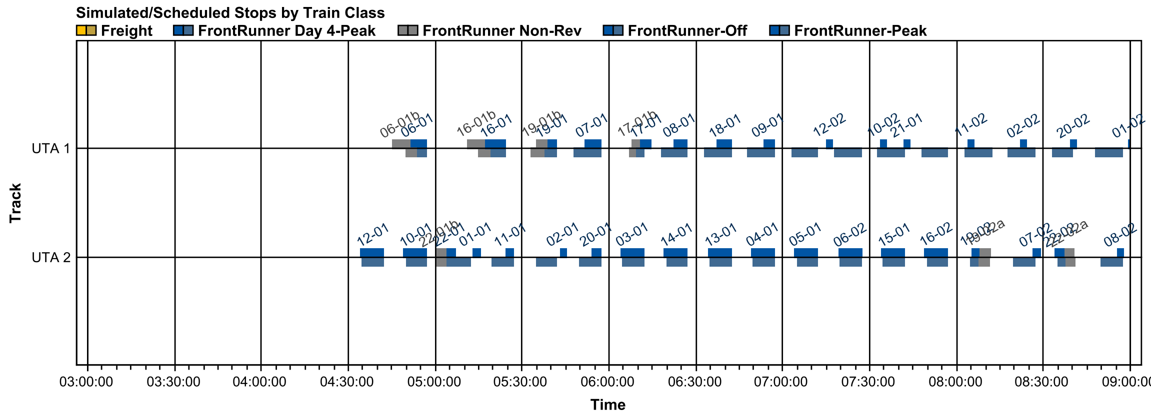


Figure 24-33: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario with Infill Stations Day 4 Simulation Results with Perturbations

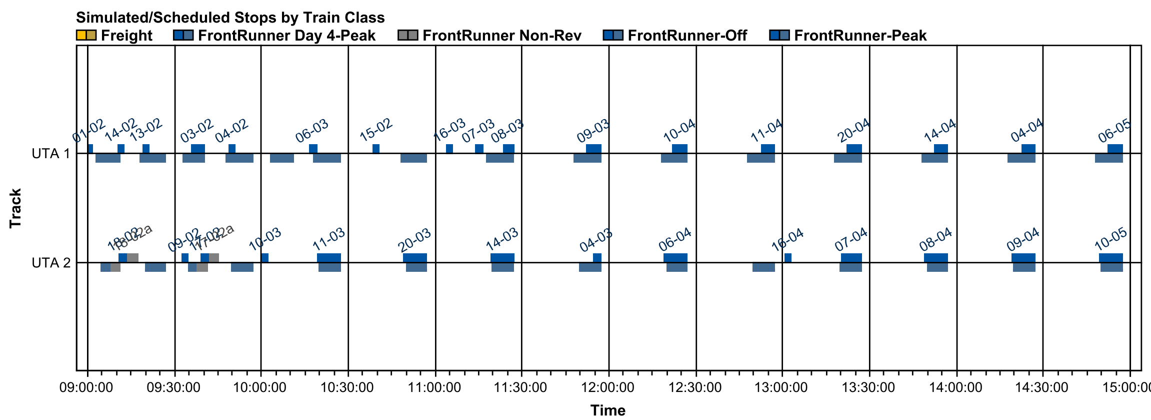


Figure 24-34: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario with Infill Stations Day 4 Simulation Results with Perturbations

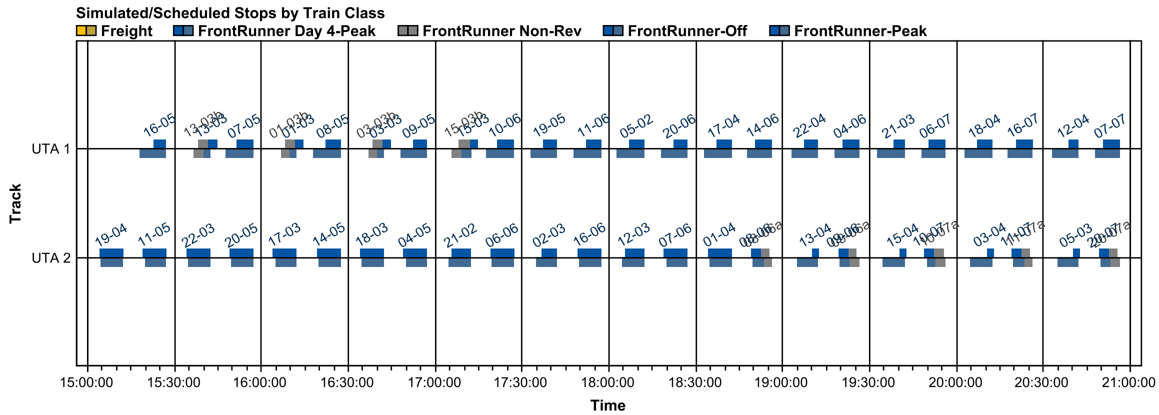


Figure 24-35: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario with Infill Stations Day 4 Simulation Results with Perturbations

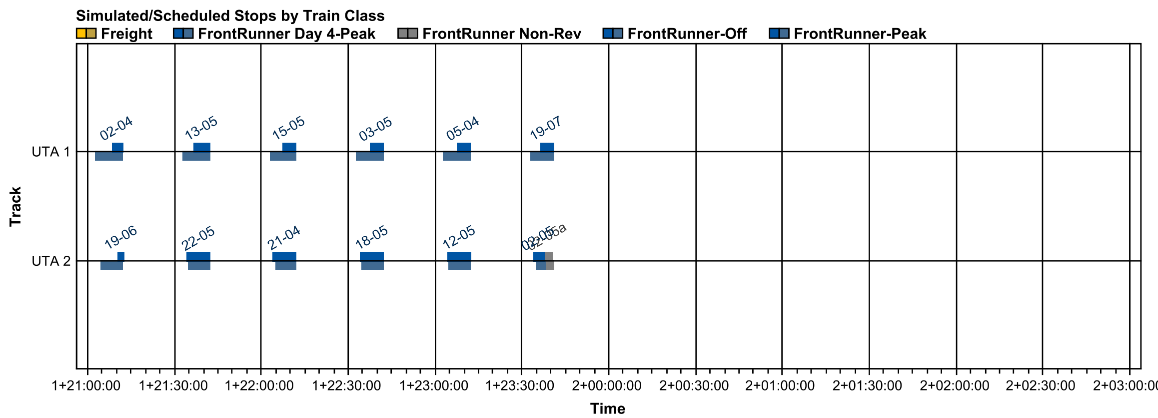


Figure 24-36: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario with Infill Stations Day 4 Simulation Results with Perturbations

24.5.2 String Charts

The Day 4 perturbation of a 15 MPH speed restriction through a grade crossing just north of South Jordan is shown in Figure 19-3749. This causes cascading delays to the trains throughout the morning peak period.

Figure 19-3850 shows the door failure for train 16-03 at Orem Station. This assumed 7-minute extended dwell while the door is disabled causes train 16-03 to run even later after it has been delayed by the crossing failure. The return southbound trip, 16-04, departs Ogden Station late and is finally able to get back on time at Vineyard Station.

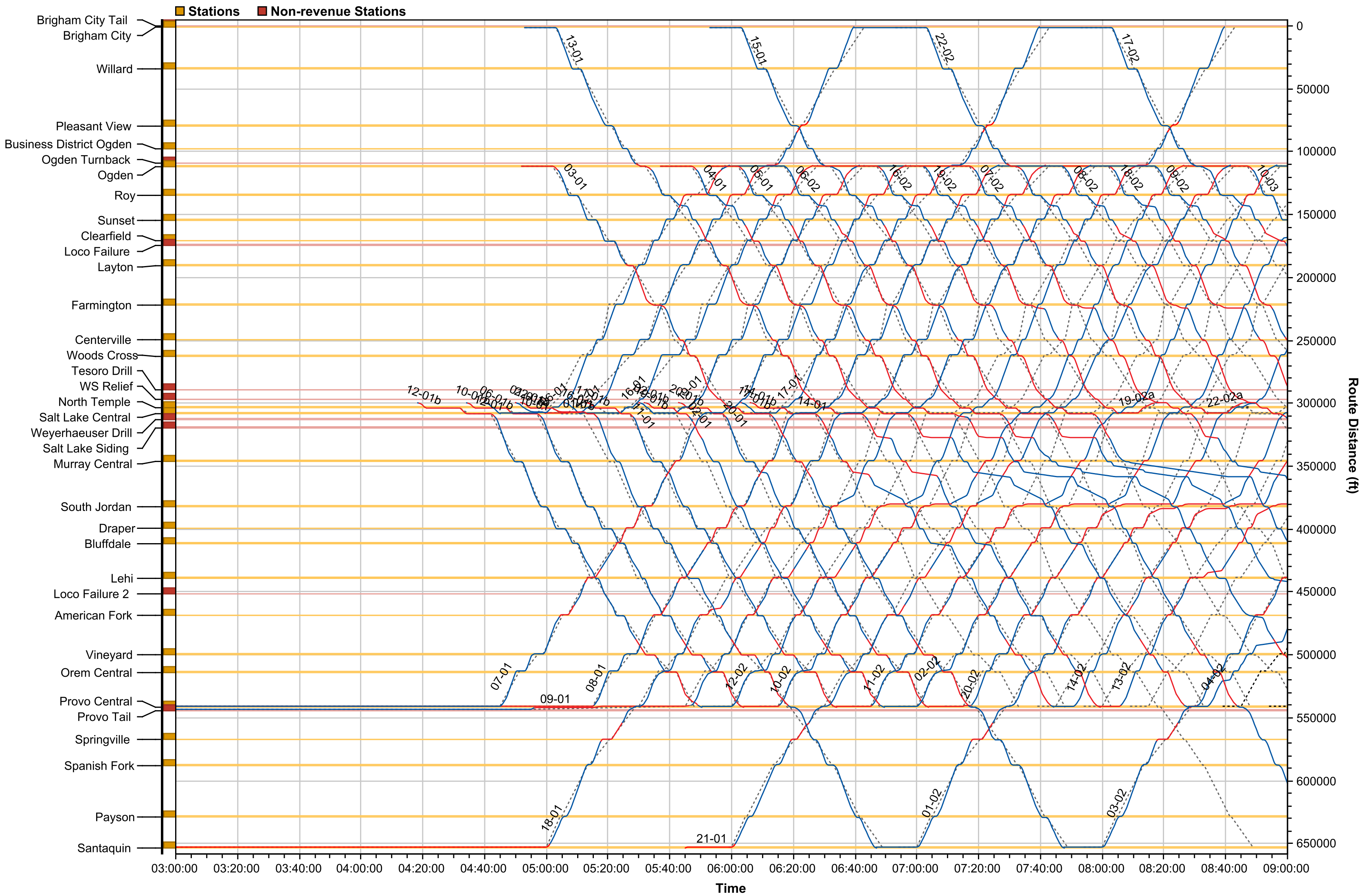


Figure 24-37: Time-Distance (“String”) Chart – 3 AM – 9 AM – High Investment Scenario with Infill Stations Day 4 Simulation Results with Perturbations

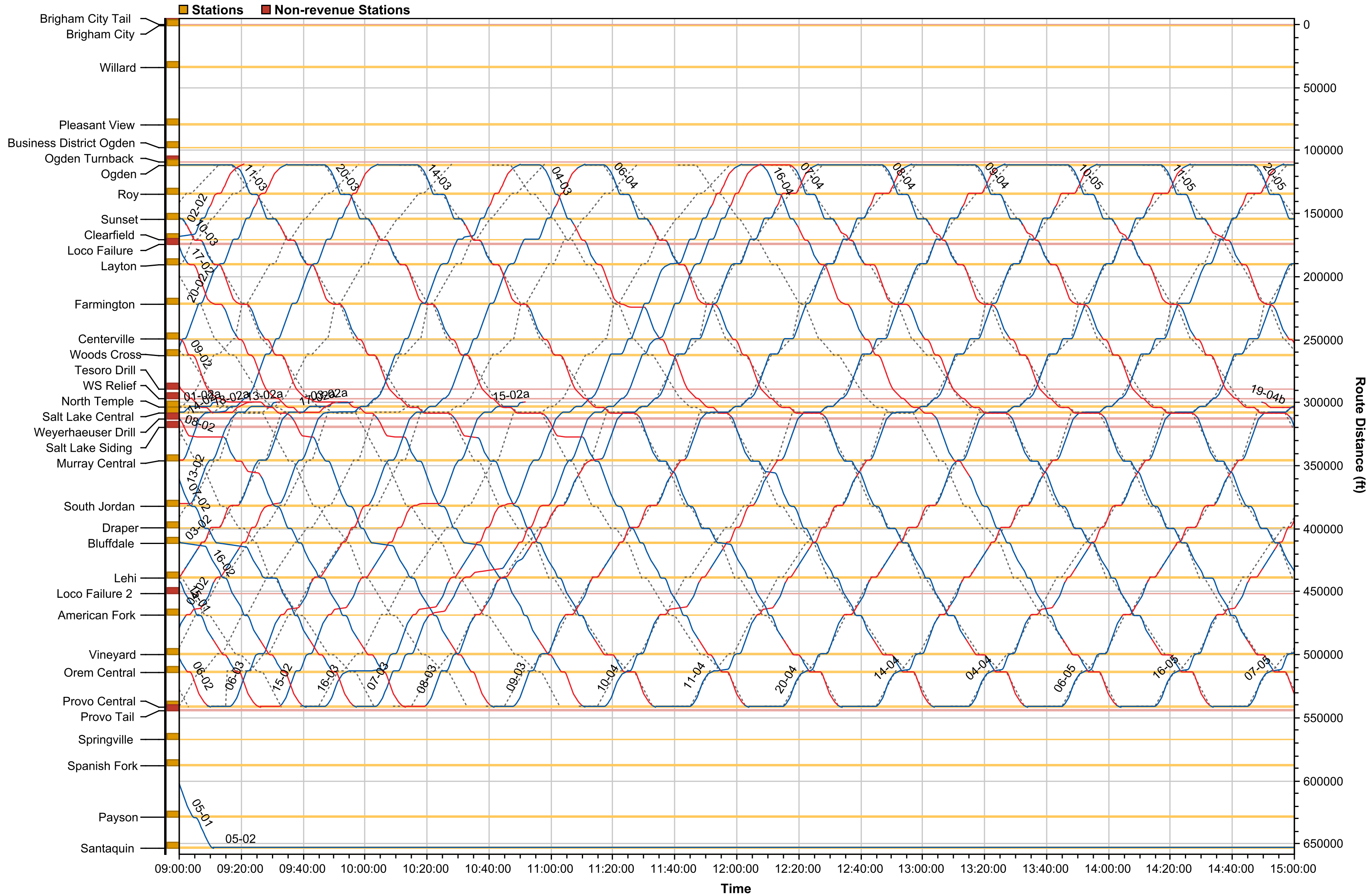


Figure 24-38: Time-Distance ("String") Chart – 9 AM – 3 PM – High Investment Scenario with Infill Stations Day 4 Simulation Results with Perturbations

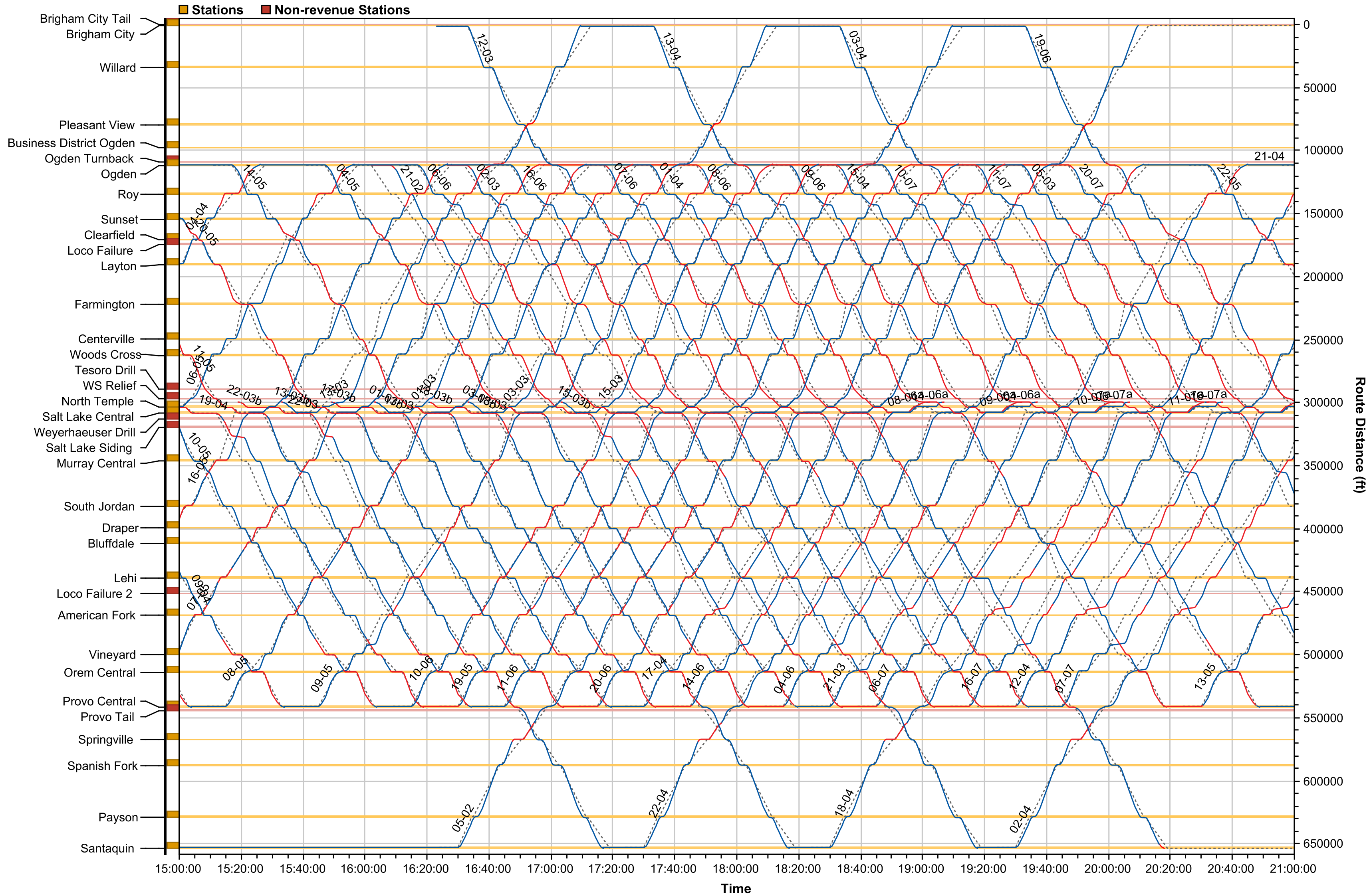


Figure 24-39: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario with Infill Stations Day 4 Simulation Results with Perturbations

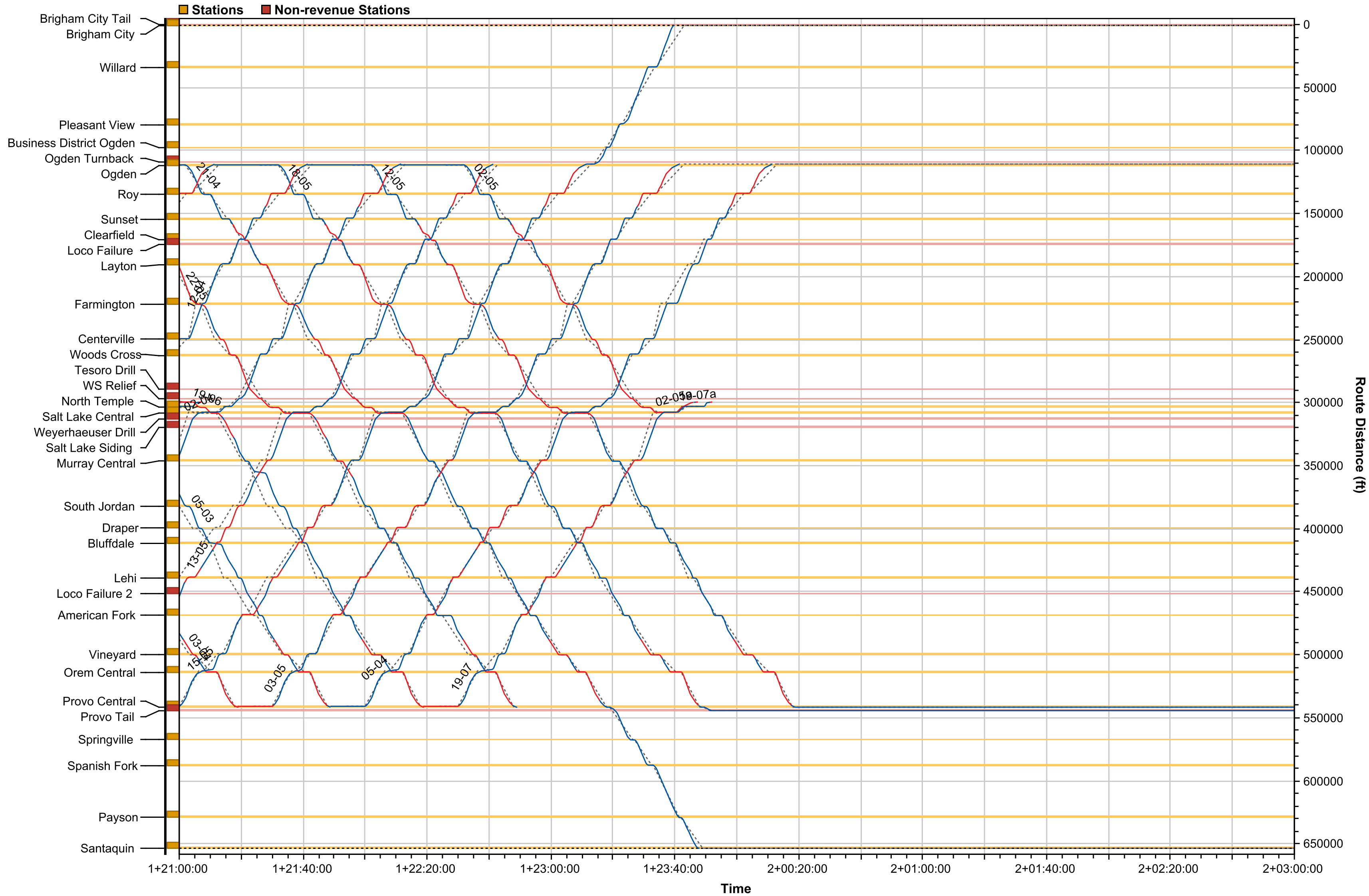


Figure 24-40: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario with Infill Stations Day 4 Simulation Results with Perturbations

24.6 Day 5 High Investment Scenario with Infill Stations Simulation Results with Perturbations

The FrontRunner - Day 5 operating plan includes a 5-minute delay for train 21-01 at North Temple due to assumed need to hold for a late connecting TRAX train. Day 5 also includes a locomotive failure on train 14-06 between Lehi station and American Fork station causing the train to stop for 10-minutes while the locomotive is reset. Station occupancy charts and string charts are included in the following sections.

24.6.1 Station Occupancy Charts – Salt Lake Central

Northbound trains are shown on UTA1 with southbound trains on UTA2. Most northbound trains arrive slightly late and depart on time and most southbound trains arrive and depart on time. In both directions, trains stay on schedule with the help of the long dwells at Salt Lake Central Station.

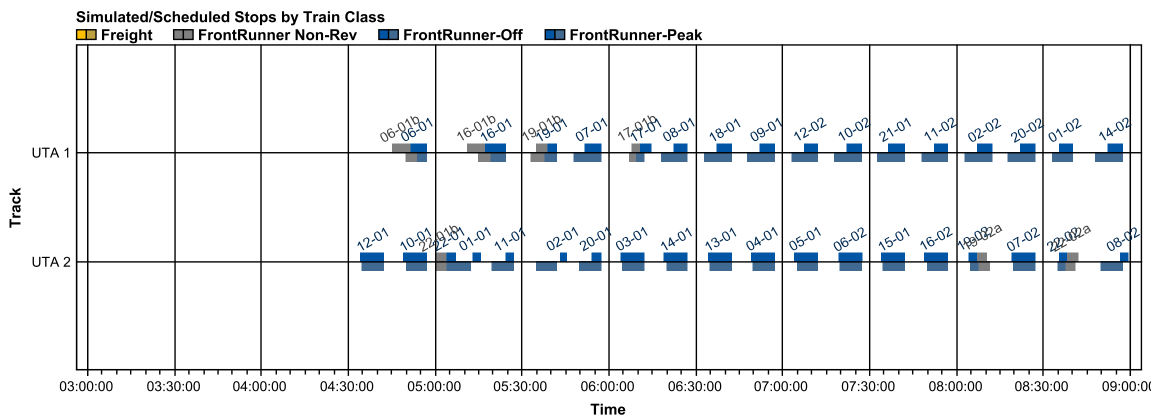


Figure 24-41: Station Track Occupancy Chart – Salt Lake Central– 3 AM – 9 AM – High Investment Scenario with Infill Stations Day 5 Simulation Results with Perturbations

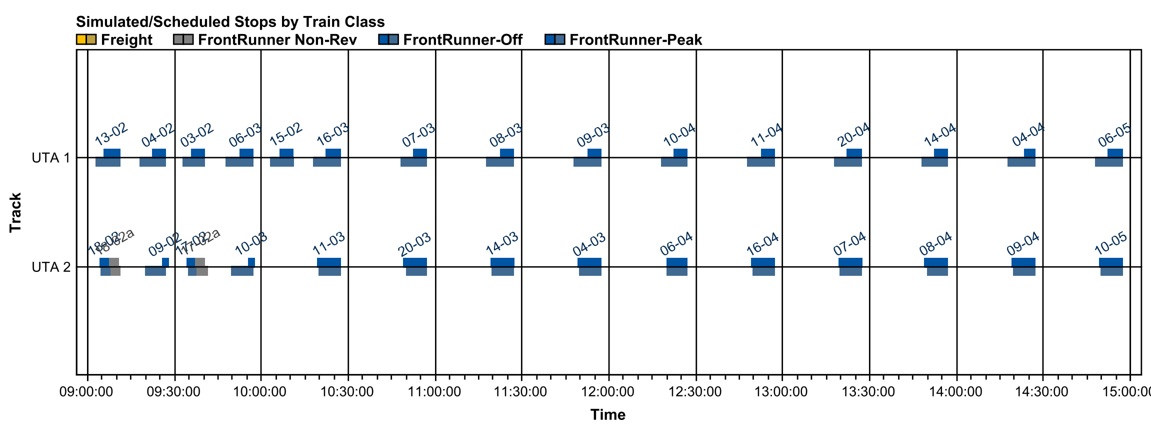


Figure 24-42: Station Track Occupancy Chart – Salt Lake Central – 9 AM – 3 PM – High Investment Scenario with Infill Stations Day 5 Simulation Results with Perturbations

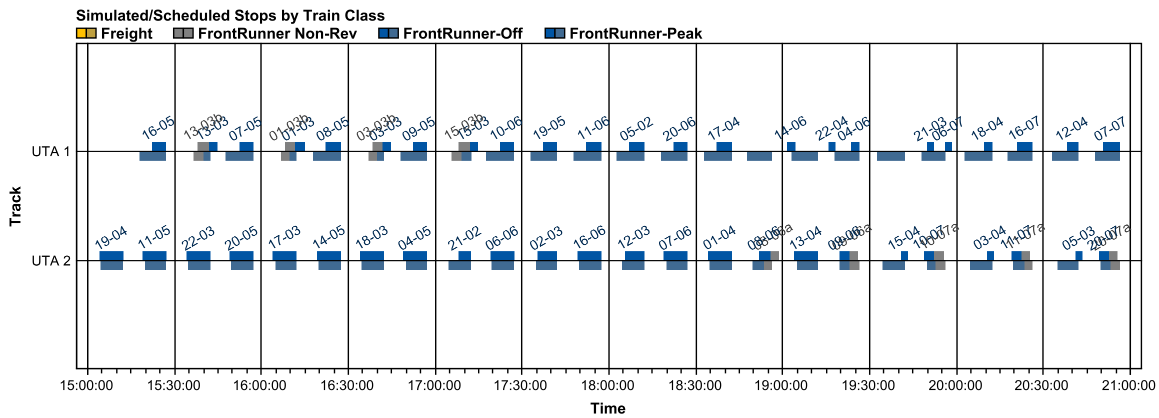


Figure 24-43: Station Track Occupancy Chart – Salt Lake Central– 3 PM – 9 PM – High Investment Scenario with Infill Stations Day 5 Simulation Results with Perturbations

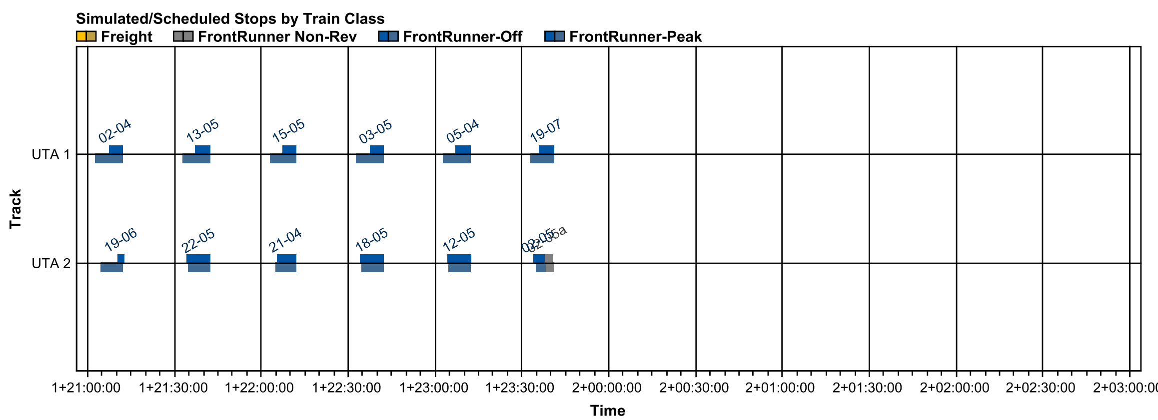


Figure 24-44: Station Track Occupancy Chart – Salt Lake Central – 9 PM – 3 AM – High Investment Scenario with Infill Stations Day 5 Simulation Results with Perturbations

24.6.2 String Charts

Figure 19-4557 shows that train 21-01 has been randomly assigned the 5-minute delay perturbation at North Temple station. With the extended double track sidings, the train causes minimal disruptions to the southbound trains that it meets and it is able to get back on schedule by Roy Station.

Under the Day 5 perturbations, train 14-06 is randomly assigned a locomotive failure and stops for 10-minutes between Lehi station and American Fork station as shown in Figure 19-4759. This causes cascading delays to trains in both directions, due to the volume of trains going through this area with short double track segments. Trains get back to normal as the afternoon peak period ends.

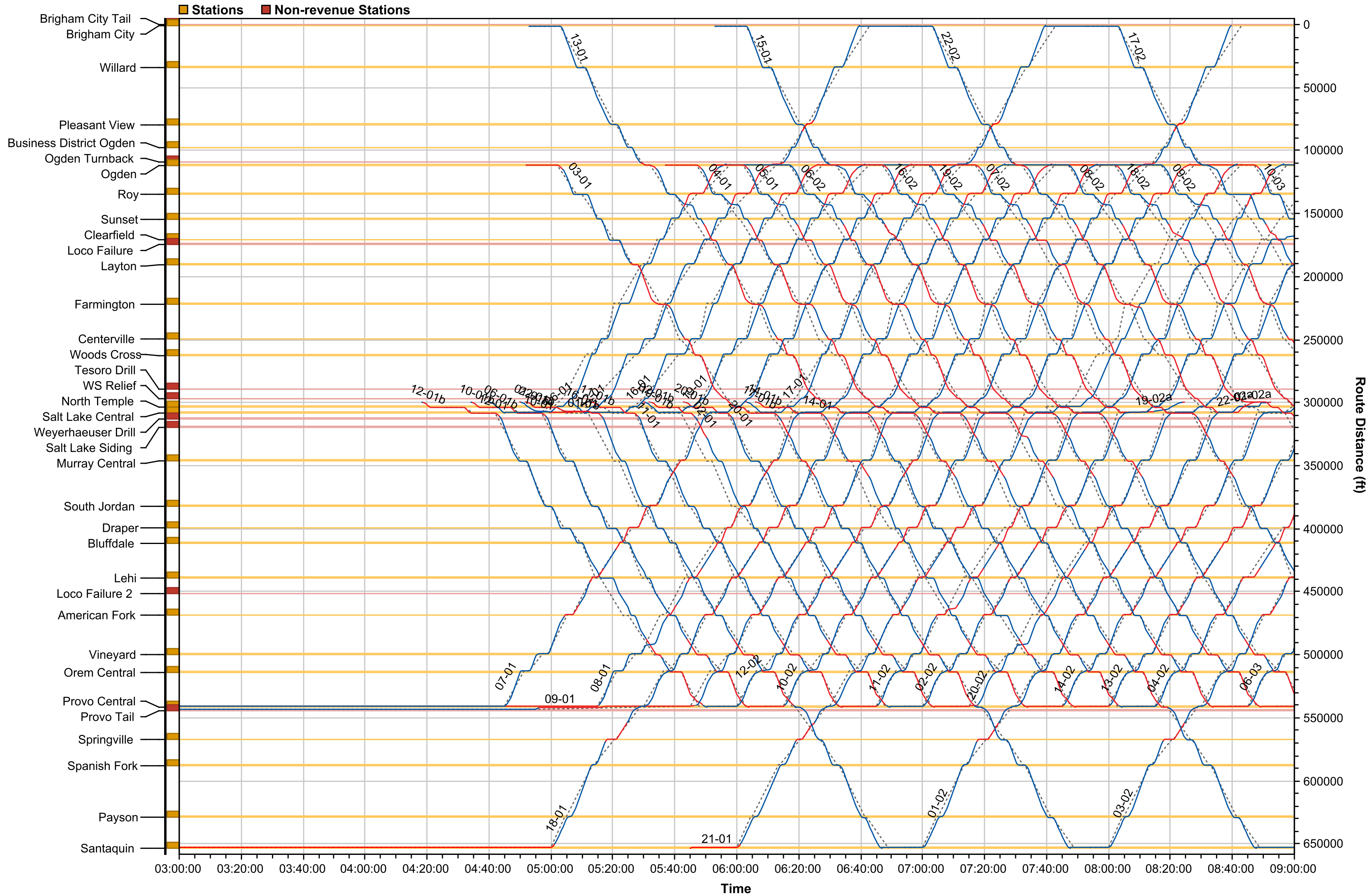


Figure 24-45: Time-Distance ("String") Chart – 3 AM – 9 AM – High Investment Scenario with Infill Stations Day 5 Simulation Results with Perturbations

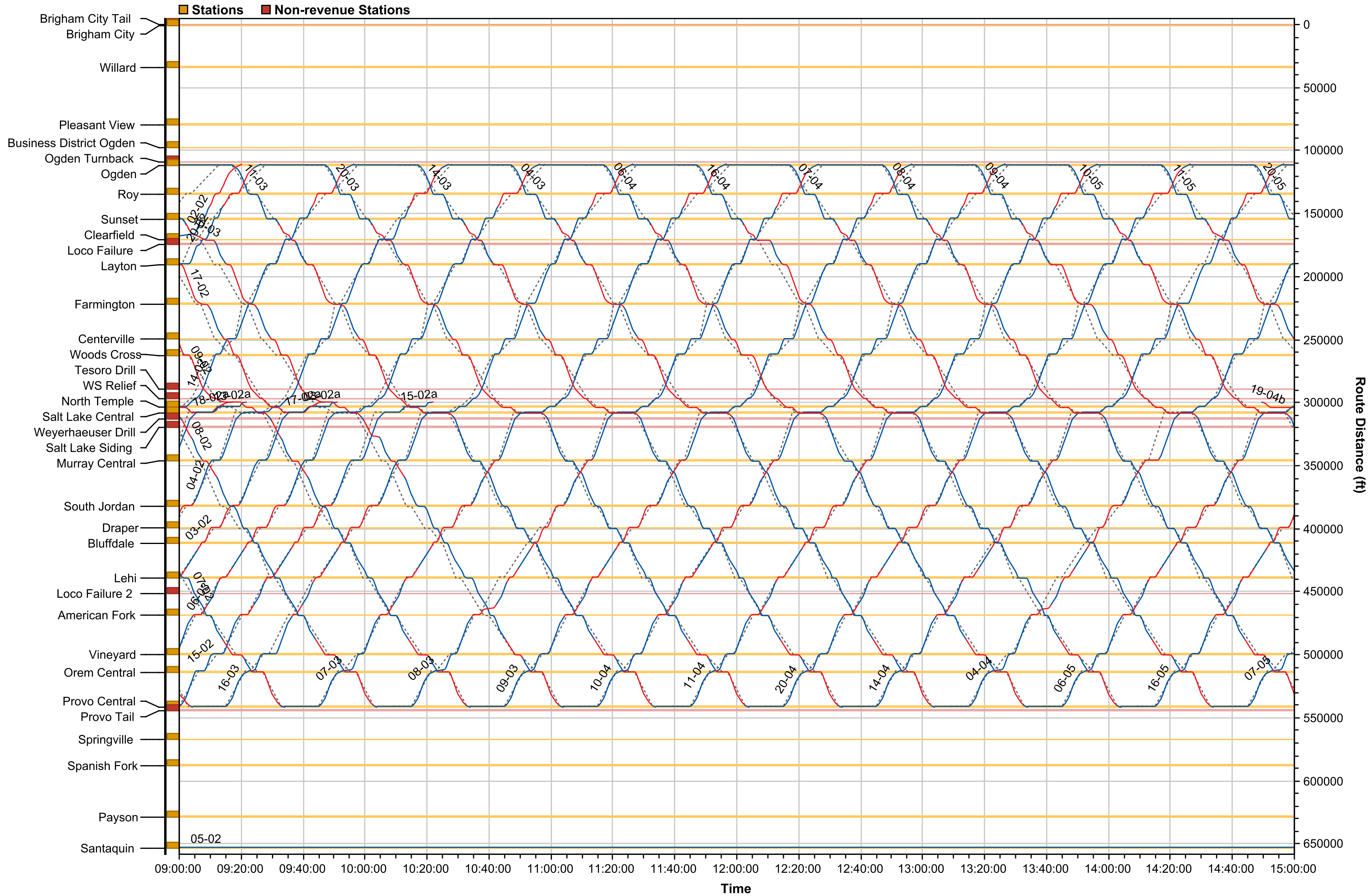


Figure 24-46: Time-Distance (“String”) Chart – 9 AM – 3 PM – High Investment Scenario with Infill Stations Day 5 Simulation Results with Perturbations

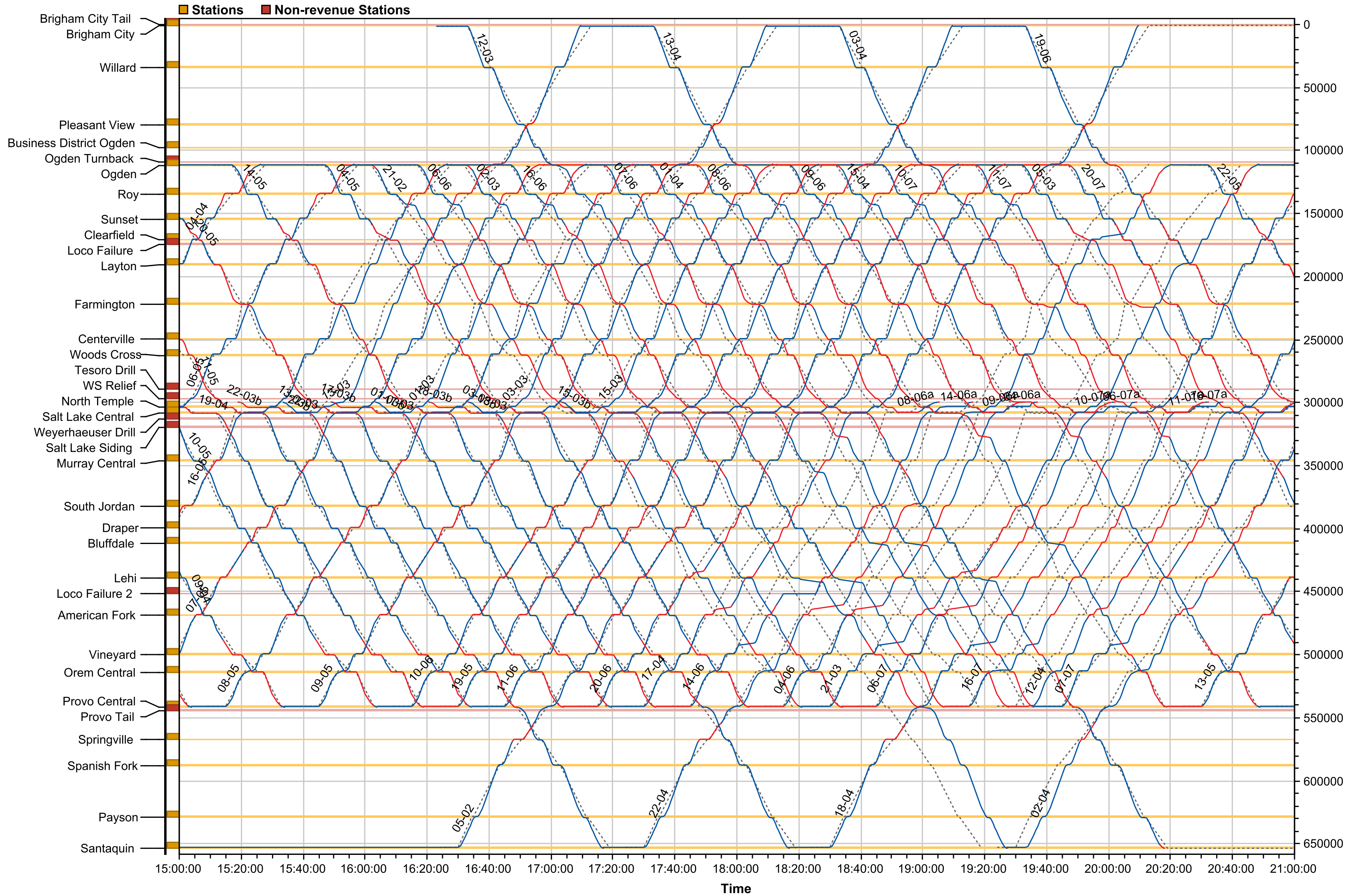


Figure 24-47: Time-Distance ("String") Chart – 3 PM – 9 PM – High Investment Scenario with Infill Stations Day 5 Simulation Results with Perturbations

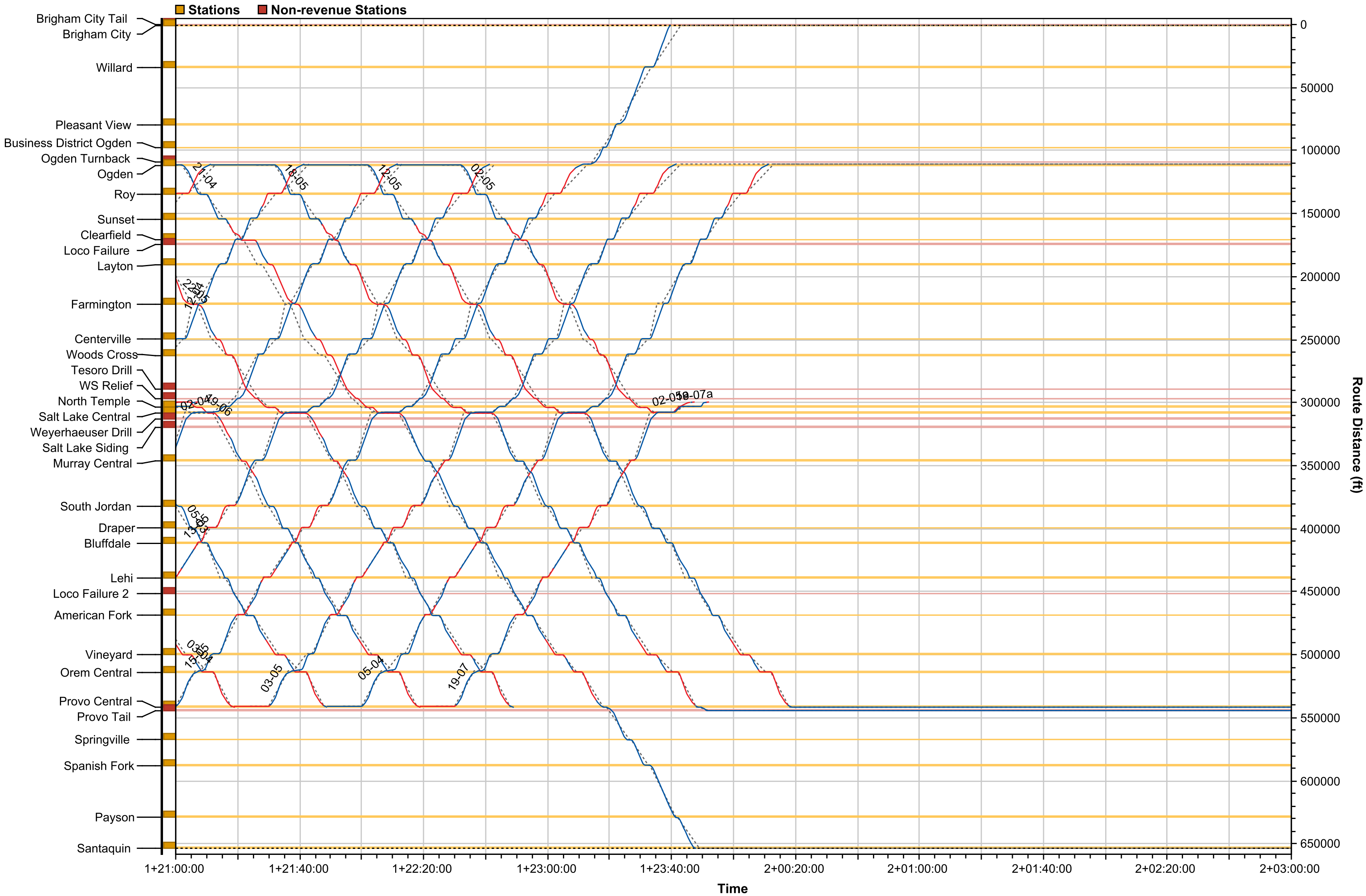


Figure 24-48: Time-Distance ("String") Chart – 9 PM – 3 AM – High Investment Scenario with Infill Stations Day 5 Simulation Results with Perturbations