SOUTH FLORIDA EAST COAST CORRIDOR STUDY

SOUTH FLORIDA EAST COAST (FEC)
ALTERNATIVES ANALYSIS

F.M. NO. 417031-1-22-01
CONTRACT: C-8F66

Draft Rail Simulation Calibration Tech Memo

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STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

December 2009

MEMORANDUM

To: Scott Seeburger, Florida Department of Transportation, District Four

From: Jim Schwarzwalder

Date: December 8, 2009

Subject: South Florida East Coast Corridor Transit Analysis Study (SFECC): SFECC BASELINE NETWORK OPERATIONS SIMULATION AND ANALYSIS

SFECC BASELINE NETWORK OPERATIONS SIMULATION AND ANALYSIS

TECHNICAL MEMORANDUM – BASE CASE SIMULATION – FINAL

Introduction

The purpose of this network simulation of the SFECC Study Area between Stuart Bridge (Mile Post 260.93) on the FEC Railway main line and CP Iris (Mile Post 365.50) is to establish a baseline of network simulation conditions that mimic the actual operational status of the FEC Railway as of March, 2008. The FEC selected the month of March, 2008 as a representative study period.

CP Iris protects a diamond crossing with the CSX Miami Subdivision. Technically, it is situated on the FEC Little River Branch between its junction with the traditional FEC Main Line at Little River and FEC's Hialeah Yard located near the Miami International Airport.

Establishment of baseline train delay data and on-time performance in simulation is essential because it is the only way meaningful quantitative and qualitative comparisons can be made with the results of subsequent, forward-looking network simulations that will mimic conjectural future passenger and freight train operations on modified infrastructure. In this context, "infrastructure" means the proposed future configuration of the track and signal system (including turnouts and crossovers) as well as proposed passenger station stops (platforms).

Contents

This technical memorandum addresses the following Scope items:

- Task 0 – Data Collection (only)
- Task 1 – Build 'Base Case' Network Simulation Model
- Task 2 – Calibration of the 'Base Case' Network Simulation Model

Software

The Project Team employed Berkeley Simulation Software's "Rail Traffic Controller" (RTC) for network simulations. Florida East Coast (FEC) has adopted the same simulation package. Similarly, all five of the nation's Class 1 railroads also license and use the RTC software (i.e., BNSF, UP, KCS, NS and CSX). RTC has a development history extending back to at least 1995. It can be run on an Intel-based laptop or desktop computer operating Microsoft Windows® XP or higher with no special supplemental software or upgrades. Other commercially available simulation software packages have not been adopted by the freight rail industry on such a scale and, despite generally comparable levels of simulation accuracy, create a risk of debating the merits of different software packages instead of focusing on operating issues and solutions.

A key feature of RTC is its built-in train dispatching algorithm, which attempts to resolve capacity and routing conflicts as a human dispatcher would, taking into account the relative priorities of train movements, train lateness, remaining crew time, and the available routing alternatives. Thus, unless the user is aware of certain esoteric operating issues, the programming of train routings in simulation is generally kept to specification of a "preferred" route, required station stops and terminal origin and destination. The software does the rest. In this fashion, RTC attempts to overcome random delays or explicit changes to the Operating Plan by developing a new operating (train routing) solution. Occasionally, RTC will fail in this attempt but when this happens, error messages point the user to the source of the problem, which is generally an unrecoverable multi-train conflict requiring explicit review and adjustment by the operations analyst.

Document Collection and Review

The following documents were requested of FEC and obtained:

- Employees Timetable Number 39 dated October 1, 2007;
- Track Charts for the FEC railway that included the territory between Camp Murphy South (MP 280) and Hialeah Yard in Miami;
- Raw O.S. ("On Sheet") train movement (traffic) data for the operating period of March 1st to March 31st, 2008;
- Train consist data for the operating period of March 1st to March 31st, 2008.

The initial request for the track charts included the entire study area from Jupiter to Miami. However, in order to employ a meaningful RTC model, the north end of the study area needed to be extended to Stuart Bridge so that any meet-pass conflicts could be sorted out by RTC before any of the trains in the simulation reached the Jupiter/Jupiter Bridge area. Follow-up requests have been made to FEC to obtain the remainder of the track charts from Stuart Bridge to Camp Murphy South. These documents had not been received at the time of this writing. This did not adversely affect the simulation development because the available track charts were sufficient in combination with inquiries made to the FEC Railway and answered by them.

FEC initially provided the Project Team with raw "O.S."[1] data in text and spreadsheet format. This data included the entering and leaving times for diamond crossings and bridge circuits as well as entering and leaving times for passing sidings and yards. However, in order to correctly model the existing conditions, a finer granularity was required, and the Project Team requested and received supplemental "O.S." data. The Project Team also received train consist data for the requested time period, which included the weights and lengths of each train, along the lead engine number.

[1] O.S. (or "On Sheet") is rail industry jargon that originally meant the manual recording of a train movement event on a long sheet of paper by a train dispatcher or operator. This practice is almost obsolete. Typically, train movement events are now recorded automatically by detection circuits in the field that transmit data to a central office.

Acquisition of RTC Model of FEC Railroad

The FEC Railroad provided the Project Team with an RTC network simulation model of the FEC railroad which included the territory between Jacksonville and Hialeah Yard in Miami – i.e., almost the entire railroad. (See **Figure 1**.) The model represents the existing track (with required passing sidings and yard track), speed limits and restrictions, grade data, and the existing signal system. During the process of developing a general operating plan for the simulation, the Project Team discovered that a few of the signals in the model were either incorrect or missing. The FEC Railroad provided track charts for those areas to allow the Project Team to correct them. The updated track charts differed from the original track charts and the Project Team has requested a copy of the updated track charts from the FEC Railroad.

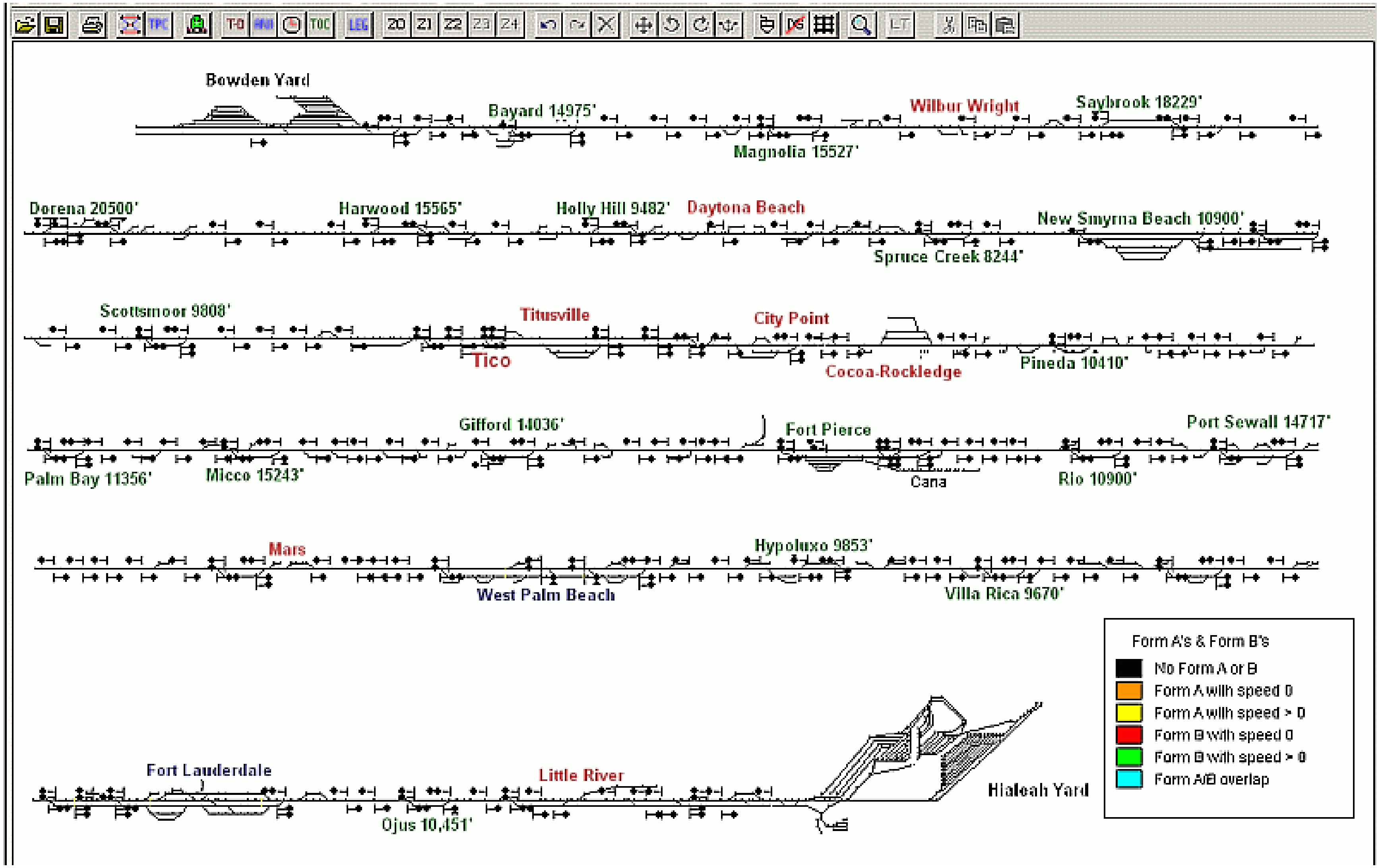

Figure 1 - Schematic Simulation Model Diagram of the FEC Railway Bowden Yard (Jacksonville) to Hialeah Yard (Miami)

The project study area includes approximately 105 miles of mainline track. It includes six passing sidings (Port Sewall, Camp Murphy, Hypoluxo, Villa Rica, Pompano Beach, and Ojus), three double track regions (Fort Lauderdale, West Palm Beach and Miami), two single track moveable bridges (Stuart and Jupiter), one double track moveable bridge (Fort Lauderdale), and approximately 28 industrial sidings.

See **Figure 2**.

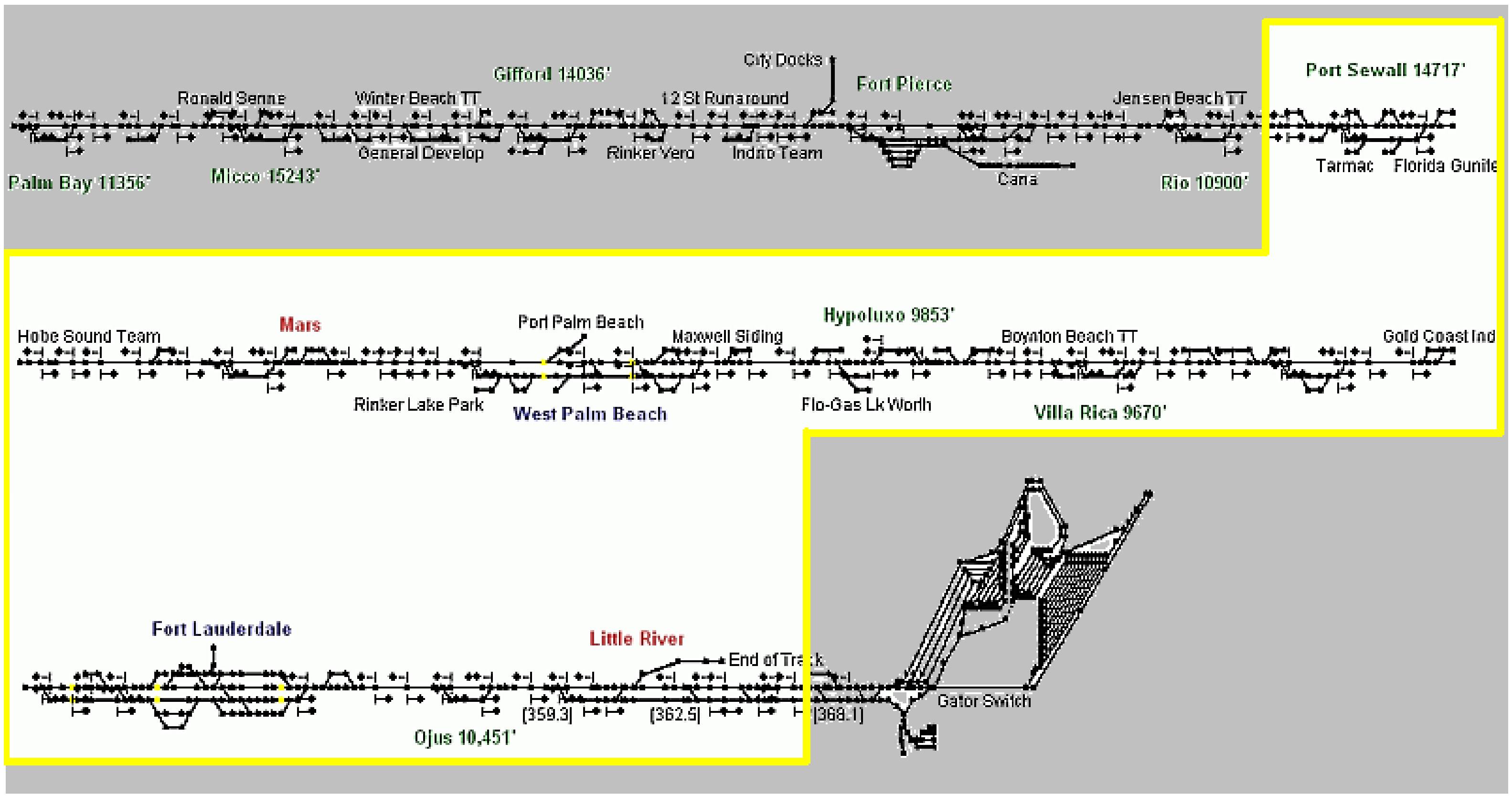

Figure 2 - Schematic RTC Diagram of the FEC Railway Project Study Area

Software Development

Due to the volume of data for the train operations during the model time window, the Project Team developed custom software to generate an RTC 'Train' file that included the required train operations in the model. This software imported the raw OS data provided by the FEC Railway and generated the equivalent trains in RTC. Trains were generated for all operations between the O.S. reporting locations of Stuart Bridge (MP 260) and CP-Iris in Miami, inclusive. Since the consist data for the study time period had not been provided at the time of this writing, generic train consists based on the trains included in the original RTC model were used for the trains generated by the software.

Calibration

Calibration is the procedure by which the operations of the FEC trains in the RTC model are checked and adjusted to mimic the actual OS data as closely as possible.

Each train O.S. record was analyzed by the software to determine the likely path and timing of a given train in the simulation model. In the event that a train's movement was either ambiguous or clearly wrong (resulting in an irresolvable simulation conflict), the *handling* of the O.S. record in question was modified to allow for presumed operations. In addition to the handling of route ambiguities, there were a number of instances where the consist of a train generated by the software was clearly different from the train in the field data, as the running times in the RTC model were significantly different from the actual O.S. times. In these cases, the train consists were adjusted to allow the train in the model to more closely follow the schedule pattern in the raw O.S. data. Adjustments were made to the number of loads vs. empties, number of total cars, and -- to a lesser extent -- the number of locomotive units.

In addition to the train cases listed above, there were a number of cases where the raw O.S. data indicated movements to and from unknown industrial sidings. Due to the ambiguity of these train movements when they were on the mainline, it was not possible to determine exactly where the train exited the mainline and entered industrial tracks. In these cases, the modeled train maintained the schedule in simulation, but was removed from the mainline in the simulation model when it was clear from movement records of other trains in the area that the train that was doing the switching work could not have been standing on the main line.

Because the RTC network infrastructure model had already been accepted by the FEC Railway the overall train performance was presumed to have been accepted by the FEC and therefore acceptable for the purposes of this study.

Preliminary Results

RTC provides a number of methods to represent the results of the simulation. Provided that the train movement records supplied by the railroad are sufficiently detailed, On Time Performance (OTP) results generated by the network simulation provide insight into how well the simulation is mimicking the historical O.S. data records of actual railroad operations. RTC allows OTP reporting sites to be included in the model. These discreet data collection points mimic the real-world locations where the railroad collected its train movement data. For example, if a train movement record identifies an occupancy time at the Jupiter Bridge track circuit, an OTP reporting point can be included at that location in the model to measure the train's punctuality in simulation compared to when it passed by that point in the field.

By including all of the trains' movement record locations in the OTP processing during simulation, an aggregate reflection of the system's On Time Performance can be generated. In baseline simulations, simulated on-time performance must be at or near 100% because the aim is to mimic train operations that have actually occurred. Minor deviations from 100% OTP can occur and can be caused by a single train operating at a slight variance in the model. Large deviations would indicate that the model is incorrectly mimicking the historical data or that there is a systematic defect in the movement records (which is rare).

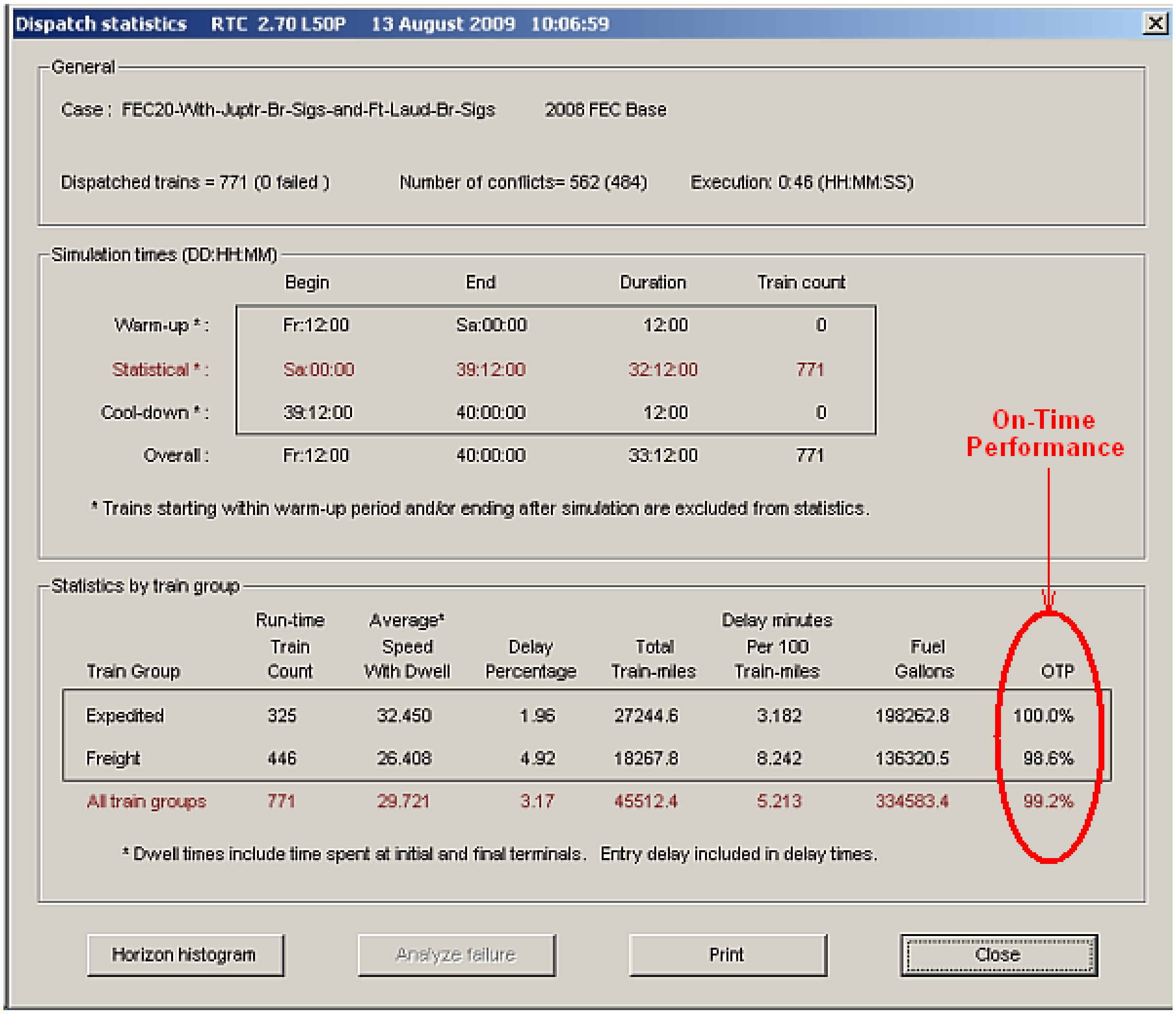

Figure 3 - RTC Network Simulation Results

In the case of the FEC model, the RTC simulation results (**Figure 3**) for the March 2008 field data show that the Expedited (intermodal) trains achieved 100% OTP and the manifest freight trains (including rock trains) achieved 98.6% OTP. Each train class in RTC can have its own set of parameters that determine OTP. The parameters for this simulation were:

Train -->	Expedited	Manifest Freight
Late	30 Minutes	1 Hour
Very Late	4 Hours	8 Hours

While every effort was made to adjust the operations such that the OTP for all train classes achieved 100%, given the fact that the actual train consist information was not used in the model, it was not possible to achieve 100% OTP for the Manifest Freight class due to limitations of the available data – notably the generic train consists that were used. Note that the above data encompassed 771 individual train movements in simulation over a 4-1/2 week period. This extensive study period supports a considerable degree of confidence that the simulation results are not skewed by circumstances such as extensive track repairs, bad weather, signal power failures or an operating incident and therefore fairly represent existing conditions.

Delay Minutes per 100 Train-Miles Operated and system velocity are standard metrics that have been widely adopted by the freight railroad industry to monitor operating performance.

- Train delay has a direct bearing on traffic congestion. A well-dispatched network that has adequate capacity to support anticipated train operations and absorb minor delays will feature moderate, low or even very low train delay metrics. This is the situation with the FEC Base Case network simulation which yielded an average of less than six (6) minutes of train delay per 100 train-miles operated. This is very low and indicates that the simulation network was robustly fluid. Delay percentage was under 3.5(%) which is also very low.

- System velocity (i.e., "average speed with dwell") is strongly influenced by average operating speed. As a standalone metric it is not especially meaningful; as a comparative metric it is a reliable indicator of improvement or degradation in overall system operating performance, especially in combination with other objective measurements. Compared with a typical freight train operating speed of 40+ mph on the FEC, the system velocity metric of 29.7 mph generated by the RTC network simulator implies that trains in the Base Case model were taking very few delays. It is worth noting that this metric is higher than what is typical for most freight railroads. This is partly because of the generally good to very good condition of the FEC's physical infrastructure and partly because of its simple point-to-point configuration featuring a high percentage of expedited intermodal traffic. It is also important to note that the study area represents less than one-quarter of the overall FEC system.

The foregoing metrics appear in **Figure 3**.

In addition to the simulation summary discussed above, RTC also produces Time-Distance charts (sometimes called String Charts) for the model. These diagrams plot distance as expressed by Stations, Mile Posts or other key physical features such as junctions along one axis and time along the other axis. This presentation is critical to observing local behavior at a particular time in the simulation, and is a necessary tool in determining the cause of delays and what factors are influencing a particular delay. See **Figure 4**.

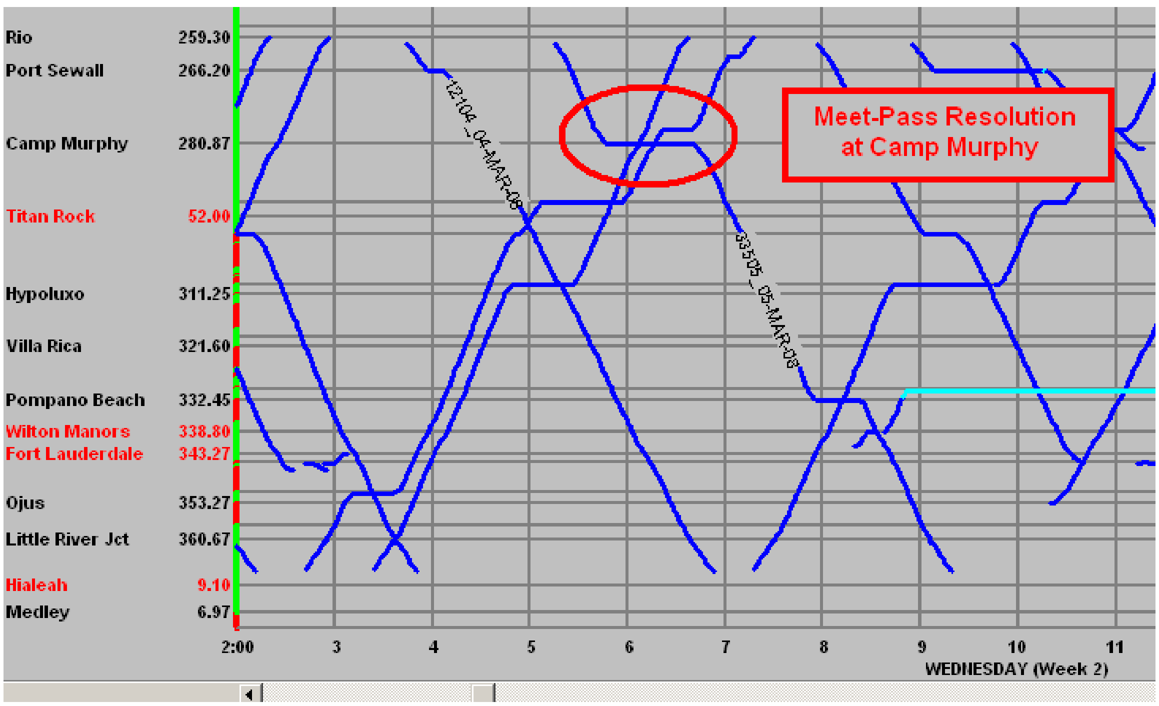

Figure 4 - Time-Distance Chart ("String Chart"), 'Rio' Siding (top) to Hialeah (bottom)

Summary/Conclusions

- The current RTC model used to simulate the operations from Stuart Bridge to CP-Iris comes as close as possible to the actual operations of March 2008 given the absence of the specific train consist data for that period. The results reflect a very fluid railroad operation with adequate capacity to handle existing traffic and very low incidence and/or duration of train delays.

- In our opinion, the baseline network simulation results represent fairly the operational status and traffic of the FEC Railway as of March, 2008 and provide a suitable basis for comparison with the results of subsequent, forward-looking network simulation analyses for this Project that will mimic proposed new passenger train operations supported by proposed infrastructure improvements that will increase the capacity of the railroad physical plant.

The model does not include any operations of Tri-Rail (SFRTA) across CP-Iris where the FEC's double-tracked line crosses the newly double-tracked CSX Miami Subdivision over which Tri-Rail's passenger train services operate. Throughout the March, 2008 period that is the basis of this Baseline network simulation modeling analysis, Tri-Rail was operating its "50-Train Plan" featuring fifty revenue train movements each working weekday between Miami Airport Station and Mangonia Park Station (north of West Palm Beach). The "50 train" count does not include non-revenue SFRTA movements operating between Miami Airport Station and Hialeah Yard (on CSX) nor between Mangonia Park Station and a small layover yard at West Palm Beach. While the operations in the RTC model reflect the actual operations at CP-Iris due to the implementation of the O.S. data, per the Scope of Work, the final model is to have a previously-built Tri-Rail model integrated into it with the crossing at CP-Iris being the common existing connection point. This phase has not yet been completed. Tri-Rail trains occupy CP-Iris for only brief periods because of their short length (two to three coaches and one locomotive). Late-night FEC traffic across CP-Iris does not typically encounter any conflicts with Tri-Rail train movements. It is anticipated that despite the fairly dense Tri-Rail traffic and occasional CSX freight trains, delays accruing to FEC freight trains in simulation at CP-Iris will not, by themselves, significantly degrade overall network operating metrics.