Jamaica Interlocking Reconfiguration Operations Simulation

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ABSTRACT

The Long Island Railroad (LIRR) operates one of the busiest passenger rail networks in the US, and for over 100 years, the Jamaica terminal is essential to maintain passenger trains to and from Manhattan. Over this time, the patterns of ridership have changed dramatically and there is a new terminal stop at Grand Central Station for LIRR passengers. The "East Side Access" will provide the LIRR system the ability to connect into Grand Central Terminal. To accomplish this, the Jamaica terminal is planned to be reconfigured along with a new operating plan. To support this expanded service, LIRR needed to evaluate the level of infrastructure and flexibility required. The current terminal has a lot of routing flexibility that limits trains speed and a new higher speed" rail configuration will reduce routing flexibility within the interlocking. A focused simulation model of the Jamaica Interlocking was developed and completed by TranSystems in 2012 and was used to iterate through numerous scenarios to evaluate the new plans to determine the level of flexibility necessary to support the new train service.

1. BACKGROUND

The current terminal has a lot of routing flexibility that slows down trains through the area. The new plan is to make a "higher speed" rail configuration that will reduce the routing flexibility within the interlocking. A focused simulation model of this area was used to conduct many scenarios and determine if the new facility plan will still offer the needed level of flexibility to support.

For large networks such as that at LIRR, a typical approach is to use of model the entire system using a simulation program that can represent main track capacity and emulate train performance characteristics. To more rapidly and more intensely evaluate the needs at the Jamaica terminal, a "two-stage approach" for modeling and analysis was used for this project. The first stage focuses on the approximate two-mile area that bounds Jamaica up to the adjacent "Hall" and "Jay" interlockings. To analyze this area, a highly flexible model, using TranSystems' own Transportation Modeling Studio (TMS), allowed for different levels of routing flexibility to be easily tested and analyzed in this focused scope.

The first stage model is designed to quantify the performance of different infrastructure configurations and determine which alternatives provide the needed throughput through Jamaica by itself. This model provided the framework to quantify if the train service plan lost or gained time through this interlocking and platform configuration.

Once the preferred configuration was determined, as a second stage of analysis, the new Jamaica infrastructure was validated in the overall system within a network model. The network model was configured using the Rail Traffic Controller (RTC) which is a rail simulation product licensed by Berkeley Simulation (www.berkeleysimulation.com). The focus of this paper is to describe the modeling and analysis performed for the Jamaica Stage 1 study.

2. JAMAICA CAPACITY IMPROVEMENT GOALS

The current Jamaica Complex has been in operation for over 100 years and there have been significant changes in ridership demands and patterns as the ridership demands have increased. The complex will become even busier with the anticipated completion of major improvement projects such as East Side Access, third-track Main Line construction, and possible double tracking to Ronkonkoma.

Modifications to the physical elements are being recommended within the Jamaica Complex are required to maximize the local and system throughput to meet the future ridership growth for the next century. The capacity will be improved by maximizing parallel routing (within Jay, Hall, Met and Union Interlockings) by creation of additional ladders, extension of E Yard over 150th St and modification of the East Layup Track into a through route. Additionally, installation of higher speed switches increases the interlocking route speeds from 15mph (max) to 30mph (and higher).

The current operation relies on a plan where there are frequent triple train connections at Jamaica for passengers traveling between Long Island and western destinations. Because of the new service to GCT, the maintaining this operation would require passengers to connect to 4 different western destinations. To accommodate the new Manhattan terminal, modification of the Brooklyn Service into a "shuttle" is proposed. Additionally, to reduce dwell times, the future operations are predicated on the use of "drop and go" passenger transfers instead of providing scheduled connections.

Long Island Railroad developed a proposed update to the track and platform infrastructure and an associated operating plan. These infrastructure modifications permit a significant increase in service levels being routed through the Jamaica Complex as shown:

Expected Trains per hour						
	Westbound			Eastbound		
	GO103	OP30	% Increase	GO103	OP30	% Increase
7am to 8am	47	58	23%	19	29	53%
8am to 9am	35	46	31%	22	23	5%
5pm to 6pm	21	26	24%	39	55	41%
6pm to 7pm	17	29	71%	31	49	58%

Table 1. Increase in Trains per Hour (Current Plan GO103 vs. Proposed Plan OP30)

Analysis of the current operations (GO 103 – Nov 2008) has been conducted to determine the minimum acceptable performance levels. All localized On-Time-Performance (OTP) statistics will be based on 2:29 minute delay criterion.

3. OPERATIONS ANALYSIS APPROACH

Operations simulation modeling was used to test and compare the performance of infrastructure alternatives to support the LIRR proposed Operating Plan 3.0. The modeling quantifies the benefit of implementing the proposed Jamaica reconfiguration versus no improvements to validate the purpose and need of the project to support the new operation.

Due to the complexity of the Jamaica Interlocking and its critical role in the overall LIRR operation and network, the simulation effort was divided into two models: 1) a local model of the Jamaica Interlocking (Transportation Modeling Studio -TMS), and 2) a network model of the entire LIRR system (Rail Traffic Controller - RTC). This methodology provides a two-staged modeling approach by first evaluating incremental changes or effects in Jamaica in an isolated environment without the effects of other parts of the network obscuring the results. Each of these models was used to compare the existing and the conceptual Jamaica designs across different demand scenarios or operating plans under both ideal and perturbed scenarios.

Some of the infrastructures tested during configuration development were Crossovers D-23 and H-111 to determine their potential operational contribution.

A variety of scenarios were conducted using the Jamaica model. These scenarios were conducted to examine:

1) Jamaica Reconfiguration Benefits: Support the comparison of performance with and without the Jamaica reconfiguration.
2) Maximum Stress and Disruption Scenarios: Examine robustness and recoverability of the proposed Jamaica reconfiguration when a high volume operating plan and different disruptions are staged.
3) Assist with the Jamaica Reconfiguration Design and Engineering process: to determine the "purpose and need" of critical study area components.
4) Perturbations were run against various scenarios to examine the sensitivities to fluctuations in the train arrival schedule.

Modeling Alternate Routing through Jamaica

In normal daily operation, the dispatchers for Jamaica will change default platform assignments to maintain sustainable operations especially during high volume AM and PM rush periods. This is necessary due to trains arriving late into the station, downstream conditions, extra platform delays and other conditions. The modeling team spent time observing dispatchers for Jay and Hall interlockings to gain an understanding of the challenges and to integrate into the modeling a realistic degree of dynamic platform selection logic to accurately assess system performance differences.

Modeling Train Performance Calculations within Jamaica

The local model can explicitly move trains through Jamaica based on the speed characteristics of the track layout, the length of the train per operating plan, and any operating restrictions. In the existing Jamaica layout, the speed in which trains can travel is based on speed restrictions that limit speed to 15 mph. In the future high speed layout, the general maximum diverging speed will be 30 mph, but there will be specific speeds attached to each route.

For the proposed new Jamaica, the speeds will increase and is assumed to be governed by the track design (especially switch design) and equipment performance (engine characteristics/speed). The local model will be able to manage train movement based on these assumptions. Because the scope of the local model is limited to several miles, and the speeds in Jamaica are governed more by operating restrictions and/or layout characteristics than by equipment/locomotive performance, the train performance calculations in the local model account for the rated maximum speed for each segment, acceleration and deceleration (by equipment type).

The model also includes the amount of headway that must be maintained between trains as they move through Jamaica's signal blocks.

The RTC based network modeling includes a detailed Train Performance Calculator including traction effort, braking curves, grade, curvature, signal block layouts and other factors.

Graphical Animation for Operation Validation

The modeling included a real time animation as one form of output. The animation shows the boundaries of the Jamaica complex with train symbols to show occupancy of tracks due to headway restrictions, etc.

The animation screen is a dashboard configuration which also has other status displays such as the current clock time, current trains traveling within Jamaica, pending arrival trains from each branch, trains waiting to access Jamaica, and others.

The animation was used for validation of the scenarios. Experienced dispatchers reviewed the animation to validate routing patterns and train behavior with concurrent trains moving in system.

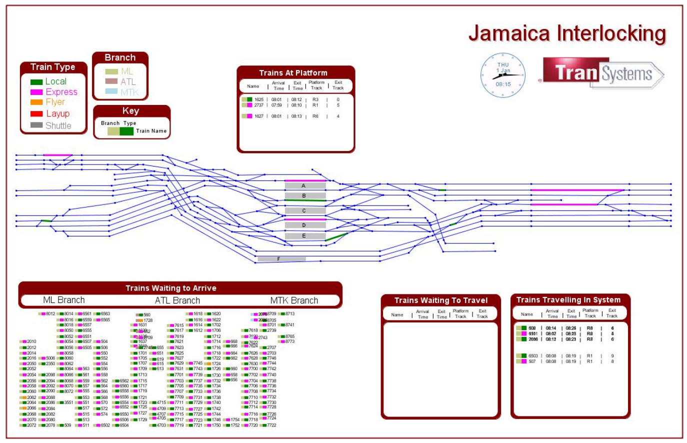

Figure 1: TMS - Local Model Animation

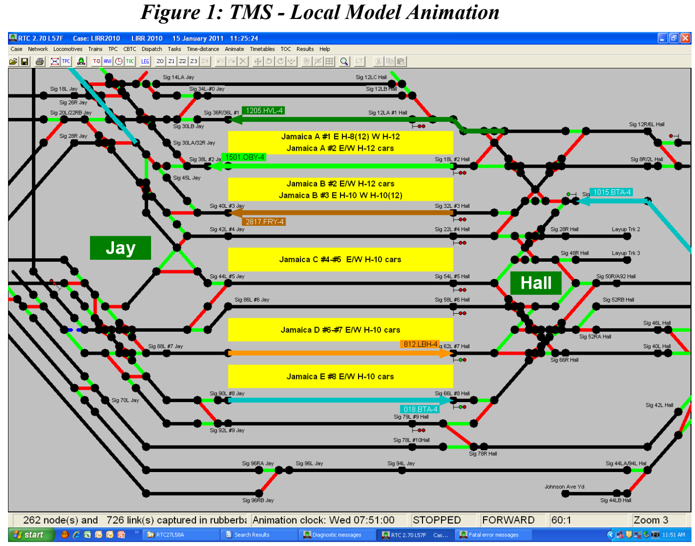

Figure 2: Rail Traffic Controller (RTC) – Zoom in view of Jamaica

4. JAMAICA NO IMPROVEMENT SCENARIOS

Scenarios were developed to evaluate and compare the local Jamaica area performance without any improvements. Scenarios were analyzed with and without operating plan changes.

Base "Current" Operating Plan

Simulation of scheduled operations and seven different perturbed runs (each with increased maximum potential random delay) placed upon the equipment arrival time into the model indicate that at increased degrees of lateness, the OTP tends to increase. The AM rush tends to experience greater OTP degradation than the PM rush (especially in the westbound direction). The trains also don't seem to be able to make up time at the platform or between platform and exit as in the previous OP 3.0 run described in the previous section. The trains tend to be even later leaving Jamaica than when they arrived at the platform to continue losing time. The continual OTP degradation through Jamaica is due to the GO 103 requirement of holding trains at platforms for scheduled train connections and is most apparent across the AM westbound trains where this is scheduled most. Also, the OTP degradation is worse in the AM rush than the PM rush due to the higher concentration of trains (123 trains AM vs. 108 trains PM).

Proposed Operating Plan

The primary assumption for the new operating plan is that Jamaica is reconfigured with increased speeds and longer platforms. This scenario quantifies the performance of OP 3.0 if Jamaica is **not** improved to offer these changes. To construct this scenario, the following model assumptions were made:

1. The new operating plan was modified to slow down trains to reflect the current 15 mph limitation.
2. The new operating plan assumes expanded 12 car trains for a number of routes. The current Jamaica platforms do not all accommodate 12 car trains. The model assumes that these shorter platforms can still be used for the longer 12 car trains, but the trains will extend beyond the platform such that will lock the signal control and potentially slow down area trains.
3. The model assumes that if a 12 car train uses a 10 car platform that there is not an increased dwell time at the platform for the extended time to manage passengers.
4. Brooklyn trains are independent of the mainline WB and EB movements (ie. Shuttles using platform F or similar is implemented). The model assumes these train are independent and these were not included.

Simulation of scheduled operations and seven different perturbed runs (each with increased maximum potential random delay) placed upon the equipment arrival time into the model indicate the OTP for the platform arrivals degrades as the level of lateness is increased. The OTP at exit also generally degrades but it is not linear due to the impact of reduced dwell times at the platform. When the new operating plan is run on the current infrastructure, there are more trains that are "held out" on arrival for longer periods of time when the level of delay is increased. This causes the trains not only to come in late, but also the travel time to the platform is extended based on the current speed limitations. When the delayed trains do get to the platform, they cannot always "make up" time due to compressing the platform time to the minimum to meet the platform departure time.

Evaluation of new operations on the existing conditions indicates an inability of the current infrastructure to accommodate the higher volume of service during the morning peak period and evening westbound direction due to cascading delays during normally perturbed operations. Simulation results indicate that during the morning peak westbound direction with the maximum induced lateness of 4 minutes, the entrance OTP is maintained at 93.18%. Due to congestion in Hall interlocking and the platforms, the OTP into the platforms decreases to 71.74%, a drop of 21.44% OTP.

5. RECONFIGURED JAMAICA SCENARIOS

The reconfigured Jamaica Complex significantly increases the capacity through a series of additional routes and increased operating speeds. Physical restrictions limit the number of longer higher speed switches which can be installed adjacent to the platforms. Although this will relocate of some of the platform decision points physically further from the platforms than today, the operational impacts of this increased distance are eradicated by the increase in operational speeds from 15 mph to a minimum of 30 mph. Improving the route speed will decrease the average train travel time through the complex by approximately 3 minutes.

Base "Current" Operating Plan

This scenario represents the current operating plan on the proposed Jamaica reconfiguration. This is an unlikely implementation, but it is useful to determine if the reconfiguration provides equivalent routing capacity as the existing configuration.

For this scenario, some modifications to the current plan are made to move the Brooklyn trains that use Atlantic Tracks 1 & 2 (west side) and moved them to use the main line tracks. Also, the speeds within (scheduled time at platform and at exit) were changed to reflect the expected speed increases from the Jamaica reconfiguration. The operating plan for this scenario assumes that scheduled connections are still maintained.

The number of expected trains per hour has been slightly adjusted due to the decrease in travel times between the model entrance and platforms.

Comparison of these runs with the current operating plan the current infrastructure indicate some modest AM improvements in the westbound operations entering the platform as the recommended routing has equivalent/improved flexibility. AM metrics leaving the platform are generally equivalent between current and recommended configurations showing routing equivalence. Equipment dwells generally cannot be shortened due to holding trains at platforms for scheduled train connections. Some reduction is expected from scheduling issues incurred from routing Atlantic Branch service to the main line tracks. Similar results are indicated in the PM analysis indicating routing equivalencies.

The analysis also demonstrates that maintaining scheduled platform connections increases platform utilization, increases inter-train dependencies and lowers overall OTP.

Proposed Operating Plan

This scenario represents the proposed operating plan on the Jamaica reconfiguration. Under this scenario, trains will take full advantage of the infrastructure configuration. It is important to note that the proposed operating plan was developed prior to the creation of this recommended configuration and different assumptions. Under the new operating plan selected eastbound Atlantic Branch service was placed on Track 8. Although previously studied configurations permitted this routing, the current configuration does not. Similarly, there are only selective Montauk Branch trains which are routed over the E Yard extension tracks with the remaining service merging into Main Line 1 towards the cluster. Maximum utilization of this route would reduce potential schedule conflicts.

For comparison purposes, this scenario removes Atlantic Branch Scoots from the analysis to ensure consistency between compared data. Since the Scoot service is operated on primarily isolated tracks and therefore does not cause any degradation of main line service. Additionally, inclusion of the Scoot trains would alter the random data stream placed on all inserted model trains and would artificially change the OTP percentages.

Due to the reconfiguration and elimination of scheduled connections, the typical operating speed under this configuration is approximately 10 mph including platform dwells and 14 mph excluding platform dwells faster than the baseline operations on the current infrastructure. The elimination of schedule connections enable dwell compression of the difference between the timetable specified dwell time and the minimum allowable dwell time. Modification of the infrastructure permitting the higher operating speeds permits a scheduled time savings of close to 3 minutes.

Simulation of scheduled operations and seven different perturbed runs (each with increased maximum potential random delay) placed upon the equipment arrival time into the model indicate that the “Platform Arrival” numbers are generally minimally lower than the Arrival OTP. This indicates that a train that arrives off its schedule is likely to encounter some congestion from other trains that are on their schedules. Review of the link nodes during the maximum perturbed scenario indicates the high volume of service schedule for Main Line 1 due to the Montauk Branch merge. Modification of the operating plan for increased utilization of the E Yard extensions would mitigate this condition.

The exit OTP numbers are the same or better than the Platform Arrival OTP, showing that many trains made up time between platform arrival and departure. This is mostly because late trains take shorter platform dwells to keep to their original departure times. The new infrastructure does not restrict speeds to 15 mph as trains exit Jamaica. Many of the reverse peak trains seem to have long scheduled dwells, including a number of trains with scheduled 5 minute dwells. In fact, the average EB dwell during AM rush is around 3 1/2 minutes. Since the compressed dwell for late trains is one minute, the late trains can make up an average of over 2 minutes, and up to 4 minutes, which is enough to put many of them back under 3 minutes late. The same is not true for the WB trains during AM rush: the average WB dwell in AM rush is under 2 minutes, so an average train can make up less than a minute via platform dwell compression. A similar situation applies for the PM reverse peak, though to a lesser extent.

The simulation results demonstrate the infrastructure's ability to reliably accommodate the higher volume of service approaching the platforms.

Maximum Stress Service

Maximum stress condition was provided by the LIRR and constructed by inserting additional trains within the new operating plan (OP 3.0). Selected additional trains had to be removed to conflicting platform availability.

Under these increased level of service many of the main line headways were reduced to approximately 2 minutes during the peak hour.

The analysis indicates that this level of service the average speed is reduced throughout the system compared to OP 3.0 by approximately 4 mph with dwell considered (19 mph) and 2 mph without dwell considered (26.5 mph) consuming an average of 30 seconds per train. Network node analysis reveals excessive utilization of the main line tracks between Harold Interlocking and Jamaica and Main Line 4 east of Jamaica in the evening.

Analyzing non-perturbed conditions (OTP and trains waiting to enter the model), the simulation concluded that the modified infrastructure permitted this substantial increase in train counts (capacity) while maintaining improved operations above those experienced during current operations.

Perturbation Scenarios

Perturbed scenarios were simulated to test the operational performance of the proposed Jamaica Interlocking Configuration under extreme conditions (i.e. a key track being out of service for 20 minutes to determine the reliability of the recommended configuration. The following perturbed scenarios are considered to provide the most intense conditions for each peak period is recommended for simulation.

Analysis of the Jamaica Complex was performed with the following local scenarios:

1) AM Peak Period - Medical Emergency – Station Track 2 – 20 Minutes
2) AM Peak Period - Equipment Failure (scheduled Flyer) – Station Track 6 – 20 minutes
3) PM Peak Period - Medical Emergency – Station Track 7 – 20 minutes
4) PM Peak Period - Passenger Issue – Station 6 Blocked – 20 minutes

Each of these scenarios was similarly analyzed; for this paper the analysis used for the perturbation scenario for Type 1 is shown for illustration.

This scenario, also described as the "Medical Emergency" scenario, is to take out Jamaica track 2 for 20 minutes period during the AM rush between 7 and 9 AM. Blocking Track 2 from 8:20 to 8:40 causes 7 scheduled trains to either shift platform tracks or experience delays less than 4 minutes as shown below:

8:20 AM Disruption on Track R2

	Trains	Trains affected
Total from 8:10 AM to 8:50 AM	40	
Chose a different platform	3	1621, 1715, 2611
Delayed on arrival between 0 - 1 minute	4	1621, 2611, 913, 131
Delayed on arrival between 1 - 2 minutes	1	1623
Delayed on arrival between 2 - 3 minutes	0	
Delayed on arrival over 3 minutes	1	1553
Delayed on arrival, but waited out the platform outage	1	1553

Table 2. Disruption Scenario with Summary of Impacted Trains

The impact of this blockage is depicted on the occupancy table below:

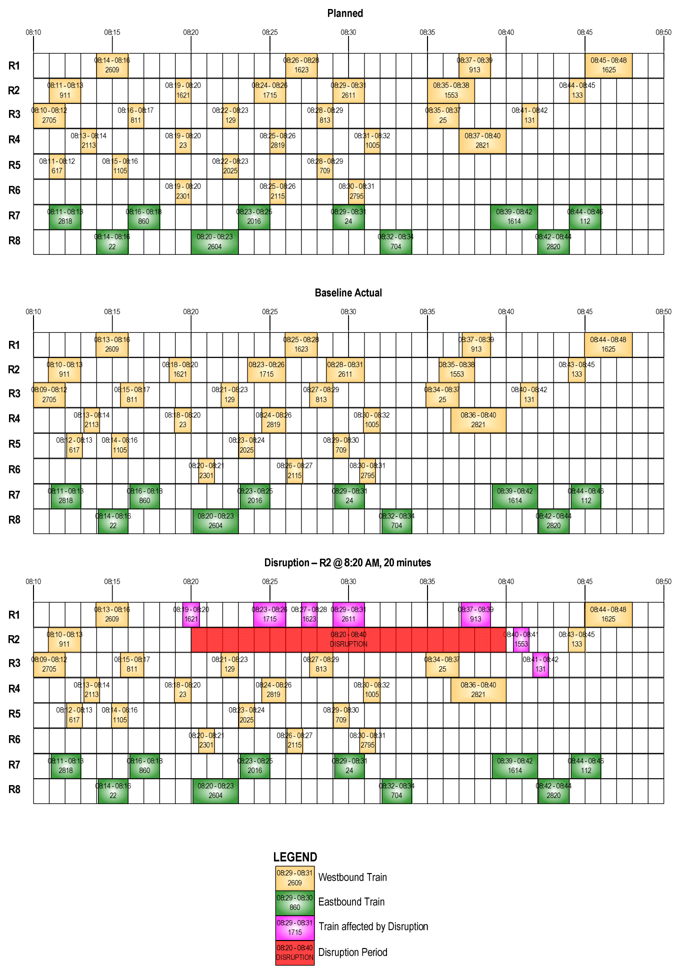

Figure 3: Track Status and Impacted Trains during Disruption Scenario

When the disruption event occurs there is capacity available in alternate platforms to allow disrupted trains to utilize. For example, looking at train 1715 the comparison clearly shows that it is able to maintain its same schedule just by utilizing platform track R1. The remaining affected trains make similar adjustments to maintain their schedules and Jamaica is able to continue operations with minor adjustments. Jamaica system has flexibility in its platform schedule to handle a disruption event.

6. CONCLUSION

The ability to isolate a complex interlocking such as Jamaica provided an analysis method that allowed for specific scenarios to be created to quantify the performance differences of facility design alternatives and operating plan.

The dynamic dispatching logic within the modeling was useful for selection of alternate platforms and provided a realistic way to quantify local flexibility that is needed on an hourly basis in this operating environment.

Additionally, the modeling provided a method to d a method to perform robustness testing to address the tradeoffs of reducing routing flexibility and Jamaica operating speeds**.**

This method proved to be a good framework for performing analysis of a station environment. A similar method is now being applied to Chicago Union Station with modifications to the dispatching logic to measure the flexibility of this stub-ended station environment and to also examine passenger flow with its constrained platform design.