FHWA-NJ-2004-016

COMPUTER MODELING AND SIMULATION OF NJ TRANSIT PENN STATION NEWARK

FINAL REPORT
August 2004

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Federal Highway Administration

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TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-NJ-2004-016		

4. Title and Subtitle	5. Report Date
Computer Modeling And Simulation Of NJ Transit Penn Station Newark	**August 2004**
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Dr. Lazar N. Spasovic and Keir Opie	

9. Performing Organization Name and Address	10. Work Unit No.
National Center for Transportation and Industrial Productivity New Jersey Institute of Technology 323 Dr. Martin Luther King Jr. Blvd. University Heights Newark, NJ 07102-1982	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation Research and Special Programs Administration 400 7th Street, SW Washington, DC 20590-0001 N.J. Department of Transportation 1035 Parkway Avenue P.O. Box 600 Trenton, NJ 08625-0600	14. Sponsoring Agency Code

15. **Supplementary Notes**

The purpose of the project was to model the impacts of proposed improvements to the Newark Penn Station pick-up/drop-off facilities and to the surrounding roadway infrastructure.

As part of the project, a Paramics simulation model for the study area surrounding Newark Penn Station was built and calibrated to existing conditions. Analyses were conducted for the base 'No Build' condition, as well as for the planned NJDOT / City of Newark improvements and for multiple NJ TRANSIT recommendations. Analyses were also completed to determine the impact of large future developments in the immediate vicinity of Newark Penn Station.

The major findings of the report include:

- The NJDOT/City of Newark proposal of adding a left turn from Raymond Blvd WB to Route 21 (McCarter Highway) SB results in negative impact and increased delay for all vehicles trips on Raymond Blvd and buses on Market Street.
- NJ Transit's combined recommendations (as outlined in the following) result in significant improvements and a reduction in delay for all vehicles and person trips on both Raymond Blvd and on Market Street.
- The most effective way to improve bus, auto, and truck circulation in the vicinity of Newark Penn Station is to implement NJ TRANSIT's recommendations and remove the proposed NJDOT/City of Newark allowance of left turn vehicles from Raymond Blvd to Route 21 SB from further consideration.

16. Key Words	17. Distribution Statement
Traffic simulation, Bus lanes	No Restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

18. Security Classif (of this report)	19. Security Classif. (of this page)	20. No of Pages	21. Price
Unclassified	Unclassified	34	

Form DOT F 1700.7

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ABBREVIATIONS USED

NJ TRANSIT	New Jersey Transit Organization
NJDOT	New Jersey Department of Transportation
NJIT	New Jersey Institute of Technology
NCTIP	National Center for Transportation & Industrial Productivity
WB	Westbound
SB	Southbound
RPE	Raymond Plaza East
RPW	Raymond Plaza West
Blvd	Boulevard
sec/veh	Seconds per vehicle

ABSTRACT

The project “Computer Modeling and Simulation of New Jersey Transit Penn Station Newark Study” was completed by the NJIT National Center for Transportation and Industrial Productivity staff under contract to the New Jersey Department of Transportation (NJDOT) and under advisement from NJ TRANSIT staff. The purpose of the project was to model the impacts of proposed traffic improvements to Newark’s Penn Station pick-up/drop-off facilities and to the surrounding roadway infrastructure.

As part of the project, a Paramics simulation model for the study area surrounding Newark Penn Station was built and calibrated to existing conditions. Analyses were conducted for the base ‘No Build’ condition, as well as for the planned NJDOT / City of Newark improvements and for multiple NJ TRANSIT recommendations. Analyses were also completed to determine the impact of large future developments in the immediate vicinity of Newark Penn Station.

The major findings of the report include:

- The NJDOT/City of Newark proposal of adding a left turn from Raymond Boulevard Westbound to Route 21 (McCarter Highway) Southbound results in a negative impact and increased delay for all vehicles trips on Raymond Boulevard and buses on Market Street.
- NJ Transit’s combined recommendations (as outlined in the following) result in significant improvements and a reduction in delay for all vehicles and person trips on both Raymond Boulevard and on Market Street.
- The most effective way to improve bus, auto, and truck circulation in the vicinity of Newark Penn Station is to implement NJ TRANSIT’s recommendations and remove the proposed NJDOT/City of Newark allowance of left turn vehicles from Raymond Boulevard to Route 21 SB from further consideration.

1.0 INTRODUCTION

Recently, New Jersey Transit (NJ TRANSIT) blocked non-authorized vehicle access to Raymond Plaza East in downtown Newark. The temporary closing was intended to help bus transit movements serving Penn Station Newark and increase security around this important transportation hub. The firms of DMJM-HARRIS and EE&K Architects PC were hired to conduct a traffic circulation study for Penn Station. The study area was defined as a circle with a 1,500 foot radius around Penn Station. The study was focused on helping the bus movements out of the NJ TRANSIT bus stops on the west side of Penn Station and onto Raymond Blvd. Currently this movement experiences excessive delays due to the lack of storage space for the left turning buses from Raymond Plaza East to Raymond Blvd and a lack of space on Raymond Blvd for the buses to merge with the westbound vehicles queued on Raymond Blvd.

This report is an overview of the research and findings completed by the research team at New Jersey Institute of Technology.

2.0 RESEARCH PROBLEM AND BACKGROUND

For security reasons New Jersey Transit (NJ TRANSIT) temporarily blocked non-authorized vehicle access to Raymond Plaza East in downtown Newark. The closing was intended to help bus transit movements serving the Penn Station Newark and increase security around this important transportation hub. The local roadways are very congested during evening peak hours and NJ TRANSIT bus movements in and out of the bus depot under the Northeast Corridor rail line were difficult to complete and buses were experiencing large delays. In conjunction with NJDOT improvements to Route 21 (McCarter Highway) in downtown Newark, NJ TRANSIT saw the opportunity to make improvements to the roadway system and improve bus flows around Newark Penn Station.

To properly conduct analyses of this tightly spaced roadway network with heavy congestion during the evening peak hours, NJ TRANSIT required a simulation model to be developed of the traffic conditions and network in the study area around Newark Penn Station. The model development was primarily motivated by the following needs:

(1) A visual and analytical platform to test the different short-term solutions, including optimized traffic signals and bus lanes.
(2) A 3D model that can be used to show what improvements to Newark Penn Station are planned for the area, and how the system will operate in the future.

The model would allow for simulation of a “what-if” scenario analysis in which impacts of the changes in parameters and policies can be evaluated so that the best scenario can be selected and deployed. The simulation model will be able to test the different scenarios that NJ TRANSIT has identified. The visual aspect of the simulation will be used to present NJ TRANSIT’s plans for the area to NJ TRANSIT executives, policymakers and the general public.

Through funding assistance by the New Jersey Department of Transportation (NJDOT) Research Division, the National Center for Transportation and Industrial Productivity (NCTIP) at New Jersey Institute of Technology (NJIT) was contracted to build such a model and complete the traffic analysis of varying NJ TRANSIT proposals for changes to the circulation patterns around Newark Penn Station.

2.1 Research Objectives

The research plan intends to address the following overall study objectives:

1. Understand the existing traffic conditions in the vicinity of Penn Station,
2. Develop a simulation model of the evening (PM) period conditions around Penn Station,
3. Identify the best improvements scenarios through simulations and analysis, and
4. Effectively present study results via a visualization tool.

3.0 RESEARCH APPROACH

The work plan comprised of a data collection, review, and modeling of existing conditions and scenarios. In order to do this the work was broken down into manageable tasks.

3.1 Task 1: Definition of Study Area

The NJIT team coordinated with NJ TRANSIT to define the study area for the model. This area was defined as the area within a circle of radius 1,500 ft having its origin and center point at Newark Penn Station.

All existing NJ TRANSIT bus route lines and stops within the study area were identified, noted, and mapped. This included an inventory of all signalized and un-signalized intersections falling within the study area. An aerial map of the study area and the underlying transportation network was then developed.

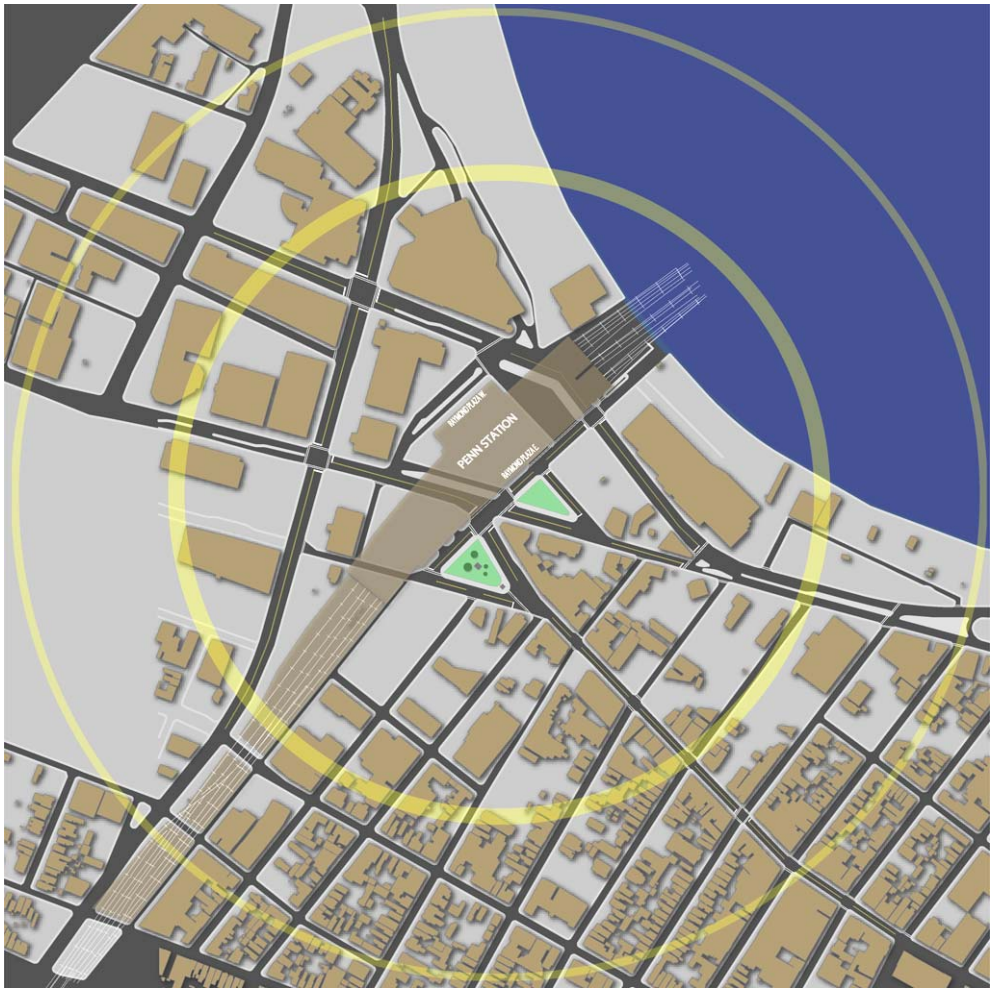

Figure 1: Illustration Map of the Newark Penn Station Site

3.2 Task 2: Data Review and Collection

The team conducted an initial evaluation of various simulation models in order to determine the most appropriate methodology for the analysis.

In order to calibrate the simulation models, data had to be gathered. The data captured comprised of information such as:

- Detailed road geometry (e.g. number of lanes, width of lanes, posted speed limits, etc.),
- Parking behavior and restrictions,
- Hourly traffic turning movement counts,
- Traffic signal location, signal plans, cycles, and timing,
- Queue information at intersection approaches, and
- Bus operation parameters (e.g. headways, average travel speeds, recovery time, etc.).

This data was collected from NJ TRANSIT, its consultants, NJDOT, and the City of Newark. Where information was not readily available, efforts were made to collect data through site visits. Information gathered during these site visits comprised of the collection of queue information, any missing traffic counts that were not readily available, and an inventory of the traffic behavior in the study area.

3.3 Task 3: Existing Conditions Simulation Network Modeling

The procedure for developing the traffic simulation model was done in three steps; development of model, calibration, and validation. A critical step in the development of the model was the estimation of an origin-destination (OD) matrix that defines the vehicular demand for the network. The estimation of how many vehicles were traveling from one portion of the network to another was completed through linear programming based on turning counts collected under previous

work efforts by NJ TRANSIT and their consultants and on probabilistic demand routes through the study area.

The simulation model was developed in Paramics with data collected in Task 2. In order to be able to conduct credible simulation analyses of the operational alternatives, the simulation model was calibrated and validated using site-specific data, including turning counts, queuing observations, and knowledge of the local roadway performance in the evening peak hour. This ensured that the results generated by the model represented actual observed traffic operations in and adjacent to the study area.

A technical meeting was held between NJIT team, NJ TRANSIT, and NJ TRANSIT consultants to review the calibrated model prior to development of the improvement scenarios. A series of animated video images (AVI) files for the evening peak period was developed and summary sheets of the results were provided for discussion in technical meetings.

3.4 Task 4: Improvement Scenario Simulation Models

Using the model developed under Task 3, the NJIT team created an evening peak hour simulation model for the each of the four different scenarios developed and provided by NJ TRANSIT. The results of the various scenarios simulation runs were compared against the existing model and the results summarized. Other scenarios developed during the course of the project by various stakeholders were also tested and evaluated for suitability.

Various performance measures were also developed to determine the effectiveness of all scenario provided by the NJ TRANSIT. A technical meeting was held to review the scenarios and discuss on the selection of the final AVI that was to be incorporated in the final presentation. This included a simulation model for each scenario, a summary of the results for each model run, and

comparison of the alternative scenario to each other and to the existing conditions.

3.5 Task 5: Presentation of Findings

The findings of the study were reported to the NJ TRANSIT project management team and later to NJ TRANSIT executives. From these meetings, the structure and content of the final presentation was determined, and a finished presentation of the key findings was prepared. That presentation was delivered to NJ TRANSIT executives, the City of Newark, NJDOT, and other key stakeholders on December 4, 2003.

3.6 Task 6: Future Work

The NJIT team compiled a summary of the steps to be taken after the study project with the view of possibly enlarging the size of the study area and its transportation network. This was done in order to analyze the transportation impacts of construction of the proposed arena and its effects on traffic conditions on downtown Newark and Ironbound section areas.

4.0 RESULTS OF THE STUDY

The results of the study are outlined in the following sections. Results are shown by combinations of recommended or tested scenarios.

4.1 No Build Analysis

As a first step in determining the base case for comparisons to the build and design alternatives, the “No Build” scenario was developed. This case excluded the consideration of any changes on Raymond Blvd, RPW, RPE, or Market Street.

Figure 2: No Build Scenario Simulation

In this scenario, the system experienced significant congestion. Analysis showed that travel times on Raymond Blvd WB from RPE to Route 21 experienced 3.75 minutes of delay beyond free flow conditions. Outbound buses from Penn Station via RPE encountered a delay of 2.10 minutes between RPE and Route 21.

4.2 NJDOT / City of Newark Recommendation: Add Left Turn from Raymond Blvd WB onto Route 21 SB

Once the base simulation model was built and calibrated, the NJDOT / City of Newark recommendation to allow left turn traffic from Raymond Blvd WB to Route 21 SB was coded and analyzed. This option would utilize an existing paved area to serve as a left turn queue bay and would not require significant construction costs.

Figure 3: Raymond WB Left Turn onto Route 21 SB

Figure 4: Simulation of Allowed WB Left Turn at Route 21

Analysis showed that system conditions further deteriorated by allowing the left turn movement from Raymond Blvd WB to Route 21 SB. Outbound buses from Penn Station encountered a delay of 3.35 minutes while automobiles and trucks encountered a delay of 4.85 minutes to traverse Raymond Blvd between RPE and Route 21.

4.3 NJ TRANSIT Recommendation #1: Westbound Bus Priority Lane on Raymond Blvd

The first of three recommendations put forward for consideration from NJ Transit, this alternative would attempt to increase the mobility of buses in the vicinity of Newark Penn Station.

The first alternative involved the continuation of the prohibition of the left turn movement from Raymond Blvd WB to Route 21 SB and the addition of a bus priority lane to allow NJ TRANSIT buses outbound from Penn Station to bypass significant delays along Raymond Blvd.

Figure 5: NJ TRANSIT Recommendation #1, WB Bus Priority Lane

Two options existed for this scenario; the bus priority lane could be place either in the curbside (right-most lane) or the left-most (median lane) along the Raymond Blvd WB between RPE and Route 21. Both options included a dedicated phase for bus movements from the bus priority lane at the Route 21 intersection. Another scenario analyzed for these options included signal synchronization to provide an optimized bus movement exiting Penn Station at Raymond Plaza East (RPE) and traveling through Raymond Plaza West (RPW) and Route 21 towards Mulberry Street.

a) Replace Left Turn onto Route 21 SB with Bus Priority Lane

I. Left Most Lane

The simulation model indicated that the buses will have a delay of 1.35 minutes to exit Penn Station and travel through the Raymond Blvd / Route 21 intersection whereas auto and trucks will have a delay of 3.75 minutes to traverse RPE, RPW, and Route 21 intersections.

II. Curbside Lane

The computer generated simulation model indicates that the buses will have a delay of 2.15 minutes whereas auto and trucks will have a delay of 3.15 minutes for the same sections of roadway.

b) Signal Synchronization to Provide with Bus Priority Movement through RPE, RPW, and Route 21

I. Left Most Lane

The computer generated simulation model indicates that the buses will have a delay of 0.60 minutes whereas autos and trucks will have a delay of 4.45 minutes for the same sections of roadway.

II. Curbside Lane

The computer generated simulation model indicates that the buses will have a delay of 1.05 minutes whereas auto and trucks will have a delay of 4.35 minutes for the same sections of roadway.

While the synchronization of bus movements provided a great time savings to buses, the modified signal timings slowed private auto and truck movements traveling next to Penn Station on Raymond Blvd. As private vehicles greatly outnumber public buses, the synchronization would result in the average vehicle delay increasing. However, it is important to look at the system from an overall view of person mobility, and consider the delays experienced by all person trips in the system.

Lacking more specific information regarding average auto occupancy in this area of Newark, a reasonable value of 1.2 persons per vehicle was assumed. As buses considered in the analysis are heavily utilized routes immediately leaving Penn Station, a high average occupancy of 50 persons per bus was assumed. The resulting average person trip delay was calculated and is shown in the following figure along with the average bus and private vehicle delays. The figure reports the average delay for the left-most and curbside options for a bus priority lane for the three signal treatments; no additional phase (A), a dedicated bus phase at Route 21 only (B), and synchronization of signals along Raymond Blvd (C). The legend reports the total number of vehicles (both bus and auto/truck) and person trips under consideration.

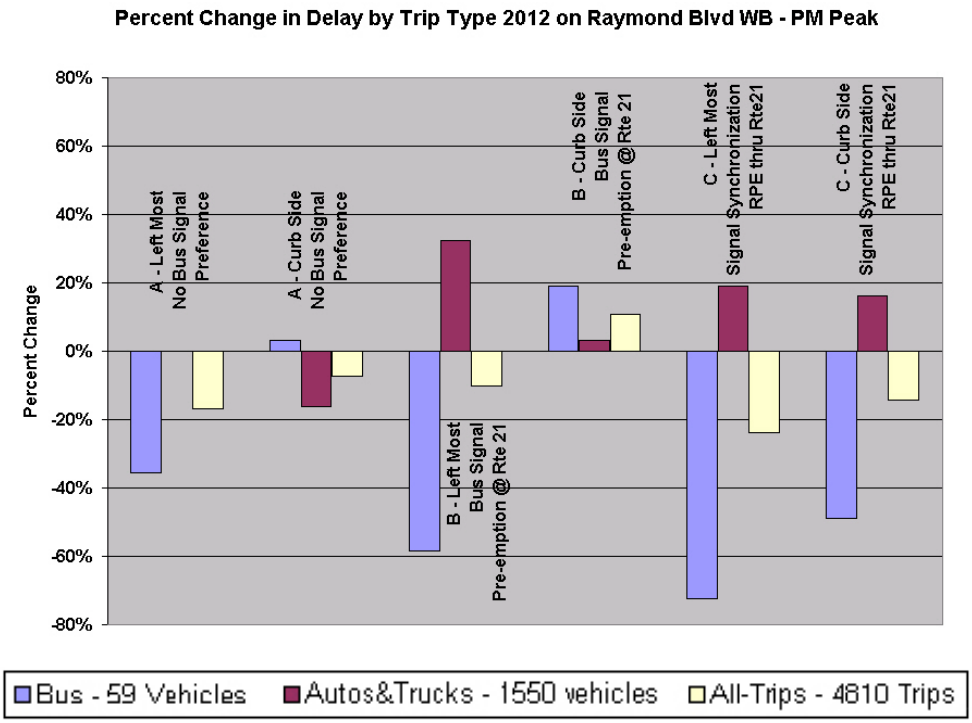

Figure 6: Raymond Blvd Delays for NJ Transit Recommendation #1 (Left Most or Curbside Lane Bus Priority Lane and Signal Treatments)

Due to the increased auto delay on Raymond Blvd, the possibility of private autos currently using Raymond Blvd WB to travel past Penn Station diverting to Market St WB was considered. As the base model developed in Paramics considered system delays and routes or reroutes traffic mid-trip based on anticipated upstream traffic delays, the diversions that drivers make to minimize travel time through the network were automatically determined.

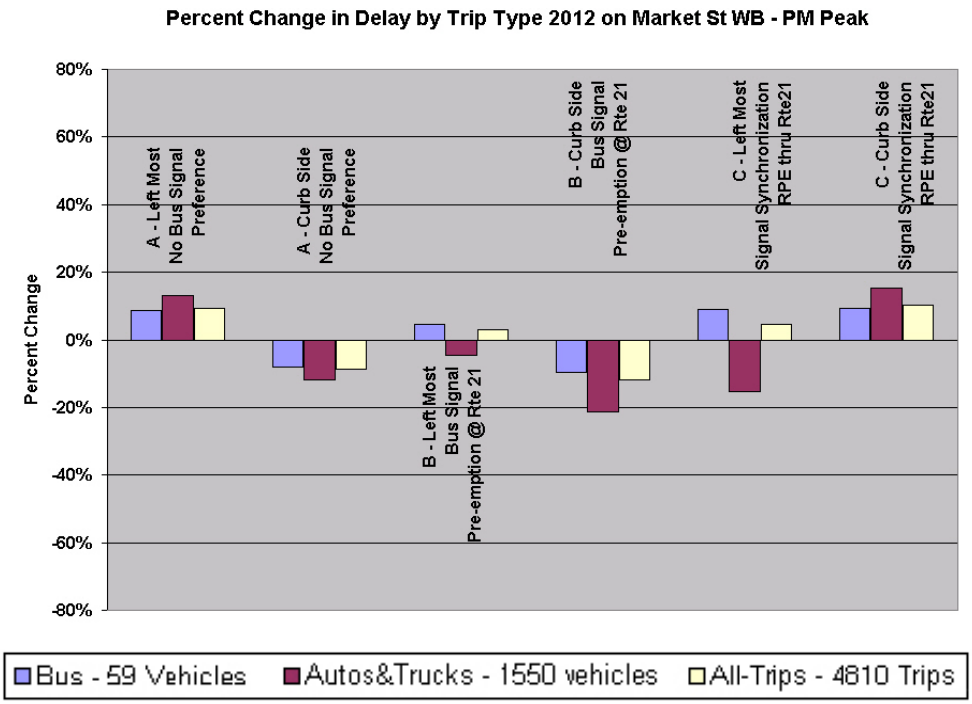

Figure 7: Market Street Delays for NJ Transit Recommendation #1 (Left Most or Curbside Lane Bus Priority Lane and Signal Treatments)

4.4 NJ TRANSIT Recommendation #2: Change Raymond Plaza West to Two-Way Traffic Flow

The second alternative put forward for consideration by NJ TRANSIT to improve circulation around Newark Penn Station was to convert the existing one-way Raymond Plaza West to a two-way roadway featuring a rotary for pick-up and drop-off traffic. The rotary would increase flexibility for pick-up and drop-off traffic by allowing a vehicle to exit via Market Street or Raymond Blvd regardless of where the vehicle entered from. The following figure shows a schematic of the two-way RPW with rotary that was considered to produce the following analyses.

Figure 8: Proposed Two-Way with Rotary Raymond Plaza West

The reconstructed RPW was coded into the model and compared against the No Build scenario. The addition of two way flows with a rotary caused delays experienced by buses traveling between Penn Station (via RPE) and Route 21 along Raymond Blvd to increase slightly from 2.10 minutes to 2.40 minutes. The average auto and truck delay between RPE and Route 21 decreased slightly from 3.75 minutes to 3.70 minutes.

An expanded analysis of the two-way RPW system involved the closure of the rotary system to reduce RPW to a simple two-way flow. In this scenario, a vehicle entering RPW from Raymond Blvd would have to exit onto Market Street. The following figures illustrate the change in the delays between the analyzed

scenario and the No Build case on Raymond Blvd WB and Market Street WB with and without the rotary open.

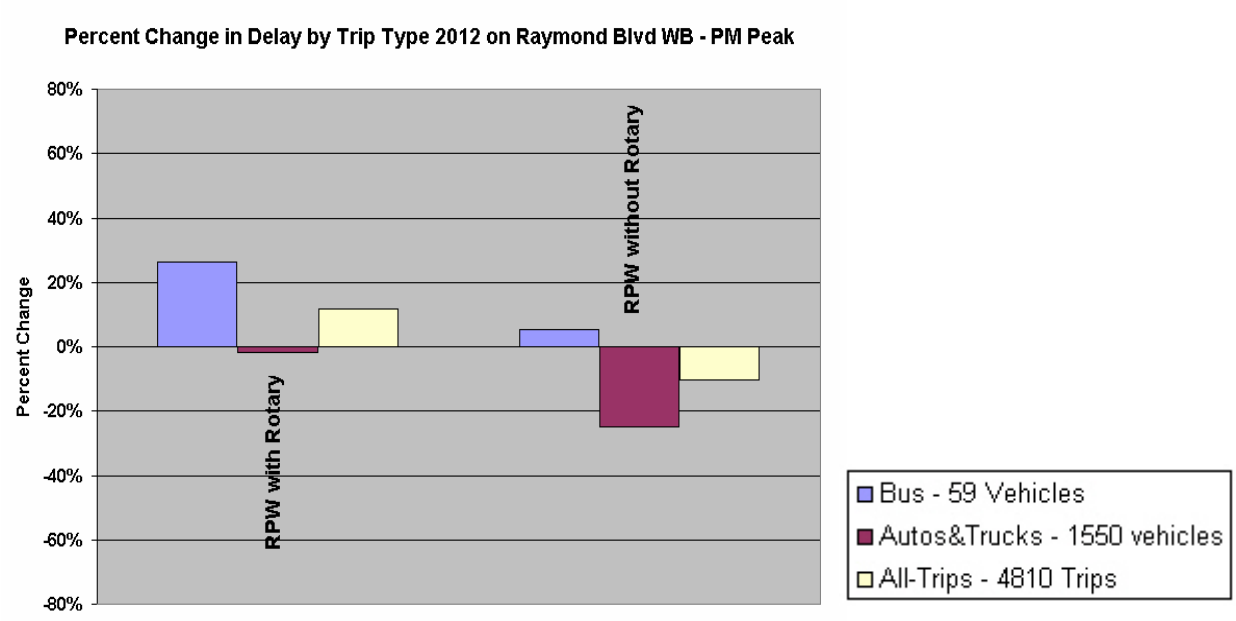

Figure 9: Raymond Blvd WB Delays for NJ Transit Recommendation #2 (Two-way RPW With and Without Rotary Element)

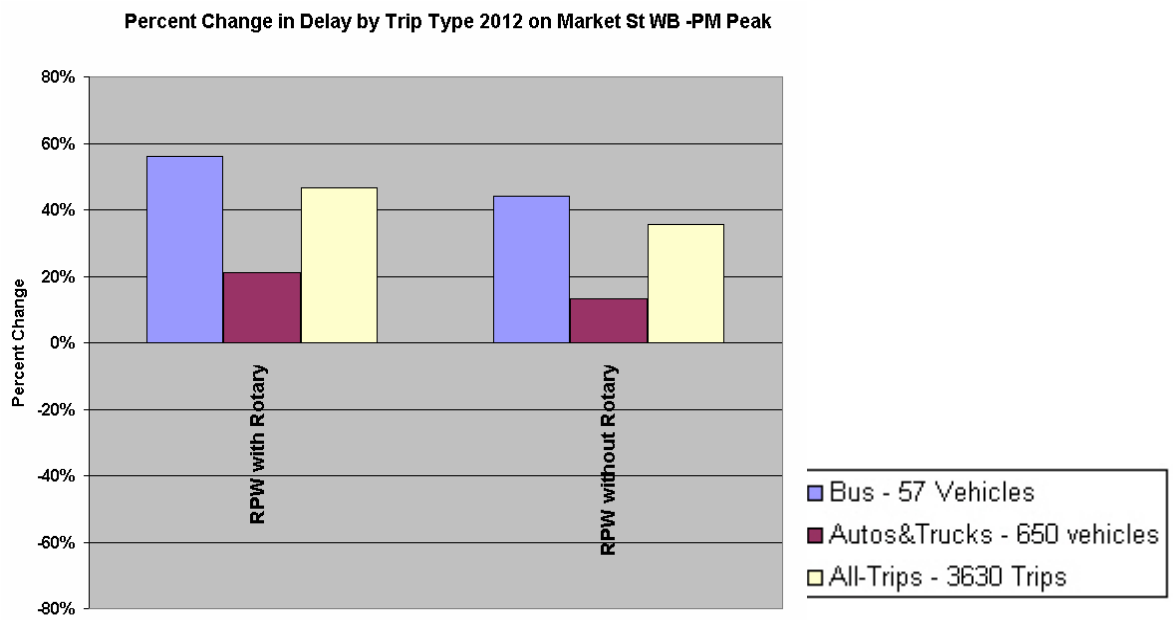

Figure 10: Market Street Delays for NJ Transit Recommendation #2 (Two-way RPW With and Without Rotary Element)

4.5 NJ TRANSIT Recommendation #3: Add Pick-Up/Drop-off Area at Raymond Plaza East and Market Street

The third analyzed improvement considered by NJ Transit called for the reopening of RPE access to and from Market Street and Commerce Street and the creation of an additional pick-up and drop-off location for Penn Station users from the Ironbound or other eastern destinations. No longer needing to access Penn Station from Raymond Plaza West (RPW), these relocated vehicles would help lower the delays at the new two-way Raymond Plaza West.

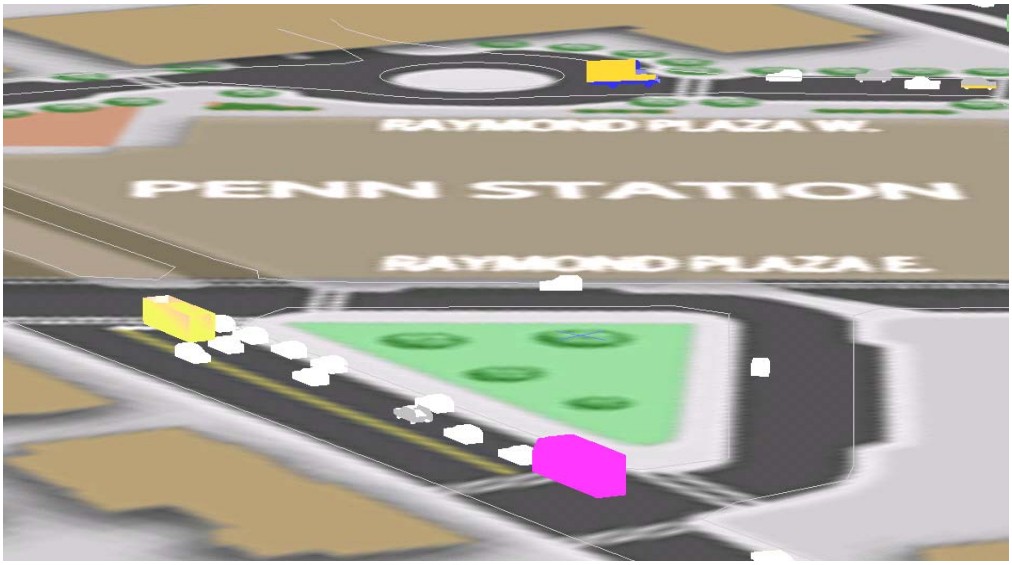

Figure 11: Added Pick-Up/Drop-Off Area on Raymond Plaza East and Market Street

The reopen RPE was coded to the model networks and analysis was conducted for the third NJ TRANSIT recommendation. All analyses completed for this alternative included the previously analyzed reconstructed two-way RPW with and without the rotary element. The following illustrates the change in delays experienced on the network as compared to the No Build scenario. Almost all vehicles benefit from the addition of the RPE pick-up/drop-off area, and in all analyzed scenarios, the net average person trip delays are reduced.

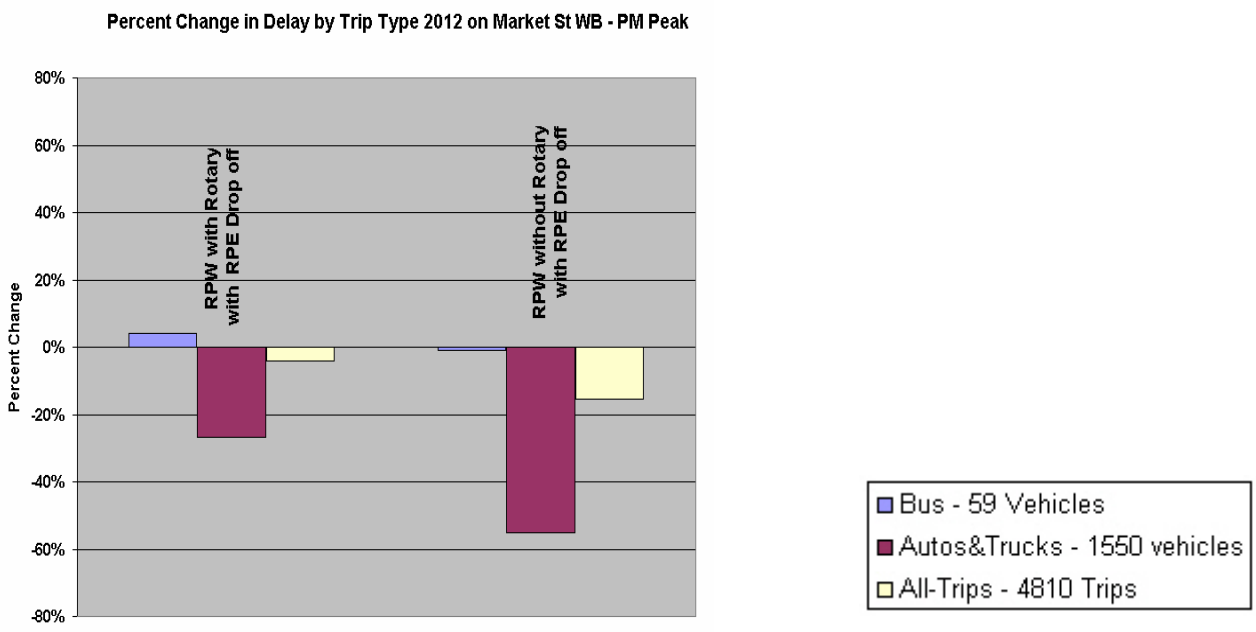

Figure 12: Raymond Blvd Delays for NJ Transit Recommendation #3 (With and Without RPW Rotary Element)

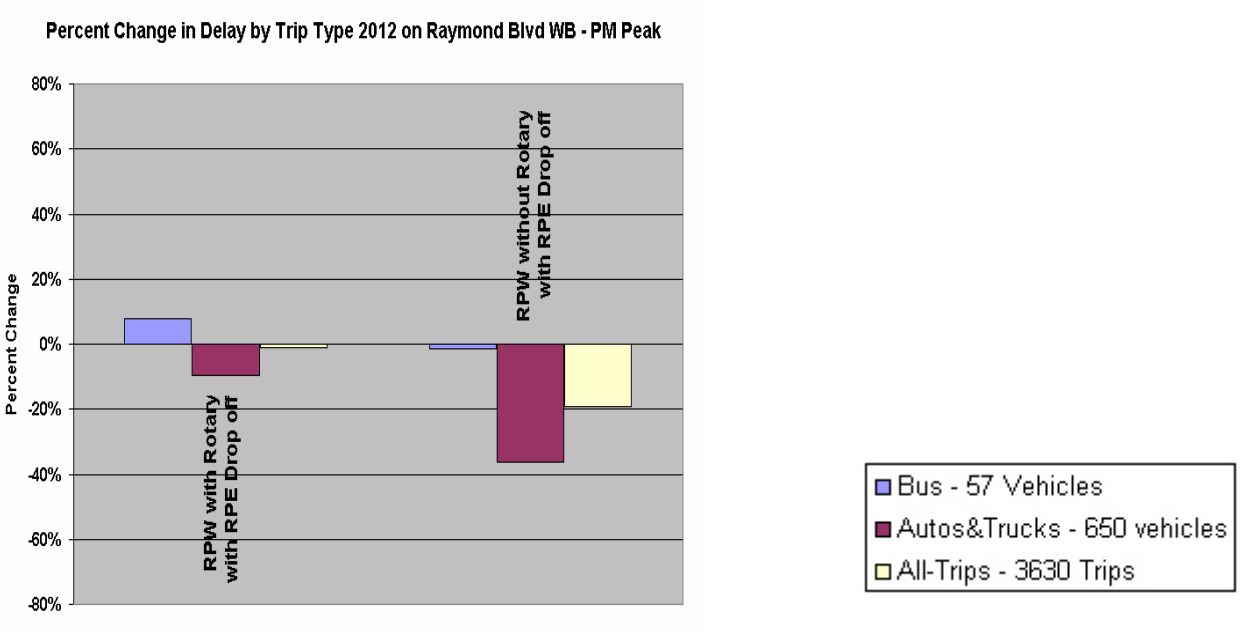

Figure 13 Market Street Delays for NJ Transit Recommendation #3 (With and Without RPW Rotary Element)

4.6 Impacts of Combined Implementation of NJ TRANSIT Recommendations

After analyzing all three recommendations and substantiating the traffic improvements of each of the suggested improvements, analyses were conducted to determine the combined impact of implementing all three improvements together.

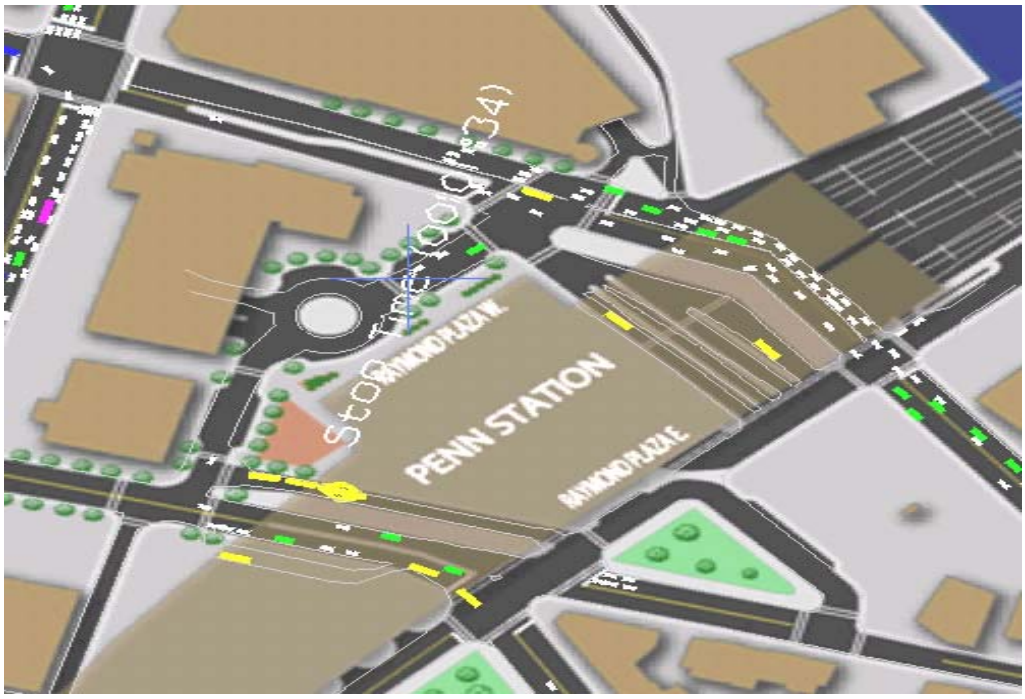

Figure 14: Simulation of All NJ TRANSIT Recommendations

The previous analyses of each recommendation included variations and alterations. The analysis of the combined implementation of all three recommendations took the best scenario of each recommendation, as highlighted below:

- Recommendation 1: Westbound Bus Priority Lane on Raymond Blvd (Left-Most Lane, Signal Phasing and Synchronization);
- Recommendation 2: Change Raymond Plaza West to Two-way Traffic Flow;

- Recommendation 3: Create Drop-off/Pick-up Area at Raymond Plaza East and Market Street

All the recommended improvements were coded into the model network and simulated. The delay for buses to exit Penn Station and travel past Route 21 along Raymond Blvd WB was 0.85 minutes whereas for automobiles and trucks the delay to travel through RPE, RPW, and Route 21 intersections was 2.75 minutes. The reductions of delays from the No Build scenario are illustrated in the following figure for both vehicle and person trips for Market Street and Raymond Blvd.

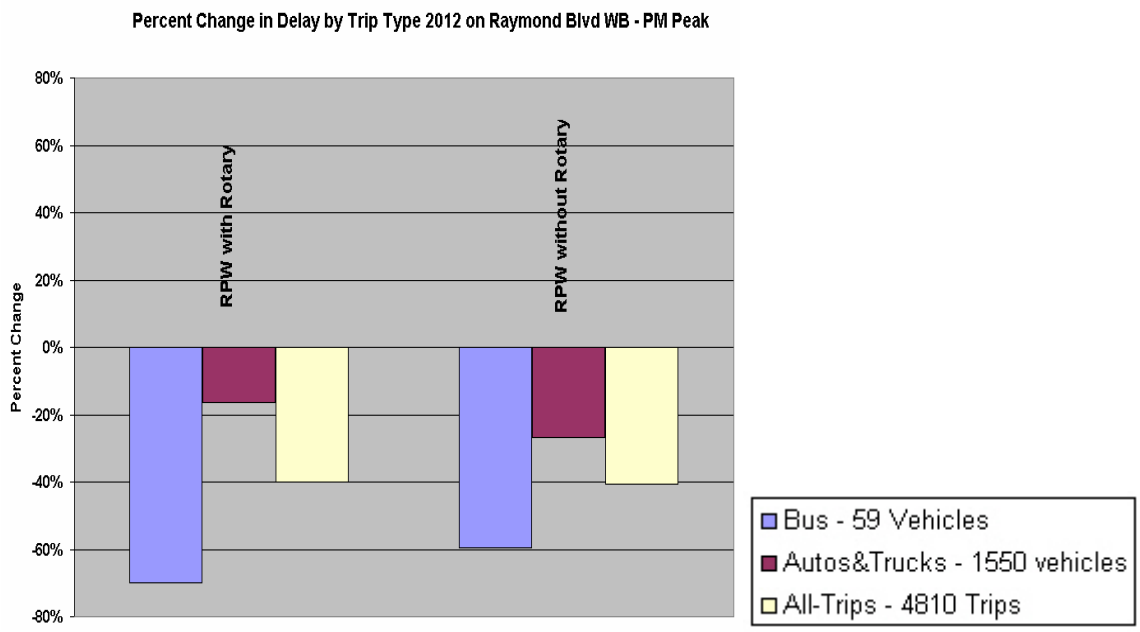

Figure 15: Raymond Blvd WB Delays: Implementation of All NJ TRANSIT Recommendations

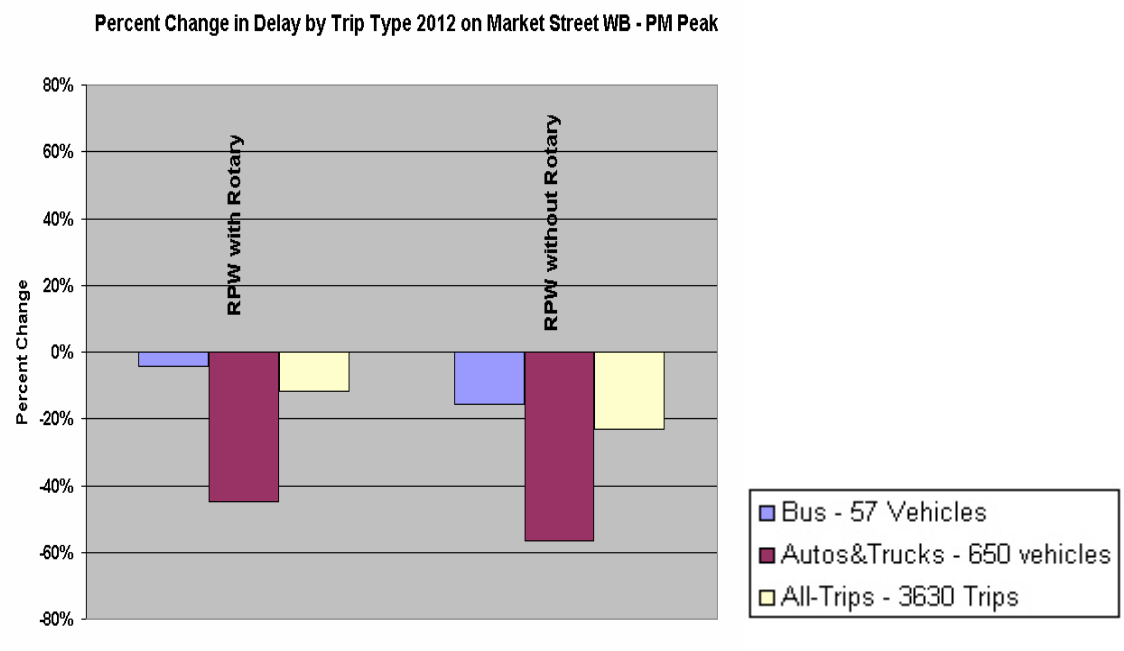

Figure 16: Market Street WB Delays: Implementation of All NJ TRANSIT Recommendations

4.7 Impacts of Proposed Developments

Several developments or redevelopments have been proposed for downtown Newark in the immediate vicinity of Newark Penn Station. The additional traffic traveling to and from the proposed developments (and their associated parking facilities) will have an impact on the already heavily congested traffic conditions within the vicinity of the improvements. This could have a detrimental effect on the circulation of private autos and buses around Newark Penn Station.

Three large developments were considered for analysis and are located in Figure 17. Each of the developments was anticipated to be developed with 500 new parking spaces. For the peak hour analyses to be conducted, it was assumed that half of the parking spaces in the new developments would empty in the evening peak hour (i.e. 250 vehicles exiting from each development parking facility in the evening peak hour).

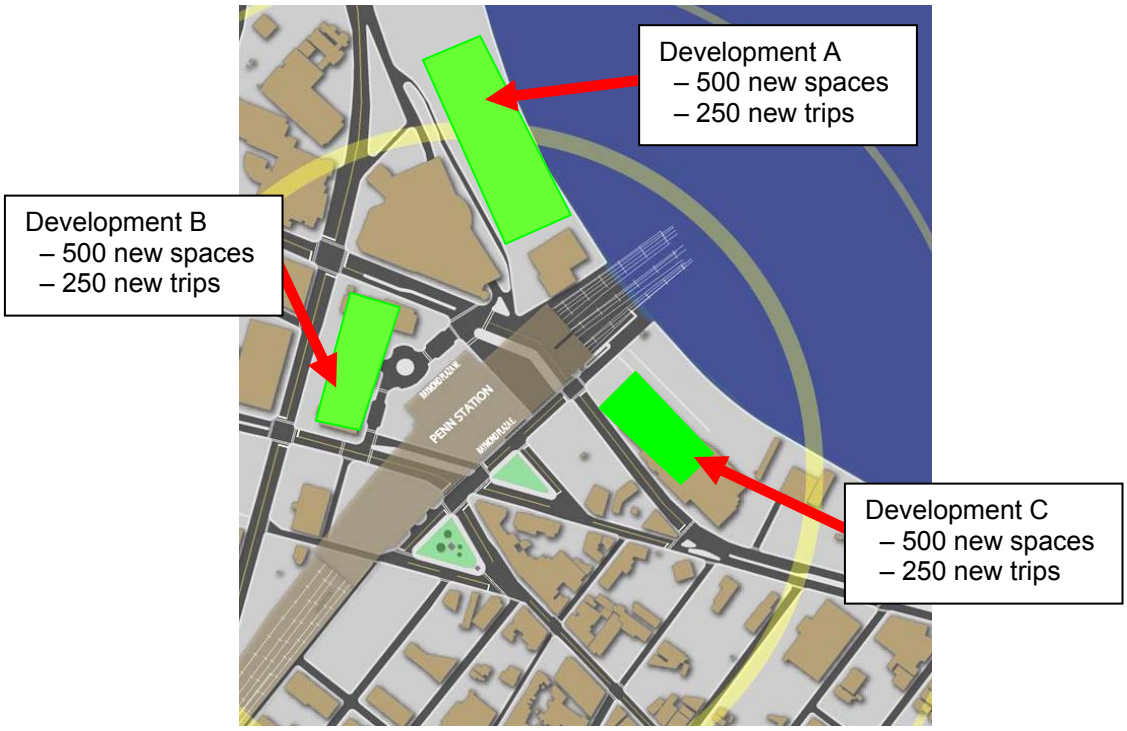

Figure 17: Proposed Development Parking and Traffic Circulation

The impacts of the developments were tested in three scenarios. The results of the scenario simulation on the network are described by each scenario:

Scenario 1: Development A Built (500 new spaces; 250 new trips)

- Raymond Blvd WB delays increase from 270 sec/veh to 320 sec/veh while new parking facilities experience only minor queues at exits.
- Network starts to fail after 30 minutes but never crashes. Approximately 275 vehicles queue in the exit lanes from the existing parking garage because they are unable to enter the network at Raymond Blvd Westbound at Jefferson Street due to congestion.

Scenario 2: Developments A and B Built (1000 total new spaces; 500 total new trips)

- Raymond Blvd WB delays increase from 270 sec/veh to 400 sec/veh while new parking facilities experience only minor queues at exits.
- Gridlock occurs about 50 minutes into the peak hour, with 400 vehicles unable to enter the network at Raymond Blvd at Jefferson Street.

Scenario 3: Developments A, B, & C Built (1500 total new spaces; 750 total new trips)

- Scenario 3 experiences the same delays and number of vehicles unable to enter the network at Raymond Blvd as seen under Scenario 2.
- Gridlock occurs around 50 minutes into the peak hour.
- Most of the 250 new trips added as a result of Scenario 3 have difficulty exiting the parking facilities and entering the network. The signals controlling this access to Raymond Blvd would need a major overhaul.

5.0 CONCLUSIONS

The following can be concluded from the evening peak hour analyses performed:

- The NJDOT / City of Newark proposal results in negative impact and increased delay for all vehicles and trips on Raymond Blvd and for autos and trucks on Market Street.
- NJ TRANSIT's combined recommendations result in significant improvement and reduction in delay for all vehicles and trips on both Raymond Blvd and on Market Street.
- Implementing only the WB Leftmost Bus Priority Lane on Raymond Blvd, with signal pre-emption and signalization, reduces bus delay by over 60% on Raymond Blvd and increases delay for autos and trucks by 20%. Changes on Market Street are negligible for all vehicles.
- Implementing only the WB Leftmost Bus Priority Lane on Raymond Blvd, with no bus signal preference, reduces bus delay close to 40% on Raymond Blvd, while having no impact on auto or truck traffic. A nominal increase in delay for all vehicles is experienced on Market Street.
- Implementing only RPW two-way flow worsens conditions for buses on both Raymond Blvd and on Market Street during evening peak hour conditions.
- Implementing all three NJ TRANSIT recommendations results in the most significant benefit for all vehicles and trips on both Raymond Blvd and on Market Street.
  - On Raymond Blvd, delay for buses is reduced over 60% and for all trips by 40%. Auto and truck delay is reduced over 20%.
  - On Market Street, bus and all trips delays are reduced by about 20%, while autos and trucks would experience over a 55% reduction in delay.
- The most effective way to improve bus, auto and truck circulation in the vicinity of Newark Penn Station is to implement NJ TRANSIT's recommendations and remove the NJDOT / City of Newark proposed left turn lane from further consideration.

6.0 RECOMMENDATIONS

The following recommendations were developed as a result of this analysis and are presented for consideration.

6.1 Phased Implementation

In consultation with NJ TRANSIT and the City of Newark, it was concluded that the improvements be introduced in phases. The phases were determined by examining the benefits to be gained versus the anticipated costs for the improvements (as developed by NJ TRANSIT). The phases proposed are as follows:

Phase 1: Continue left turn prohibition from Raymond Boulevard WB to Route 21 SB.

Phase 2: Add Left-most bus priority lane on Raymond Boulevard WB from Raymond Plaza East to Route 21 without signal pre-emption or synchronization.

Phase 3: Implement additional pick-up/drop-off on Raymond Plaza East at Market Street and Commerce Street.

Phase 4: Reconstruct Raymond Plaza West two-way flow with rotary; add bus signal phasing (queue jump) on Raymond Boulevard WB at Route 21 and signal synchronization on Raymond Boulevard from Raymond Plaza East through Route 21.

6.2 Mode Split

If future development and redevelopment is to be viable in the area, increasing transit mode share is critical. Analyses reveal that the future roadway infrastructure can not accommodate the additional building facilities in the downtown core.

To maintain circulation levels comparable to those that will result from the widening of Route 21, the transit mode-share must increase from 35% to 50% or greater.

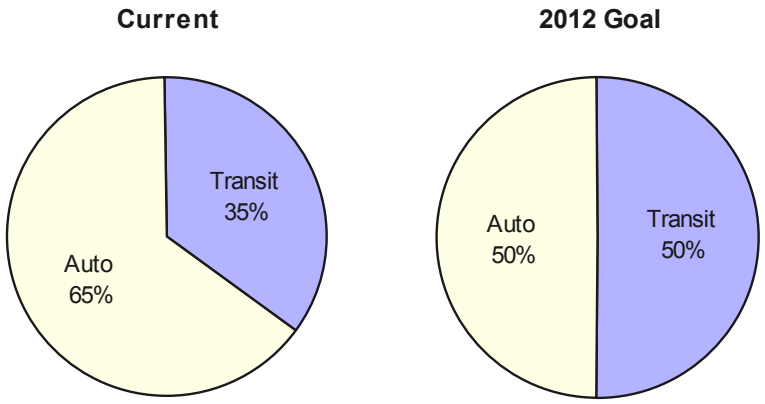

Figure 18: Current and Future Goal Mode Split for Downtown Newark