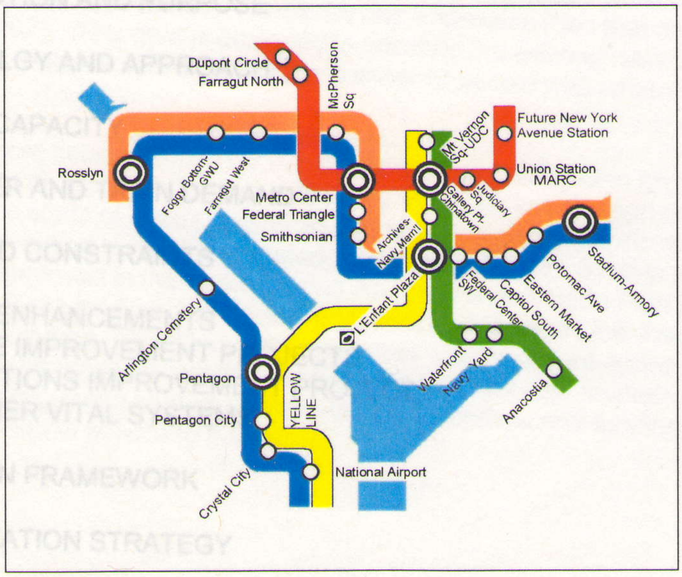
Washington Metropolitan Area Transit Authority



CORE CAPACITY STUDY

MILESTONE REPORT 6
FINAL REPORT

February 2002

Capital Transit Consultants

Washington D.C.

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1. INTRODUCTION AND PURPOSE

1.1 Introduction

As they enter the new millennium, the people of the National Capital Region are riding a wave of unprecedented growth and development that shows no indication of abating. Specifically, projections for the next 25 years include:

- Regional population spiraling upward by 20%, to 5.6 million people
- Regional jobs growing to 3.6 million
- An economy advancing by a factor of 1.5
- Steady growth in the number of domestic and international visitors, which currently amounts to over 23 million per year.

Today, the region is home to 4.7 million residents, making it the sixth largest metropolitan area in the nation. However, it is the second most congested, eclipsed only by Los Angeles. Unlike Los Angeles, where contemporary multi-modal public transportation is a relative newcomer, the people of the National Capital Region have long invested in and enjoyed the benefits of a balanced transportation system which includes significant bus and rapid rail service provided by the Washington Metropolitan Area Transit Authority (WMATA).

Since the 1970's, the Metro system has served as a vital element in the region's transportation equation. Metro has garnered an enviable share of the regional modal split and has been particularly instrumental in relieving congestion in the core downtown area while also meeting mobility demands presented by major events in the nation's capital as attested to by these facts:

- 40% of all trips into downtown Washington D.C. are made on transit
- 18% of regional rush hour trips are made on transit, effectively removing an estimated 257,000 automobiles from the local roads and highways
- Metrorail ridership has increased from 137 million passenger trips in 1988 to 157 million in 1999, an increase of 15%. With the opening of the Outer Green Line in 2001, passenger trips were projected to increase by 4 million trips annually.
- The bus and rail system regularly transports nearly one million customer trips per day during the high tourist season, with more than 550,000 daily riders on Metrorail.
- Metrorail routinely supports major events, providing between 500,000 and 800,000 passenger trips.

The recent opening of the last five stations on the Outer Green Line marked the completion of the original 103-mile Metrorail System at a total cost of about $10 billion. This same system would cost over $20 billion if it were built today.

The Metrorail System as it existed at the time of the Core Capacity Study is shown in Exhibit 1.1.
The Core Capacity Study also included planned and programmed extensions and additions to the System. The Year 2025 system considered as the base for this study included the following:

- Extension of the Blue Line to Largo Town Center
- Addition of New York Avenue Station on the Red Line
- Addition of the Dulles Rail Corridor to Dulles Airport and Loudoun County
- Extension of the Orange Line to Centreville

Exhibit 1.1 Metrorail System Map

🟥 Red Line • Glenmont/Shady Grove
🟧 Orange Line • New Carrollton/Vienna/Fairfax-GMU
🟦 Blue Line • Addison Road-Seat Pleasant/Franconia-Springfield
🟩 Green Line • Branch Avenue/Greenbelt
🟨 Yellow Line • Huntington/Mt. Vernon Sq/7th St-Convention Center

Regional forecasts recognize that the region will continue to grow and that the demand for transit service is projected to double from 600,000 daily boardings (April 2000) to 1,200,000 by the year 2025. In March 1999, the WMATA Board of Directors adopted the Transit Service Expansion Plan created to accommodate that increased demand for service. The Transit Service Expansion Plan has four major elements:

- Improve access to the Metrorail System and expand its capacity
- Improve bus service and expand service coverage
- Selectively add stations, and provide additional capacity at existing stations
- Expand the length of exclusive transit fixed guideways, including Metrorail, LRT and BRT facilities.

The forecasted doubling of over-all ridership will have a significant impact on the ability of the current Metrorail System to provide acceptable levels of passenger service, mobility and accessibility throughout the region. That impact will be felt most acutely in the central "Core" of the Metrorail System. The Core accounts for only 35% of the 85 stations and 19% of the trackage in the entire 103-mile rail transit system. Yet the Core serves 60% of all Metrorail customers and 90% of all transfer activity. 100% of all train trips on the Metrorail System pass through Core.

The Core area contains 29 stations: seven (7) stations on the Red Line between Dupont Circle and the future station at New York Avenue; 13 stations on the Blue/Orange lines between Rosslyn and Stadium Armory; eight (8) stations on the Blue/Yellow-Yellow/Green lines between National Airport and Mt. Vernon Sq.-UDC; and seven (7) stations on the Green-Yellow/Green lines between Anacostia and Mt. Vernon Sq.-UDC. (six stations on the core serve two lines.) The Core area is shown schematically in Exhibit 1.2 and in a traditional aerial-photo base format in Exhibit 1.3.

WMATA recognized that a thorough assessment of the Core of the system was required to define the improvements necessary to accommodate more trains and riders. The Core Capacity Study was commissioned to provide a meticulous exploration of the line and station capacity and the vital operating systems such as train control, traction power and communications. Every significant element of the system had to be examined to identify where existing capacity and infrastructure will have to be increased in order to serve the projected ridership.

1.2 Purpose

The Core Capacity Study was a comprehensive study of the rail system and its stations capacity issues and of major vital operating systems such as train control, traction power and communications. The focus of the Study was to answer two questions:

1. Can the Core, as presently configured, sustain current ridership volumes and the increases in ridership associated with ongoing economic growth at an acceptable level of performance? If not, what must be done to accomplish this?

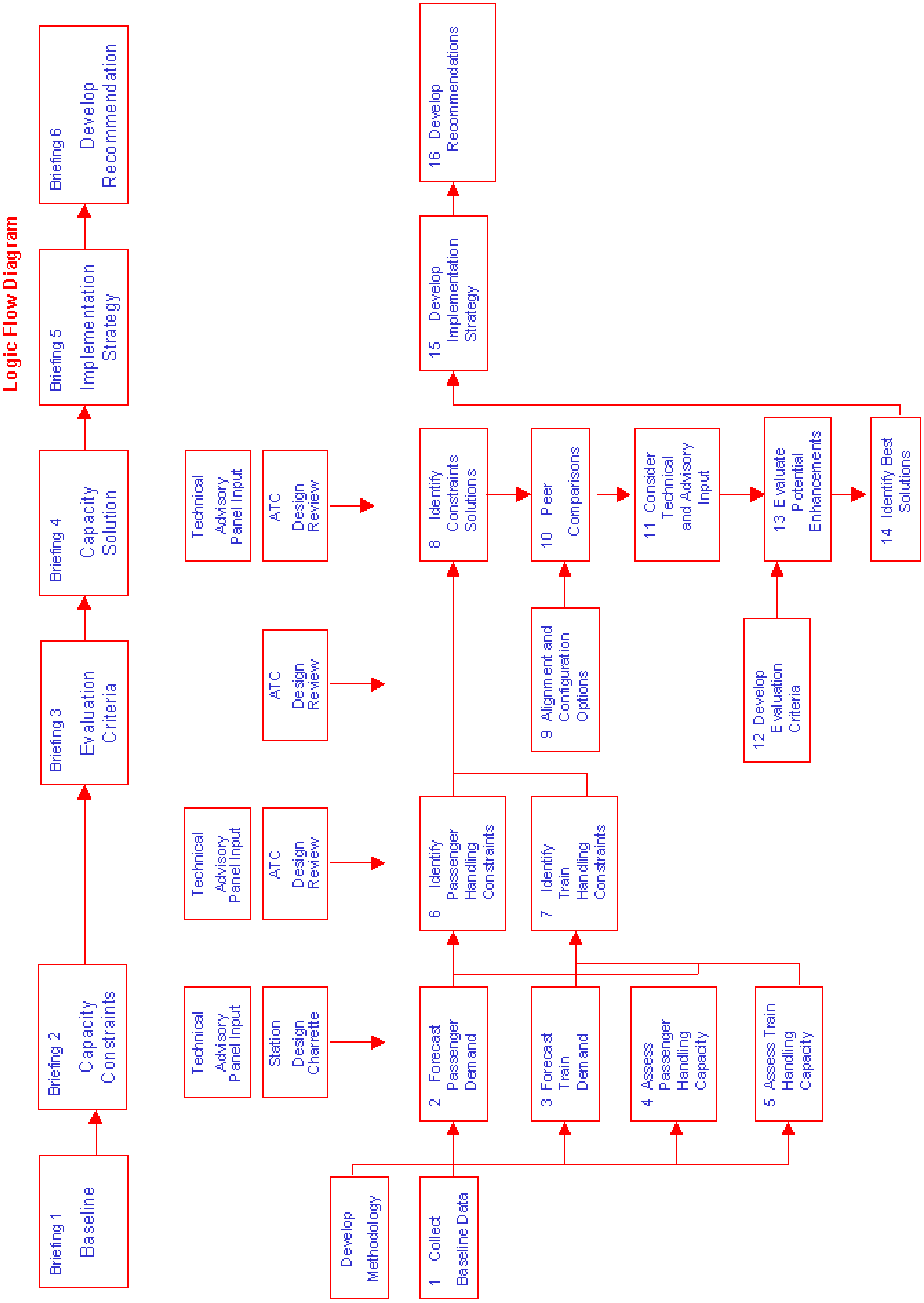
2. Can the Core, as presently configured, sustain the increased passenger demand generated from future expansions? If not, what must be done to accomplish this?

A study methodology and approach, as described in the Core Capacity Milestone Report 2, was established to answer the above questions. The Logic Flow Diagram, which describes the study process, is shown in Exhibit 1.4.

Exhibit 1.2 Core Area Schematic Map

Exhibit 1.3 Core Area Aerial Map

Exhibit 1.4 Logic Flow Diagram



The Core Capacity Study was segmented into seven elements, each resulting in a report of findings and recommendations as follows:

- Program Baseline (Milestone Report 1, November 2000)

  The Program Baseline element established the starting point for the study. It described the Metrorail System in sufficient detail to facilitate the subsequent capacity calculations, comparison of future demand with system capacity, and identification and evaluation of strategies to provide additional capacity where needed.

- Methodology & Approach (Milestone Report 2, December 2001)

  The Methodology & Approach element defined the process used to analyze baseline data, forecast future demand, and generate information on capacity constraints within the Core. It also identified how the available information would be used to develop solutions to meet projected ridership demands and address the system constraints.

- Issues & Constraints (Milestone Report 3, December 2001)

  The Issues & Constraints element identified and quantified areas where the current Core system and approved improvements to system capacity would fall short of meeting the projected doubling of demand during the next 25 years. Evaluation criteria were developed to assess proposed system enhancements.

- Line Improvement Projects (Milestone Report 4, January 2002)

  The Line Improvement Projects element presented solutions to the line and systems issues and constraints identified in Milestone Report #3 and packaged the solutions into 20 line projects. Each line project description was supported with information on types of construction, project cost, engineering issues, construction issues, schedule duration, and project benefits / impacts.

- Station Improvement Projects (Milestone Report 5, January 2002)

  The Station Improvement Projects element presented solutions to the stations issues and constraints identified in Milestone Report 3 and packaged the solutions into 32 station enhancement and passenger connector projects. Each project description was supported with information on station capacity constraints, enhancements to address the constraints, project cost, engineering issues, construction issues, schedule duration, and project benefits / impacts.

- Implementation Strategy (Board Workshop Reports)

  The Implementation Strategy took the form of three Board Workshop Reports presented in September, October, and December 2001 to the WMATA Planning and Development Committee and a Jurisdictional Transmittal submitted to the numerous WMATA Compact member jurisdictions and signatories. The Board Workshop Reports were developed to facilitate the Board’s review of key findings and staff recommendations resulting from the study. The Jurisdictional Transmittal consolidated the study findings, recommendations, and funding requirements for subsequent review by the recipients.

- Final Report (Milestone Report 6, February, 2002)

The Final Report summarizes the findings and recommendations of the Core Capacity Study as contained in greater detail in the aforementioned Milestone Reports.

2. METHODOLOGY AND APPROACH

The purpose for the development of both the methodology for the study and the basic assumptions was to:

- Establish the key assumptions that were used throughout the study
  - Define the Core System
  - Develop the extent of the Programmed and Planned System
  - Assumed Networks and Operating plans for various analysis years
- Develop interrelationships among groups
- Develop an Analysis Approach for the study

Another important aspect was to develop a forecasting methodology to predict ridership and station volumes. The predictions were subsequently tied to the results from the Council of Government regional model set (version 2).

Presently RAILSIM Network simulation of WMATA Metrorail System accurately models the dynamic behavior of the multiple trains governed by the Automatic Train Control (ATC) System and operating under Manual Train Operations. This model, along with other power simulation analysis tools, was verified to accurately model future WMATA Automatic Train Control (ATC) system.

The study was divided into 17 groups to ensure that the Metrorail needs were fully taken into consideration and to facilitate coordination with the concerned WMATA personnel. The seventeen task groups established were;

1. Passenger Demand
2. Intermodal
3. Station Design
4. Passenger Communications
5. Revenue Collection
6. Operations
7. Rolling Stock
8. Train Control
9. Traction Power
10. Track, Way & Structures
11. Miscellaneous Systems
12. Operations Control Center
13. Vital Communications
14. Safety
15. Security
16. Maintenance
17. Stakeholder Assessment

The CTC management for Core Capacity Study was organized in a multi-level structure to ensure coordination and integration of the CTC activities that support each of the Focus Issues. For example, the passenger demand analysis would provide a key input to many of the other issues such as station design, track and way, operations, revenue collection and rolling stock.

The methodology was organized and undertaken in this sequence:

- Collect Baseline Data
- Forecast Passenger Demand
- Forecast Train Demand

- Assess Passenger Handling Capacity (of Stations)
    - Passenger Station Model
- Assess Train Handling Capacity
    - RAILSIM Network Simulation
- Identify Passenger Handling Constraints
- Identify Train Handling Constraints
- Identify Other Vital Systems Constraints

- Identify Constraint Solutions
- Alignment and Configuration Options
- Peer Comparisons
- Technical and Advisory Input
- Develop Evaluation Criteria
- Evaluate Potential Enhancements
- Identify Best Solutions
- Develop Implementation Strategy
- Develop Recommendations

The methodology & approach can be found in depth in Milestone Report 2.

2.1 Collect Baseline Data

The first step in the work was the development of a baseline of the System. Two baseline systems were identified for use in the study:

- Current baseline – the system in place in April 2000
- Future baseline – the system planned to be in place by year 2025

Current baseline is the starting point for the entire study. It describes the Metrorail system in sufficient detail to facilitate the subsequent calculation of the system capacity utilization. The program baseline is not intended to comprehensively describe all Metrorail system elements, it specifically focuses on those system element aspects that are more directly related to Metrorail system capacity.

System elements that drive capacity are those that can be modified to increase system capacity. Examples include operations, rolling stock, train control, traction power, stations and fare collection. On the other hand, System elements that are driven by capacity-related changes in other system elements are necessary to accommodate changes in other system elements. Examples include communications, HVAC, and safety.

The future baseline includes the following planned improvements:

- Extension of the Green Line to Branch Avenue
- Extension of the Blue Line to Largo Town Center
- New York Avenue Station
- Dulles Corridor Rail Extension to Dulles Airport and Loudoun County
- Extension of the Orange Line to Centerville

The data on the current baseline system can be found in Milestone Report 1 and was also discussed in Workshop 1.

2.2 Forecast Passenger Demand

The implications of Metrorail's demand characteristics are that the ridership forecasts must:

1. Produce significant travel demand detail by time of day
2. Explicitly recognize variation within the year due to events and changing seasons
3. Produce significant demand detail for all relevant system elements
    - Line
    - Station Entrance
    - Surface to Mezzanine
    - Mezzanine to Platform
    - Inter platform passenger transfers at transfer stations

Lacking the availability of a traditional simulation model that meets the requirements of the Core Study, CTC devised an approach that relied on applying the following factors to the derived station entry/exit data.

- Population and employment growth factor
- System growth factor
- Increased mode share factor
- "Metrochek Program" factor

The details on these factors can be found in Milestone Report 2.

The results of the factored station entry/exit data were assigned to a VISIM transit network software. The software performs a stochastic, multi-path dynamic transit assignment that loads sequentially passenger travel in extremely small units of time, updates network times to reflect demand related dwell times and then assigns traffic for the next time slice. This was used to develop a load profile and estimate transfers.

The 2000 load profile baseline and the maximum load point count data were factored by the ratio of the respective assignment results for future forecast years for all years up to 2025. The model provided forecasts of line volumes and transfers for the four-hour peak period. These volumes were converted to the peak-half-hour (PHH) forecasts using appropriate factors.

The PHH forecasts were multiplied by factors of 1.218 for year 2000 and 1.246 for year 2025 to arrive at the design capacity. These factors were used to account for any unaccounted changes in the PHH forecasts affecting Core demand as well as daily variations from the monthly averages.

2.3 Forecast Train Demand

The passenger demand generated for the stations was used to develop train operational demand requirements. The identified requirements were compared to train handling capacity to assess where the capacity constraints exist. The following factors that were considered in establishing train demand:

- Cars per Train
- Car Loading
- Train Frequency
- Train Performance

The inter-relationship between passenger and train demand was used in the development of capacity solutions.

2.4 Assess Passenger Handling Capacity

The Metro system elements studied in assessing passenger handling capacity included stations, platform to train interface, and trains.

For stations, elements that affect the passenger flow rates and movement were considered. The passenger flow was tracked from arrival at the station, to entry on the platform and boarding of trains and passenger exits were tracked from alighting of trains to the platform and to exiting of the station. The elements investigated were fare collection equipment, vertical circulation and platform configuration. These elements were further organized by station entrance and by line direction.

Values for the appropriate flow rates and the associated factors for use with each station-element were established by reviewing design data from several sources. This included station design guidelines from New York City Transit Authority (NYCTA) and WMATA's own design data.

All rates and calculations are based on values for the Peak Half Hour (PHH). These unit rates were used to calculate the capacity deficiency and capacity requirements.

Exhibit 3.1: Station elements capacity rates

Station-Elements	Capacity / Unit (Rate)	Reference
Escalators	3,000 Pass / PHH	NYCTA (3,060 Pass / PHH)
Stairs	1,650 Pass / PHH	NYCTA (1,650 Pass / PHH)
Fare Gate Arrays	660 Pass / PHH	WMATA (22 Pass/min)
Fare Vendor Machines	75 Pass / PHH	WMATA (2.5 Pass/min)
Exit Fare Vendors	75 Pass / PHH	WMATA (2.5 Pass/min)
Platform Occupancy	0.143 Pass / S.F.	NYCTA (1/7 Pass / S.F.)

The following assumptions were crucial in determining the capacity of station elements:

- Faregate arrays are can be used in only one direction at a time and are unidirectional; therefore they have a uniform capacity.
- Escalators, Stairs are uniform across all stations and have standard capacities.
- Stairs could be used by passengers in either direction for either entering or exiting the station. It was assumed that a stair is shared equally by traffic in both directions.
- The gross platform area was reduced by 25% to account for obstructions on the platform.

2.5 Assess Train Handling Capacity

Analysis of train handling capacity differs from that of passenger handling capacity. While passenger handling capacity analysis involves consideration for passenger use only, train-handling capacity involves the analysis of various systems elements. For example, studying train operations with shorter headways involve considering train control systems in addition to traction power.

The train handling capacity is expressed in terms of “headway”. For a given car size and train length, the headway between trains decides the throughput capacity for a given line/direction. Minimum Sustainable Headway is the interval between trains for a given line in a given direction that offers a high level of train throughput, while providing some contingency to recover from service perturbations. The term is expressed by the equation:

Minimum Sustainable Headway = X + Y + Z

Where:

X = Minimum Train Separation
Y = Governing Station Dwell Time
Z = Operating Margin

These three components of Minimum Sustainable Headway are defined and discussed below.

Minimum Train Separation

Minimum Train Separation is the minimum time between trains, measured from the time one train departs (starts) any given station to the time the following train arrives (stops). Achieving Minimum Train Separation may result in a small increase in end-to-end runtimes, since additional throughput can be gained if train separation is allowed to fall below what is required to operate at full-unimpeded speeds.

Minimum Train Separation is determined by system design and performance factors comprising:

- Vehicle performance
- Train control system
- Traction power system
- Station spacing
- Track configuration
- Train length.

Station Dwell Time

The achievable Train Throughput Capacity of the Metrorail system is greatly impacted by the length of time a train must dwell at a station to allow passengers to board and exit. The amount of station dwell time required by a train is affected by:

- The number and width of doorways along the length of the train
- Operating policies and practices
- The number and behavior of passengers waiting on the platform, alighting from the train, boarding the train, and remaining on the train.

Operating Margin

After Minimum Train Separation and Governing Station Dwell Time, which together comprise “Service Headway”, the third component required to determine the Minimum Sustainable Headway is the Operating Margin. This factor is an amount of time between successive trains that is inserted into a timetable to allow resilience and accommodate minor delays without significantly impacting following trains. Without it, a delay event occurring to any one train would propagate to all trains behind the event train.

The complexity of the Metro Core System demanded extensive modeling efforts to analyze train size and train throughput. Minimum Train Separation was determined using the Systra Railsim simulation model, and corroborated using operating data from the Metrorail Operations Control Center (OCC) and from CTC field surveys. The model was run to simulate realistic and sustainable operation. To facilitate analysis of the train handling capacity, the RAILSIM simulations were performed for the following scenarios:

- April 2000, Actual Ridership, 6 Car Trains
- April 2000, Actual Ridership, 8 Car Trains
- Present Dwells, 6 Car Trains
- Present Dwells, 8 Car Trains
- Year 2025, Forecast Ridership, 6 Car Trains
- Year 2025, Forecast Ridership, 8 Car Trains

In order to determine sustainable headways, a model was prepared based on default train performance schedules. The minimum sustainable headways thus obtained would determine the train handling capacity of the Metrorail system within the core.

2.6 Identify Passenger Handling Constraints

Identifying passenger-handling constraints involved comparing existing capacities to the projected demand. With knowledge of forecast passenger demand and the available capacity for given station-elements, the capacity utilized was determined by dividing the demand with the capacity. The capacity utilization determined for each station-element would be later summarized for each station.

Following station elements were investigated:

- Escalators / Stairs
- Faregate Arrays and
- Platform Occupancy

A spreadsheet model (Passenger Flow Model) was established to compute the capacity utilization for station elements. The model was set-up such that it would compute the capacity utilization based on entry/exit and line/direction for a given station. The model is covered in detail in Appendix B.

The assumptions made while computing the constraints were:

- All calculations are based on the Peak Half Hour
- The AM Peak Half Hour data is used as the basis of all calculations, and is a direct input to evaluate AM Peak Half Hour performance
- PM Peak Half Hour data is not directly available, and so it has been estimated to be of the same magnitude as the AM Peak Half Hour but with the direction of flows reversed.
- Passengers and Trains entering platforms are assumed to arrive uniformly throughout the Peak Half Hour.

Revenue Collection
- The rail fare collection system will operate in 2025 as it does today; that is, a distance-based fare structure with faregates configured to open and close with each successful entry
- The queues presently experienced at rail station vendors are acceptable
- Use of smartcards will increase to 75% of all gate and TVM transactions by 2010.
- An increase in the use of smartcards will increase the throughput of faregates.
- Smartcards increase the complexity of transactions at vendors, but decrease the frequency of use of vendors.

Keeping in view of the service to be provided to the patrons, the capacity utilization at and below 70% was considered to be at an acceptable level. The capacity utilization computed using Passenger flow station model (see Appendix B) is color coded for quick interpretation. *Green color indicates* *acceptable capacity utilization (<=70%), yellow color indicates marginal capacity utilization (>70%) and red color indicates capacity deficiency (> 100%).*

The station element where the capacity utilization was over the acceptable level was marked as a constraint. This was done for all station-elements for all stations.

Another system element that affected the passenger handling capacity of stations is Revenue Collection (or fare collection) system. The relationship between the two is covered in Chapter 3. The station constraints are covered in depth in Milestone Report 3 and are also discussed in Workshop # 2.

2.7 Identify Train Handling Constraints

As in the previous section, the Train Handling Constraints were identified and quantified by comparing the existing capacities to the projected demand. As in station constraints, the train handling constraints are covered in Milestone Report 3 and are also discussed in Workshop # 2.

The capacity used was expressed in terms of Train Throughput Capacity (TTC) while the forecasted demand was expressed in terms of Maximum Link Load Volume (MLLV). TTC is governed by the minimum sustainable headway whereas the MLLV is dependent on the line and direction. The equations are:

TTC = Peak-Half-Hour / Minimum Sustainable Headway
TTD = V / QC where,
V – Maximum Link Load Volume during Peak-Half-Hour
Q – Service Quality Standard (assumed as 120 for the analysis)
C – Number of Cars per Train (six-car and eight-car trains)

EMME/2 model was used to identify the maximum link load volumes on various lines (refer Appendix B). Similarly RAILSIM model was used to determine the minimums sustainable headway. These models together helped identify and quantify constraints and were used for subsequent analysis of proposed recommendations. The CTC Model, developed in conjunction with University of Pennsylvania and served as an independent check of the Railsim model; determined which headways to test with Railsim, and enabled the CTC team to complete rapid analyses of Train Throughput Capacity within only a few hours of new input data becoming available.

Train Throughput is also affected by other vital systems elements. The elements include Traction Power, Rolling Stock, Train Control and Track Configuration among others. The relation among these various system elements is covered in Chapter 6.

The assumptions made while computing the constraints were:

Train Operations

- WMATA's service quality standard for car loadings will remain 120, defined as the mean number of passengers per car through the maximum link in the peak-within-the-peak 30 minutes.
- Trains can run at the maximum design length of eight cars.

Traction Power

- The substation upgrades that are considered here are based on the substation upgrades as covered in the Power Master Plan (PMP) produced by WMATA.
- National Airport substation and U Street substation represent typical 13.8 kV service from PEPCO and 34.5 kV service from VEPCO. Therefore the upgrade costs associated could be extrapolated to other stations within the core.
- The substation units would be upgraded by 3 MW as recommended by PMP (though a 2 MW upgrade may be sufficient to meet the traction power requirements of the system.)
- Sufficient spare ducts exist between the substations and the wayside 3rd rail to accommodate the additional cables required

2.8 Identify Other Vital Systems Constraints

Metrorail system elements that do not directly affect the passenger moving are HVAC, OCC, Communications and Maintenance. All these elements are however vital in keeping the Metrorail operations running. After identifying passenger and train handling constraints, the next step was to identify constraints in the systems referred above, and their possible effects on the system.

The assumptions made while computing the constraints were:

HVAC

- Passenger head load per person is 1,000 BTU/hr.
- Area allocated per person on platform is 16 SF and 40 SF on mezzanine and ticketing areas.
- The standard 350-ton per station capacity provides a satisfactory public area environment for current conditions.
- The use of a spot-cooling concept will continue.
- Station platform and mezzanine floor areas will increase by 30%.
- The calculations performed at Farragut West and Union Station was extrapolated to other core stations.

Communications

- Current or planned replacement programs for various communications systems will affect the ability to handle 2025 ridership.

Maintenance

- Three primary characteristics were looked into to assess the maintenance/storage capacity of each yard: the rail car capacity of the storage tracks, the rail car capacity of the maintenance facility and the employee vehicle parking capacity.
- Other necessary facilities at a yard will not be covered in this study.
- The analysis addresses only 103-mile Metrorail system, i.e. it does not include the yard capacity needed for new Metrorail lines and extensions to existing lines.
- The maintenance of wayside equipment typically requires 1000 feet of track length; the length of approximately 12 rail cars.
- Each line was separately analyzed to check the yard capacity for each line.

2.9 Identify Constraint Solutions

Sections 2.6 & 2.7 resulted in a comprehensive list of passenger and train handling constraints for the System. This list served as a basis for potential solutions to be provided for eliminating the constraints. Although the focus issues have been pursued separately in their analysis, they are all interrelated. The potential solutions should be proposed keeping in view these interrelationships.

The steps to follow are:
- Estimate additional capacity required to meet needs
- Identify what portion of the additional capacity needs could be practically constructed and what capacity deficiency remains.

The proposed solutions were evaluated based on the framework as established (section 2.12).

2.10 Alignment and Configuration Considerations

Section 2.7 calculated additional capacity required for several of the constraints. However, not all of the constraints can be addressed by merely increasing the capacity, as there is a limit to which capacity could be increased. Under these circumstances, the option to consider alignment and system configuration may be warranted to provide innovative solutions. These innovative solutions are capable of relieving multiple constraints.

To assist in considering alignment and system configuration, additional demand analysis was performed in parallel with sections 2.2 & 2.3. Specifically origin-destination pairs were studied to identify underlying travel patterns. Line profile data was also studied to identify current and projected travel patterns.

Peer comparisons were prepared that compare the WMATA System to NYCTA in New York City, CTA in Chicago, BART in San Francisco, and MARTA in Atlanta. Comparison to New York and Chicago allows consideration of what larger cities are doing to address passenger demand. Comparisons with BART and MARTA will provide input on how systems using similar transit technology and modern technology innovations are addressing current day needs. The comparison was made for passenger and train handling capacity.

Comparison with other transit systems was also developed for train control system.

2.11 Technical and Advisory Input

Technical Advisory Panel

A Panel was established that included representatives of each of the following disciplines:
- Architecture
- Infrastructure
- Operations planning and modeling
- Systems
- Technology
- Operations

The panel reviewed, commented on, and participated in discussions regarding the development of “best possible” solutions for passenger and train capacity problems.

Industry Participation

Two of the most complicated technical issues addressed in the study are train control and station design. To facilitate industry input, a station design charrette, and a train control industry review panel were held.

Station Design Charrette

Input from selected architects was solicited in a design charrette held in October 2000. The charrette focused on capacity solutions that might be useful to WMATA in accommodating the tremendous projected increase in demand in Core stations, particularly at the transfer stations: Metro Center, L'Enfant Plaza, Gallery Place, and Union Station, all with internodal transfers.

Train Control Industry Review

Representatives of each of the major train control and signal suppliers were invited to take part in monthly design review sessions. The focus of the review was to assess the current Train Control system and functionality, look at projected needs, and how the current system might be revised to meet those needs. Additionally new technology, and overlay systems was considered.

2.12 Develop Evaluation Criteria

In order to find "best solutions" to capacity constraint problems, it was necessary to identify what the term "best" meant. Issues as diverse as safety, cost effectiveness, efficiency, and reliability were all considered.

A framework was prepared that assisted the Authority to screen potential enhancements. WMATA proposed a comprehensive list of 14 evaluation criteria. The 14 criteria were split into 5 core criteria which related to study goals and priorities and the remaining 9 criteria. These core criteria provided data and information that would clearly differentiate among alternatives and directly support decisions that must be made at this stage of the planning, project, and program development. The proposed core criteria were:

1. Increase capacity (to meet year 2025 requirements)
2. Net positive impact on level of service
3. Enhanced flexibility and failure management (for revenue and non revenue operations)
4. Cost and cost performance
5. Constructability and disruption

2.13 Evaluate Potential Enhancements

Continuing from Technical and Advisory Input referred in section 2.11, the potential enhancements identified were evaluated from the established framework. Solutions developed to capacity constraints identified in sections 2.8 & 2.9 varied in the extent to which they would impact the Metrorail system's capacity. Some might affect policy and standards, while others might involve significant capital investment and construction. These solutions might also have a secondary impact on existing lines and systems. It was therefore necessary to evaluate the potential enhancements for the benefits they provided for the cost they incurred.

The evaluated potential solutions were summarized in a matrix form arranged with each of the capacity constraints problems as described in sections 2.6 & 2.7.

2.14 Identify Best Solutions

Potential Enhancements thus reviewed would result in a list of “best solutions”. These solutions included input form the seventeen task group members, the technical advisory panel, industry review comments and senior WMATA management input during the evaluation process.

The list is accompanied by order of magnitude cost estimates, construction time frames and other relevant technical data. This represents a “needs list” for WMATA.

2.15 Develop Implementation Strategy

The “needs list” also contains the proposed enhancements. To implement these enhancements WMATA would, however, require organizing various work elements that will account for work:

- with different system elements and disciplines
- with higher priority
- that can be staged to meet incremental demand requirements
- that has significant lead-time

The developed implementation strategy would:

- Identify work programs and packages (such as fleet procurement versus fleet modification, station enhancements, station interconnectors, new lines etc.
- Provide order of magnitude cost estimates for work programs
- Identify schedule requirements, including lead times, construction duration
- Prioritize enhancements based on the benefit provided, the cost necessary to implement, and the available finances.

2.16 Develop Recommendations

To proceed with the work identified in the implementation plan, it was necessary to prepare appropriate documentation and supporting data for the WMATA staff and the WMATA Board for their consideration in the budgeting process. In addition to capacity constraint issues, there may be other competing needs for scarce budget dollars. Accordingly, the needs, benefits, and budget requirements to support the implementation strategy were needed.

Recommendations will be developed for:

- Current Actions
- Budget applications for fiscal year 2002
- Five-year program plans
- Long range 25-year strategic plan

3. EXISTING CAPACITY

The capacity of the metrorail system within the Core, for the baseline year 2000 was assembled by reviewing existing information on the system. This chapter summarizes those findings by individual focus group. The scope of the Core capacity study identifies 17 focus groups and so the current capacity for the metrorail system is summarized below by each focus group.

3.1 Existing Ridership

The amount of total Metrorail ridership growth from 1987 - 1999 has increased 17 percent in average weekday ridership and 11 percent in ridership for the Metro Core. In 1999, 58 percent of total weekday ridership was in the Metrorail Core System. The line capacity is computed based on the headways during rush hour and the number of cars per train. Each line runs on a frequency of a three-minute headway.

The load profiles are based on an average of more than 140 passengers per car over peak-half-hour, which indicate that the demand warrants an increase in capacity. Existing passenger volumes at each station are compared to the total capacity under the existing 140 passengers per carload limit and the future 120 passengers per carload limit. An average of 66 seats per car is used to calculate the seating capacity of each train. Each of the five Metrorail lines has a maximum load point along the route where the vehicle passenger load is the greatest. (Refer to Exhibit 4.1-5) During special events it is beneficial to separately review Metro ridership to understand its implications on system capacity. For example, the celebrations at the National Mall on the fourth of July increase Smithsonian's passenger traffic threefold. More information can be found in Chapter 5.

3.2 Intermodal

CTC is assessing the adequacy of existing intermodal connections within the Core. The CTC's scope of work includes the collection of existing demand data from other modes that connect with Metrorail, the collection of demand forecasts prepared by these other modes, and the comparison of current and future demand with available transfer capacity. In addition, CTC is assessing the potential for expanded park-and-ride capacity and bus transfer facilities within the Core.

The Virginia Railway Express (VRE), MARC and AMTRAK and Reagan National Airport are modes that connect with Metrorail. Approximately one quarter of VRE's passengers transfer to Metrorail. Based on the recent onboard survey, half of the passengers of MARC Commuter Rail transfer to or from Metrorail at Union Station. Union Station is currently AMTRAK's third busiest station. CTC is pursuing additional data on AMTRAK ridership. According to the Metropolitan Airports Authority's 1998 User Survey, the proportion of airport users arriving by Metro was 17 percent, up from 11 percent in 1996 at Reagan National Airport.

The Pentagon is the largest bus-rail transfer point in the region.

Park and ride lots assist passengers in making convenient connections to transit, thereby increasing ridership. Parking at non-core stations, while not a core capacity issue, will indirectly affect the core ridership. Therefore, non-core parking needs to be considered if ridership projections are to be met. However, such a study is not within the scope of the Core Capacity Study.

3.3 Station Design

The 29 stations and lines within the Core area include platforms, mezzanines, passageways, station furniture and miscellaneous accessories. They have the following design types and configurations:

PLATFORMS
Platforms are typically side or center platforms. The Core area has 11 side platform stations. Side platforms vary from nearly 13 to 22 feet wide by 600 feet long. The Core area also has 15 center platform stations, including the future New York Avenue Station. Center platforms vary from about 32 to 38 feet wide by 600 feet long.

The Core area has three cross-vault stations with both platform types. Metro Center, L'Enfant Plaza and Gallery Place are three cross-vault stations that serve three or four lines on two levels of the station. These lines cross each other at a 90-degree angle, with lines traveling in a north/south and east/west direction.

MEZZANINES
They are rectangular with various types of openings for escalators and stairs. While irregularly shaped and tapered to two or three pairs of escalators down to the platform on each side of the tracks. These mezzanines generally have less square footage than the rectangular mezzanines above the center platforms. Mezzanines could also be of oval size with varying square footage.

PASSAGEWAYS
Passageways are adjacent to the mezzanines, and form a curved ninety-degree area from the escalator to the mezzanine, or a rectangular area from the escalator directly into the mezzanine.

STATION FURNITURE AND MISCELLANEOUS ACCESSORIES
- Granite marble benches
- Dioramas
- Telephones
- Passenger information display systems
- Trash Receptacles
- HVAC Pylons

The station component inventory is tabulated in Milestone Report 1.

3.4 Passenger Communications

The operation of passenger communications systems, specifically the messaging of the Public Address (PA) system and Public Information Display System (PIDS), can directly affect Metrorail system capacity by affecting passenger behavior while waiting on station platforms, or boarding or alighting from trains. Each passenger station in the WMATA Rail System has an independent Public Address (PA) System that provides the means for making general purpose and emergency evacuation announcements throughout the passenger stations. Each revenue vehicle is equipped with a public address system. Audio signals are sent via the train-line from the PA equipment in the cab to speakers on all the cars in a train.

Exhibit 3.1: Summary of Public Address System Operation

Origin	Priority	Routine / General Purpose Announcements	Emergency Announcements
Automatic PA Announcement System (APAAS)	1	N/A	Pre-recorded announcements to same station only
Rail Operations Control Center (OCC)	2	Live or pre-recorded announcements to one or more stations	Live or pre-recorded announcements to one or more stations
Station Kiosk(s) PA Control Panel	3	Live announcements to same station only – no pre-recorded message playback	Live announcements to same station only – no pre-recorded message playback
Dispatcher PA Control Panel (certain end of line stations only)	4	Live announcements to same station only – no pre-recorded message playback	N/A
Train PA System	N/A	Live announcements to same train only – no pre-recorded message playback	Live announcements to same train only – no pre-recorded message playback

3.5 Fare Collection

The Metrorail fare collection system directly affects the system's people handling capacity, primarily through the throughput capacity of the faregates and secondarily through the transaction rates of the ticket vending machines (TVM's). Cubic Transportation Systems provided the existing Metro Rail fare collection system to WMATA. Fare Vending Machines were installed in 1991-1992, and the majority of the passenger gates were installed in 1993-1994. The original system was based solely on use of magnetic stripe farecards. Beginning in 1998, Cubic Transportation Systems in Metro Rail stations gradually installed smartcard equipment, and Smartrip smartcards were available for wide scale public use in early 1999. Fare vending machines transmit information on individual sales transactions, cumulative sales, equipment status, and equipment summaries to the mainframe computer.
The exhibit below gives the capabilities of various machine types for the passengers.

Exhibit 3.2: Fare Vending Machine and Exit Fare Machine Types and Capabilities

Machine Type	Machine Capability						
	Purchase Passes	Purchase Farecards	Increase Value of Farecard	Increase Value of SmarTrip	Accepts Cash (coin/bill), Provides Change	Accepts Credit/ Debit Cards	Provides Audio Direction
Standard Farecard Vendor		X	X		X		
Express Vendor	X	X	X	X	X	X	X
SmarTrip Vendor (originally used with "GoCard")		X	X	X	X	X	
Exit Fare Machine			X		X		

3.6 Operations

The present capacity of the Metrorail Core is defined partly by its infrastructure and systems but also by the way these assets are operated, particularly the train service during peak periods. The critical operations parameters that impact the present capacity of the Metrorail Core include train service headways, platform dwell times, train lengths, other operating policies and procedures, and the levels of service performance that WMATA presently achieves.

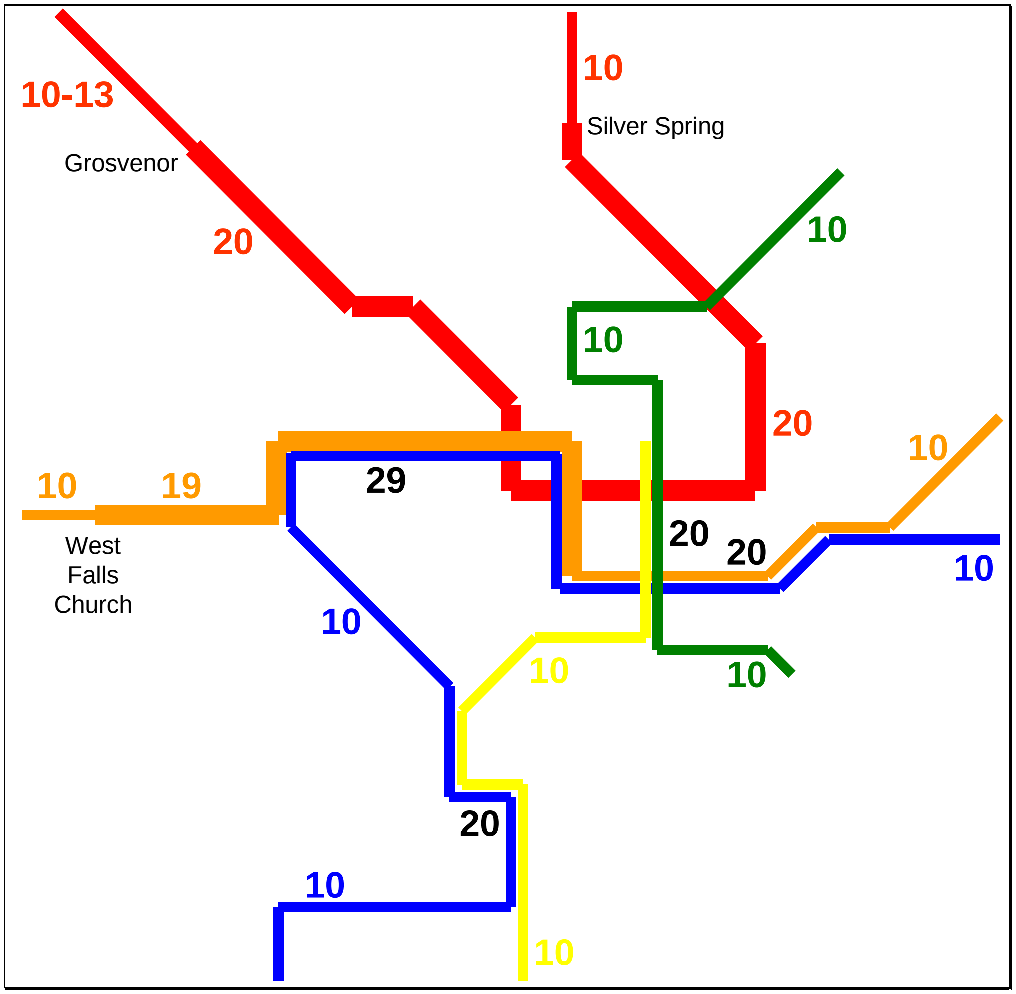
Scheduled peak period train lengths as currently timetabled for each line are as below:

Exhibit 3.3: Train lengths for different lines

LINE	Cars per Train
Red	6
Orange / Blue	4 or 6
Yellow	4 or 6
Green	4

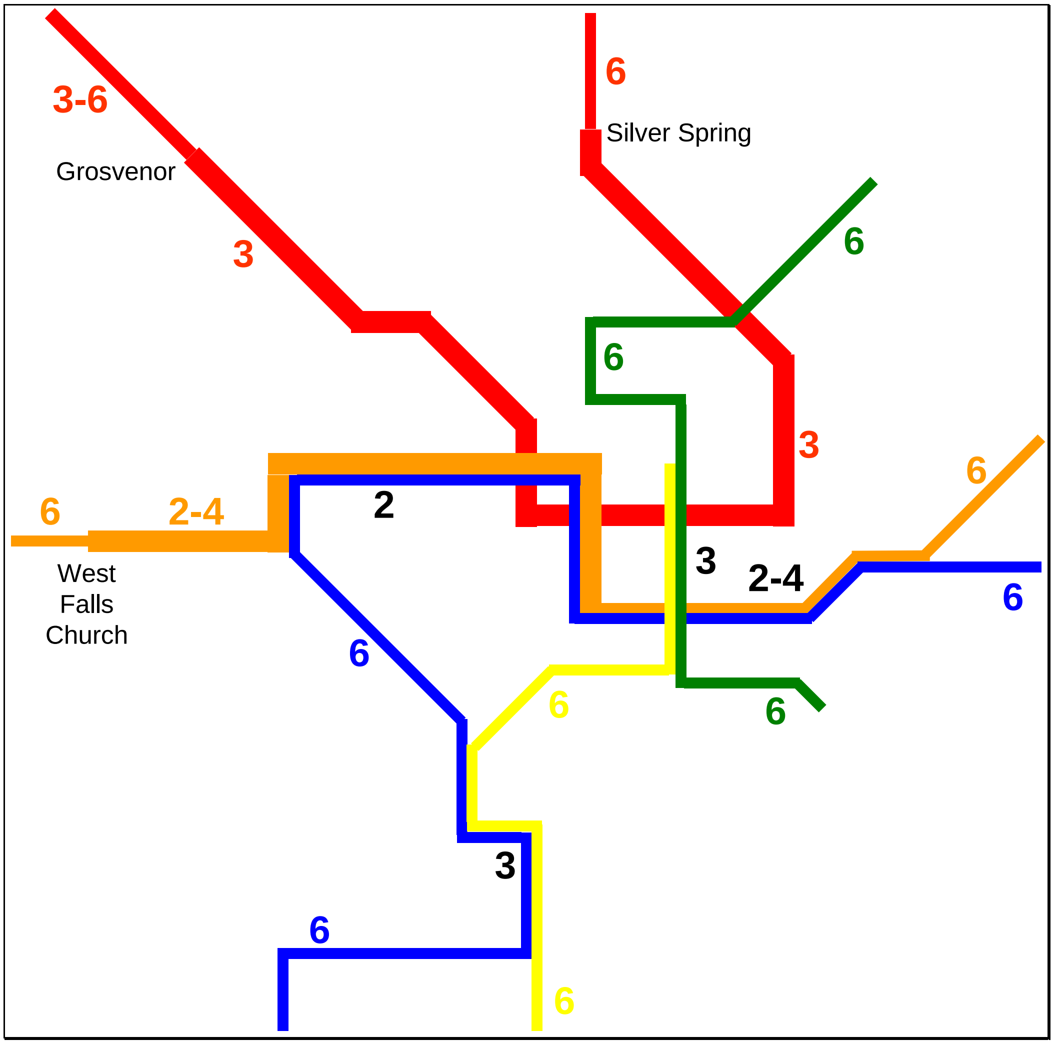
Currently timetabled AM peak service levels expressed in frequencies (trains per hour) and in headways (intervals between trains) is as shown in the figures below.

Exhibit 3.4: Metrorail Scheduled AM Peak Service Frequencies (Trains per Hour)



NOTES:
1. Frequencies apply for the inbound direction only
2. Frequencies in line color are for sections unique to one line
3. Frequencies in black are for sections shared by two lines

Exhibit 3.5: Metrorail Scheduled AM Peak Service Headways (Minutes Between Trains)



NOTES:
1. Headways apply for the inbound direction only
2. Headways in line color are for sections unique to one line
3. Headways in black are for sections shared by two lines

The only section of the system where this headway is scheduled for more than ten minutes, during AM peak period, is between Rosslyn and Stadium-Armory on the Blue-Orange Line. A sustained two-minute headway is scheduled in the Maryland direction in the AM peak for 56 minutes, and in the Virginia direction in the PM peak for 22 minutes. Station dwells are scheduled at 12 seconds in the current timetable, except for major transfer stations where scheduled times range from 19 to 23 seconds. However, the station dwell times actually achieved in revenue service are typically longer than those scheduled. This has a critical impact on Metrorail operating performance.

Platform lengths at all Metrorail stations allow for eight-car train operation, but six-car trains are the longest currently operated.

To respond to vehicle failures, 16 roving vehicle technicians are distributed around the mainline during both the morning and evening shifts, but only Monday through Friday. Except during special events, there are no roving vehicle technicians on Saturdays, Sundays or holidays. All roving technicians carry radios, but only some of them have been issued mobile phones. The average response time to a train failure is approximately five minutes.

WMATA does not publish a minimum equipment list for Metrorail rolling stock. There are, however, some specific criteria for removing trains from revenue service during a run (known as "offloads"). These include cutting out Automatic Train Protection (ATP), operation of the door bypass, and (depending on train length) cutting out one or more of the trucks.

When a train fails in revenue service, WMATA's emphasis is on getting the train moving again and off the mainline. With most stalled trains, the train operator and OCC staff do not attempt to troubleshoot the problem. WMATA's experience is that the variety of car types increases the complexity of troubleshooting and hence the risk of errors and prolonged delays. Troubleshooting is not usually attempted until a vehicle technician is on-board and the train is moving.

Approximately six wayside technician crews based mainly at bifurcation points handle wayside equipment failures. The average response time to a wayside equipment failure is approximately six minutes.

Exhibit 3.6: Selected Metrorail Performance Statistics

Performance Measure	**Period Under Review**	**Target (If established)**	**Achieved (Best Week)**	**Achieved (Worst Week)**
Trains in Peak Service	Apr 2000	112 (1)		
Cars in Peak Service	Apr 2000	612		
Car-Miles in Revenue Service (per week)	10 Oct 99 – 08 Apr 00	900,000	1,020,000 (2)	830,000
Headway Adherence (trains per month operating at a headway not more than 2 minutes longer than scheduled)	1 Sep 99 – 29 Feb 00		92.4% (3)	89.0% (3)
Service Interruptions (train incidents per week resulting in delays to passenger of 4 minutes or more)	10 Oct 99 – 08 Apr 00	18	15	41
Car-Miles Between Service Interruptions (mean revenue car-miles per week between train incidents resulting in delays to passengers of 4 minutes or more)	10 Oct 99 – 08 Apr 00		63,000	21,000
Passenger Offloads (number of occasions per week when passengers were offloaded from a train being removed from service)	10 Oct 99 – 08 Apr 00	30	16	58

NOTES:
(1) In addition, seven gap trains are scheduled to be available.
(2) Actual car-miles operated often exceed the 900,000 car-miles scheduled as a result of providing additional services for special events.
(3) Measured each month, not each week.

3.7 Rolling Stock

The characteristics and capabilities of the Metrorail rolling stock have a significant, direct impact on the capacity of the Metrorail system, both in terms of passenger movement and train throughput. The rolling stock characteristics that most directly affect Metrorail system capacity consist of its physical design, systems design and performance characteristics.

There are four series of rolling stock in the fleet, namely 1000, 2000, 3000, 4000 and 5000. The 1000 series is manufactured by Rohr, the 2000, 3000 and 4000 series by Breda and the 5000 series by CAF. The fleet total will be 950 cars at completion of CAF order of 192 cars. (6000 series).

All Metrorail cars are configured with transverse seating, except for some longitudinal seats near the door vestibule areas, which are reserved as senior and disabled priority seating. The seating capacity for all series cars is 64.

All Metrorail vehicles are specified to exhibit identical performance characteristics as a prerequisite for universal fleet interoperability. The propulsion control system and the station berthing and train control system interface are two design characteristics that have significant impacts on system capacity.
The propulsion system consists primarily of two inverters or converters that drive four traction motors. These traction motors provide driving power and dynamic braking for the vehicles. The traction motors are mounted on each truck, one for each axle. On the 2000, 3000, and 4000 Series vehicles, the traction motors are AEG Westinghouse resiliently mounted DC motors that are self-cooling. The 1000 Series have General Electric AC motors, which are also self-cooling.

The WMATA (ATC) system by Alstom (formerly GRS) provides assurance that trains operate in conformance with signal and speed indications, but also provides fully automated train operation. The ATC system consists of three primary systems that are the Automatic Train Protection (ATP), Automatic Train Operation (ATO) and Automatic Train Supervision (ATS)

3.8 Train Control System

The characteristics and capabilities of the Metrorail train control system have a significant, direct impact on the capacity of the Metrorail system, in terms of train throughput. The Automatic Train Control system is designed to automatically regulate the Metrorail train movements throughout the entire rail system. Block signal design and cab signaling are two main elements of the ATC system that directly impact system capacity. They both are characterized by minimum headway and average speed on each line.

The deceleration time on the approach to the station, the dwell time and the acceleration time on exiting the station impact the capacity of the line. These characteristics are minimally dependent on the ATC system. (Only that part of the ATC system, which assures precise stopping at the station, is involved). The remainder of the characteristics are stipulated by passenger comfort and safety regulations (deceleration and acceleration time, as well as minimum speed at entry to the station), vehicle dynamic characteristics (brake and acceleration rate) and vehicle interior configuration (number of doors, seating arrangements, etc.), which, together with the passenger volume, affect dwell time at the station.

Of these three characteristics, the dwell time at the station has the most significant impact on system capacity. However, it is important to emphasize that dwell time does not depend on the sophistication level of the ATC system.

The ATP function enforces safe train operation. It detects the location of each train and imposes speed limits to restrict speed where required by curves and grades. The ATP ensures that the train is properly berthed within the platform, and opens the doors automatically on the platform-side of the train.

The ATO system handles start-up and acceleration to running speed, maintains en route speed, and at passenger stations stops the train smoothly at the proper platform position for the length of the train. The ATO system ensures that the vehicle operates at speeds below the ATP speed command that it receives, and provides advance information to the train on changing track grades so as to enable the vehicle to anticipate propulsion or braking requirements.

The ATS system controls the arrival and departure of trains from all stations. The ATS also checks the time the train arrives in a station against the schedule, and either attempts to correct the difference in time or notifies the Central Control operator if there is a discrepancy.

The original block signal design meets the requirements of 2-minute minimum headway for trains maintaining allowable speed on the lines. The system is capable of running the trains on a 90-second headway for brief periods for schedule recovery purposes only. It is not designed to maintain a 90-second headway during all times of revenue service.

There are about 45 interlockings in the system. The majority of the interlockings performing vital functions of route setting and control of safe train movement are relay-based interlockings. Based on the 25 years of service to-date, the useful life of the vital relays on most of the system is expiring. The replacement of non-vital portions of interlocking equipment with computer-based systems, which began in the 1980s, improved the maintainability of the system and its flexibility to accommodate changes. But this did not increase the capacity of the system as expressed by minimum headway, maximum speed of the train, average journey time or passenger comfort.

3.9 Traction Power

The characteristics and capabilities of the Metrorail traction power system have a significant, direct impact on the capacity of the Metrorail system in terms of train throughput. Maximum train length, maximum train acceleration and minimum headway are limited, in part, by the capabilities of the traction power system.

The existing Core system has been designed with the following goals in mind:

- Delivery of power to operating trains without overloading or overheating of the wayside system components.
- Delivery of power to operating trains with suitable power quality to facilitate train operation.

For the Core Area, the existing traction power system is currently capable of supporting operation of 6 car trains at 120-second headways. Substation facilities however, have been constructed with spare room to install additional substation equipment in order to support 8-car train operation.

Upgrading the traction power system to support 8 car trains at 120-second headways has not yet been accomplished; hence, the existing system can currently support only 6-car/120 second operation. The traction power requirements for operations at service levels greater than 8 car trains at 120-second headways have not been analyzed.

3.10 Track, Way and Structures

The characteristics and capabilities of the Metrorail track system have a significant, direct impact on the capacity of the Metrorail system, in terms of train throughput. Civil speed limits related to track geometry, such as turnout size at a terminal crossover, directly affect train throughput.

The track system will be evaluated in terms of capacity. The baseline documentation for the track system will define the starting point for describing potential changes in component quantities, installation configuration and/or design.

3.11 Miscellaneous Systems

3.11.1 TUNNEL VENTILATIONS SYSTEMS

Tunnel ventilation systems consist of Vent Shafts, Under Platform Exhaust System and Dome Relief Systems. They provide Heat Removal, Blast Relief and access to emergency stairways and maintenance access ladders.

The heat generated in the subway is caused by the traction equipment, train auxiliaries, wayside and station lighting and equipment, subway passengers and solar heat carried by train, train piston-action and natural convection. Conduction through the tunnel walls will typically provide sufficient tunnel heat removal. However, when tunnel temperature conditions exceed the established limits, mechanical ventilation is utilized.

Vent shafts are provided to each end of each underground station to reduce excessive air movement within stations due to piston-action of trains. The equipment include pneumatically operated dampers, emergency access/egress stairs, drainage systems, fire standpipe systems, surface gratings and emergency/maintenance exit hatches, conventional and emergency lighting and supervisory control and surveillance systems.

Two 50,000 cfm tunnel exhaust fans (as part of Under Platform Exhaust System) are provided for each station. These fans and their corresponding vent shaft dampers can also be controlled from the Operations Control Center (OCC). In addition to pneumatic controls, the tunnel ventilation fans are provided with redundant electric control to permit, in the event of failure, control locally or from OCC. A duplex compressor at each chilled water plant provides compressed air for operation of the tunnel ventilation system. This pneumatic control system also serves station systems such as the air conditioning/chilled water system.

The tunnel ventilation system works on “automatic” mode with the use of vents and fans.

3.11.2 AIR-CONDITIONING

Underground station cooling is accomplished by a spot cooling system. This system is designed to cool only the occupied portions of the platform and mezzanine. Mechanical cooling is supplemented by additional cooling resulting from natural stratification and convection of air due to temperature differences, the reduction in piston airflows through the station and the subsequent reduction in the flow of unconditioned air within the station, and heat transfer to the ground sink through the station walls. Each station is typically provided with 350 tons of refrigeration capacity. The platform and mezzanine design temperature is 85^{o} F Dry Bulb at an outdoor design temperature of 91^{o} F Dry Bulb and 74^{o} F Wet Bulb.

Air conditioning units supply conditioned air via supply air registers or pylons. The maximum capacity of each pylon is 3000 cfm. Return air from platform areas is carried through under platform tunnels from return grilles incorporated into platform benches, in escalator well ways, or located on the station end walls. Four platform air conditioning units are provided for side platform stations and two units for center platform stations. Each mezzanine is provided with one air conditioning unit that is sized to handle 100% outside air.

Air conditioning units consist of filters, chilled water coils and a fan section and include filters, water coils and an electrical power supply.

3.11.3 DOME RELIEF

Underground stations are also provided with openings to the surface designed to provide gravity relief of stratified air from the station dome. Recent dome exhaust fans have a capacity of 25,000 cfm and can be reversed with a capacity of 70% in the reverse direction.

3.12 Operations Control Center

Since the system is fully automatic and it is technically possible to operate it even in the absence of the OCC, neither the OCC equipment nor the Line Controllers impose any significant limitations on train or passenger throughput until an incident occurs that requires their intervention. Thus, technically speaking, the OCC does not impact the theoretical throughput of the system. However, both OCC equipment and personnel have a significant effect on how incidents are handled, and on the overall impact of each incident. It is primarily this impact on service that must be addressed by the Core Capacity Study, with recommendations on how to minimize the overall impact of an incident.

There are three levels of personnel in the OCC that are directly responsible for the movement of trains: Superintendent, Assistant Superintendents, and Line Controllers. Passenger Operations Supervisors make the station public address announcements; they continually monitor the train radio and Rail Operational System (ROCS) computer screen displays to determine when announcements are needed. The announcements can have an impact on passenger behavior, but the actions of the Passenger Operations Supervisor generally have no impact on the ability to move trains through the system. Personnel situated in the OCC dispatch wayside maintenance crews. Their efficiency in responding to and resolving a maintenance problem can have an impact on the ability to recover from a wayside incident.

- In the future, it will be critical that headways be maintained during rush hours, in order for the rail system to handle the higher volume of passengers. It is anticipated it will become critical to have a quicker response and resolution time for even minor incidents involving trains or wayside equipment, in order to maintain passenger throughput.

- The OCC equipment, used in the real-time operation of the system, includes The ROCS, radio, telephone, public address, and the Central Display Board.

Under the mandate of the General Manager, the Central Control Improvement Panel (CCIP) has been meeting since October 1999, as a means to identify and find the means to quickly correct those problems affecting the OCC which impact service. They are addressing problems at three levels: short term goals, near term goals (up to two years), and long term goals (up to five years). Significant progress has been made in some areas, such as the performance stability of ROCS. The stated long-term goal is to develop a new Control Center and meld this effort with the Core Capacity Program effort. However, with the CCIP not looking beyond five years, it is unknown how much of their work will continue to be relevant in the context of the Core Capacity Study's twenty-five year view.

3.13 Vital Communications

Communications systems are critical to the operation of the rail system, but they do not have the same type of direct relationship to system capacity that you find with other electrical systems such as traction power and train control. Increasing the capacity of one or more of the communications systems will probably not lead to a direct increase in the passenger carrying capacity of vehicles or passenger stations. However, as more passengers use the rail system in future years, changes may need to be made to passenger stations and non-communications systems, which may affect the communications systems.

The design characteristics of vital communications systems do not directly affect system capacity. Changes in the design characteristics of these systems, such as capacity or degree of automated capability, will be driven by changes in the design and operation of other Metrorail systems.

The Carrier Transmission System (CTS) is an integral part of the WMATA Rail Rapid Transit System's telecommunications network. The CTS multiplexes voice and data information uses a T-carrier digital format to transmit information between the CTS hub located at the Jackson Graham Building and CTS remote terminals located in passenger stations, yards, and selected buildings along the WMATA right-of-way.

The Fiber Optic System (FOS) is an integral part of the WMATA Rail Rapid Transit System’s telecommunications network. The FOS provides the primary transmission media for multiplexed voice and data signal transmissions between the Jackson Graham Building (JGB) and the passenger stations.

Major components of the FOS system include the fiber optic cable plant, fiber optic add/drop repeaters and fiber optic terminals.
(System details)

The Telephone System provides telephone service to WMATA personnel in selected rooms and areas within the passenger station, in selected ancillary buildings associated with the passenger station, and along the right-of-way. The system is not intended to provide telephone service to passengers. Telephone switching functions are provided by the existing Rolm 9000 PBX (Private Branch Exchange) located in the Jackson Graham Building. Telephone circuits are connected to the Rolm PBX via the Carrier Transmission System and the Fiber Optic System. All telephone instruments are wired to the Communications Equipment Room using a dedicated cable pair.

Metrorail Mobile Radio Subsystem (Rail MRS) provides two-way voice communications between control consoles located within the WMATA Rail Operations Control Center (RAIL OCC) and portable, vehicular and rail car radios, utilized throughout the WMATA Rail Rapid Transit System and the Washington Metropolitan Area.

The Kiosk System provides an effective communications interface with the public. Each Kiosk in the Rail System has an Attendant/Passenger Interphone System. This system provides for communications between passengers and the Station Manager (also referred to as a Kiosk Attendant) at the Kiosks.

Intercoms are also installed in elevator cabs and landings to provide a means for passengers to communicate with the Station Manager in the event they need assistance. Intercom systems are provided at other locations throughout the WMATA Rail System to provide communications support for the WMATA staff. At end-of-line stations where there is no yard, a separate Intercom System provides communications between the Dispatcher's Room, the Train Control Room and, at some locations, the Operations Room.

The Closed Circuit Television (CCTV) System enables Station Managers to view the passenger station platforms, escalators, Automatic Fare Card (AFC) vending machines, elevators, mezzanine areas, and passageways within the passenger station limits. Cameras are located throughout the station so that the combined fields of view provide coverage of over 90% of the public area. Coverage is provided for bottom landings of escalators and stairs, doors of entrance elevators, interior cab of each entrance elevator, entrances into station areas from passageways to such elevators, the AFC vending machines, and the rear sides of all escalators and stairs in public areas. CCTV viewing by the Authority in passenger stations is for the purpose of general security surveillance and crowd control.

Each passenger station in the WMATA Rail System contains a Passenger Emergency Reporting System (PERS) that provides Rail System patrons with a means of reporting emergency situations from the passenger station platforms to the Station Manager located in Kiosk. Call Station Panels are mounted on pylons approximately 200 feet from the end of each platform. Intercom facilities between these call stations and a control panel in the station kiosk permits verbal communications to take place between the Station Manager and rail system passengers. Separate Passenger Emergency Reporting Systems are provided for each Passenger Station, even when stations serving different routes are co-located.

The purpose of the Fire and Intrusion Alarm (FIA) System is to provide alarm warnings to assist WMATA employees in protecting the public, employees and property. Fire Detectors and Intrusion Detectors are located in passenger stations and associated ancillary buildings. The Station Manager monitors the FIA System at each passenger station. Visual and audible indications of an alarm or trouble condition are made at the Kiosk FIA Annunciator Panel to alert the Station Manager of a situation requiring attention. Fire and Intrusion Alarms are also reported to monitoring equipment located in the Rail OCC via the Data Transmission System (DTS).

The Automatic Public Address Announcement System (APAAS) is designed to promote a safe and expeditious evacuation of patrons from a passenger station upon detection of a fire. APAAS provides a preprogrammed emergency announcement that is automatically broadcasted within a passenger station upon detection of a fire within station limits. The announcement is activated (triggered) upon receipt of a fire alarm indication from the Passenger Station Fire and Intrusion Alarm (FIA) System.

3.14 Safety

Increased capacity will directly affect the safety program. Because the system is aging, more safety surveys and audits will be required. All changes or upgrades to the system that will be created to handle the new ridership will need Office of Safety review and approval. It is likely that the FTA will increase the rigor of safety assessments and approval in the very near future, though this oversight may be delegated to the State level. Also, numerous other operational changes, such as increased headway, could require an increase to WMATA safety intervention.

The cornerstone of the WMATA safety program is the System Safety Program Plan (SSPP). It is developed by the Standing Safety Executive Committee viewed biennially, and approved by the General Manager. The Baseline Study uses the current SSPP, dated June 23, 1999. WMATA's safety philosophy is to apply a multi-layered approach to safety, designed to protect the public, Transit Authority employees, and contractors. The layers are as follows:

- Prevent all potential accidents
- Maintain a constant vigilance to unexpected safety issues
- Perform a disciplined and proactive auditing and employee safety-training program.

Other safety-critical indicators that are tracked monthly are:

- Station Over-Runs
- Ran Red Signal Incidents
- Doors Opening Off-platform Incidents
- Automatic Train Protection Cut/Out Incidents

3.15 Security

The Metrorail security functions does not directly affect system capacity, but rather changes in the security function will be driven by changes in passenger volume, and in the design and operation of other Metrorail systems. System security is an integral part of any successful public transit program. As system capacity is expanded to meet increases in demand, it becomes imperative for the system security program to adapt in response to these increases, in order to maintain customer confidence in a safe and secure system, and thus help sustain continued growth.

As demand for transit increased over the years and the system expanded, it became evident that more effort was needed from MTPD to maintain a safe and secure system that can sustain ridership growth. This proved to be a difficult task as a result of inadequacy of original staffing formula, changing characteristics in the workforce and required assignments. MTPD was faced with establishing a priority incident response strategy. Under this strategy, MTPD optimizes its response to security incidents by constantly reallocating its limited resources to respond to high priority incidents first. Although this strategy has worked well in maintaining overall system security, it has its limitations. For example, under the priority system, minor security infringements, such as misconduct or violation of food and beverage consumption restrictions, do not result in an immediate MTPD response. Such minor infringements are tracked through complaint reports and customer service calls, and are investigated as resources become available.

3.16 Maintenance

Maintenance facilities are an integral part of running a system. Maintenance facility sufficiency and efficiency can have a great impact on the overall system capacity. Reliability of facility equipment and structures is crucial to fleet readiness and availability. Capacity is diminished when maintenance inadequately address maintenance needs, most important of which is vehicle availability.

Maintenance practices vary by individual system and component. They can follow either a preventative or corrective philosophy. Preventative maintenance programs tend to be very effective in maintaining the maximum achieved reliability by virtue of their very nature. The goal of such maintenance programs is to regularly anticipate potential system or component failures, through constant monitoring, and prevent them from occurring. As such, these programs result in continued maximum achievable reliability and can also help in extending the useful life of a given system. On the other hand, corrective or "reactive" maintenance programs address failures after they occur and they tend to be ineffective in maintaining a constant level of reliability, and generally results in a shorter useful system life.

The Metrorail plant maintenance function can directly impact Metrorail system capacity by affecting the availability of station escalators, thereby affecting pedestrian circulation in stations. Conversely, other plant maintenance functions do not affect system capacity, but may be affected by changes in the design and operation of other systems.

WMATA relies on only eight facilities for rail car maintenance for the 103-mile system. Their location and capacity were dictated by the fleet size projected for each line and the availability of land adjacent to the metrorail lines. The yards are mostly at the outer ends of the lines not only because that location is most efficient for overnight storage but also because outlying land is more readily available and less expensive than centrally located land. Refer Exhibit 3.7 for the statistics on the shop and yard capacity.

Exhibit 3.7: Maintenance Shop and Yard Storage Capacity, Year 2000

Yard	Maintenance Shop Spaces	Yard Storage Spaces
Brentwood	28	74
Glenmont	0	132
Shady Grove	20	168
Alexandria	20	176
New Carrollton	8	102
W. Falls Church	20	148
Branch Ave.	8	178
Greenbelt	22	284
TOTAL	126	1262

West Falls Church and New Carrollton Rail Yards serve the Orange Line. Currently West Falls Church stores 76% of the line's cards whereas New Carrollton stores 24% of the line's cars.

The Red Line is served by the Shady Grove, Brentwood and Glenmont Rail Yards. Currently Shady Grove stores 43%, Brentwood stores 23% and Glenmont stores 34% of the line's rail cars.

Greenbelt and Branch Ave Rail Yards serve the Green Line. Currently Greenbelt stores 64% of the line's rail cars and Branch Avenue stores remaining 36%.

The Blue and Yellow lines are served by the Alexandria and New Carrollton Rail Yards. At present, Alexandria Yard stores 100% of the Yellow line's cars and 60% of the Blue line's cars. New Carrollton stores 40% of the Blue line's cars.

3.17 Stakeholder Assessment

WMATA's key stakeholders groups include Congressional authorizing and appropriations committees, legislative bodies and chief executives from Virginia, Maryland and the District of Columbia, and regional business leaders. Congressional stakeholders are key to obtaining Federal transportation funds. Legislatures and chief executives from Maryland, Virginia and the District are key to raising the local match to Federal funds. Stakeholders will need to be provided with persuasive justification if WMATA is to receive the necessary Federal, state and local funding to carry out the program.

WMATA was successful in obtaining federal funds and a local match for the planned New York Ave Station and for extensions to Largo and Dulles Airport. These projects also received strong support from business leaders.

Although WMATA projects have a history of support from the stakeholders, they will need to be convinced of the need for funding the core capacity program. It may be noted that core capacity program was first presented to the WMATA Board on February 17, 2000 and is a relatively new program for the stakeholders. WMATA's assessment is that a message has to be send to the congress from the industry that WMATA is outgrowing its design capacity and that additional funds would be needed to allow continued growth and economic development.

4. PASSENGER AND TRAIN DEMAND

Lacking the availability of a traditional simulation model that meets the requirements of the Core Study CTC relied on a sketch planning approach to produce more reliable forecasts of station and line volumes. The approach is called Factoring Approach to Predict Future Travel (FRATAR Approach). This approach was used to simulate baseline 2000 demand as well as to develop a new 2025 station-to-station trip table and an estimate of station entries and exits.

Year 2000 (base year)
The factoring approach used WMATA's March 15, 2000 station-to-station trip table (derived from faregate data), WMATA's April 2000 data on station entries / exits, and WMATA's April 2000 data on peak load point volumes as a base.

The AM peak period MinUTP Metrorail transit network was used to obtain demand. The network was modified to accurately account for the current Metrorail train operations. The details on the Network modifications and assumptions can be found in Milestone Report 3. The network provided the following results for the four-hour AM peak period:

- Station Boardings and Alightings, Entries and Exits
- Transfer Movements
- Passenger Loads on each link of the system by direction
- Maximum Load Point Volumes

As WMATA's vehicle capacity standards are all measured against the peak-half-hour, the peak four-hour base year estimates were converted to peak half-hour volumes. The conversion was done using factors derived from the ratio of the maximum half-hour counts to the four-hour count using existing WMATA data. The factors were applied to each line and direction for all the above results. For the Core as a whole, this produced an average half-hour peaking factor of about 22% of the AM peak period (6.5% of daily).

Year 2025 (forecast year)
The factoring approach utilized simulated AM peak period trip table and WMATA's April 2000 data on station entries / exits. This data was multiplied by a series of factors that include:

- Population and employment growth factor
  This factor reflects anticipated growth in the area surrounding each station. Factors were calculated for each station using the Transportation Planning Board's Round 6.2 population and employment projections for 2025. For each core station, the growth was considered for the region within walking distance of a ½ mile both origins and destinations.

- System growth factor
  The System growth factor reflects systemwide ridership increases that are expected to result from effective inflation-adjusted fare decreases, headway reductions and an increase in congestion and increased parking fees from 2000 to 2025.

- "Metrochek Program" factor
  Additional riders were added to some stations to reflect the Federal Metrochek program. A total of 40,000 trips per day were added, based on WMATA's estimate. These were allocated to stations based on there proximity to concentrations of Federal employees.

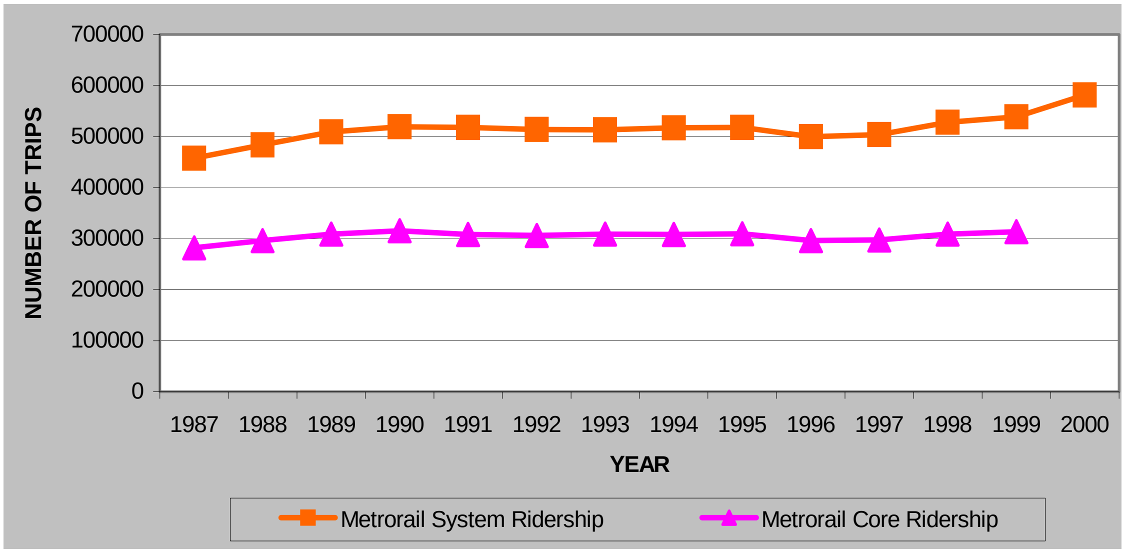
Using these growth factors, the 2000 AM peak period trip table was fratared in MinUTP to obtain a 2025 four-hour AM peak period trip table.

4.1 Passenger Demand for Year 2000

4.1.1 TOTAL 2000 METRORAIL RIDERSHIP

From 1987 to 1999, Metro Core average weekday ridership increased by 11 percent. For the system as a whole, the increase was 17 percent. In 1999, the Metrorail Core System average weekday ridership accounted for 58 percent of the total system ridership. The trend in the ridership is as shown below:

Exhibit 4.1: Trends in Average Metrorail Weekday Ridership



Note:

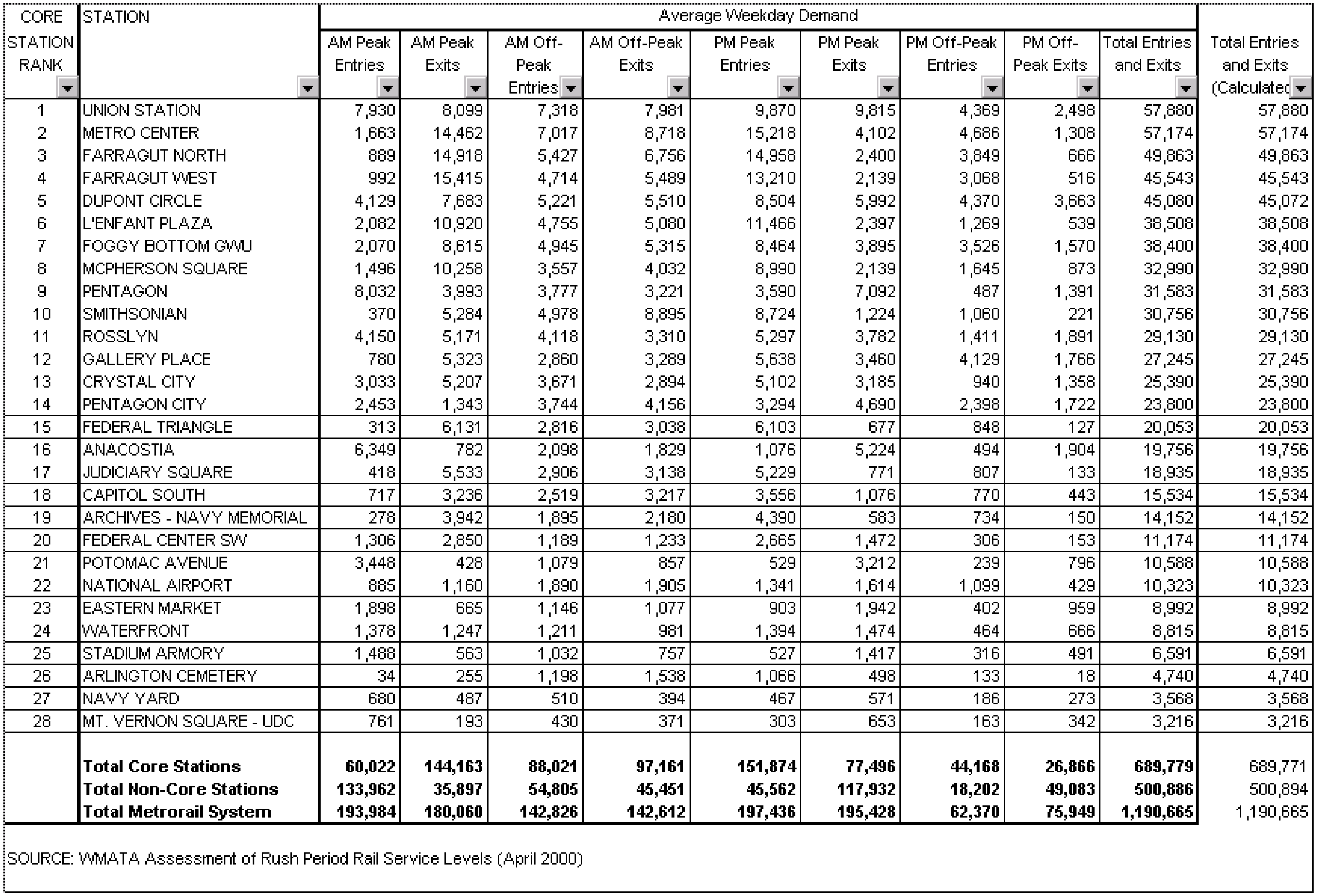
2000 Metrorail Core Ridership Data Unavailable

4.1.2 2000 AVERAGE WEEKDAY STATION VOLUMES

The total average weekday entries and exits by station for the Metrorail System in April 2000, as determined by faregate readings are shown below. Passenger entries and exits at each station are classified into four operating time periods – AM Peak, AM Off-Peak, PM Peak and PM Off-Peak. “Entries” refers to the number of people arriving at Metrorail station from outside the system while “Exits” refer to people departing from a station and leaving the system. Each entering and exiting rider makes use of the escalators, fare gates, mezzanines and platforms within stations. The AM Peak is defined as the weekday four-hour period from 6:00 to 10:00 AM while the AM Off-Peak period is from 10:00 AM to 3:00 PM. The PM Peak is defined as the weekday four hour period from 3:00 to 7:00 PM while the PM Off-Peak is from 7:00 PM until 12:00 Midnight (currently 2:00 AM on Friday).

The heaviest passenger traffic within the Metrorail System is at Core area stations. The ten busiest stations are all located within the Core Area and account for over 35% of the system-wide daily traffic. Union Station is the busiest station, followed closely by Metro Center. Those two stations account for nearly 10% of the daily system-wide traffic and approximately 17% of Core area daily traffic. Passenger volumes decrease significantly for the stations located outside the Core. Detailed passenger traffic and ridership trends at each station are shown in Appendix A. The station data show the total time-of-day entries and exits for the station, as well as time-of-day entries and exits at each entrance for stations having more than one point of entry.

Exhibit 4.2: Metrorail Core Average Weekday Entries and Exits (2000)



CORE STATION RANK	STATION	Average Weekday Demand									
		AM Peak Entries	AM Peak Exits	AM Off-Peak Entries	AM Off-Peak Exits	PM Peak Entries	PM Peak Exits	PM Off-Peak Entries	PM Off-Peak Exits	Total Entries and Exits	Total Entries and Exits (Calculatec
1	UNION STATION	7,930	8,099	7,318	7,981	9,870	9,815	4,369	2,498	57,880	57,880
2	METRO CENTER	1,663	14,462	7,017	8,718	15,218	4,102	4,686	1,308	57,174	57,174
3	FARRAGUT NORTH	889	14,918	5,427	6,756	14,958	2,400	3,849	666	49,863	49,863
4	FARRAGUT WEST	992	15,415	4,714	5,489	13,210	2,139	3,068	516	45,543	45,543
5	DUPONT CIRCLE	4,129	7,683	5,221	5,510	8,504	5,992	4,370	3,663	45,080	45,072
6	L'ENFANT PLAZA	2,082	10,920	4,755	5,080	11,466	2,397	1,269	539	38,508	38,508
7	FOGGY BOTTOM GWU	2,070	8,615	4,945	5,315	8,464	3,895	3,526	1,570	38,400	38,400
8	MCPHERSON SQUARE	1,496	10,258	3,557	4,032	8,990	2,139	1,645	873	32,990	32,990
9	PENTAGON	8,032	3,993	3,777	3,221	3,590	7,092	487	1,391	31,583	31,583
10	SMITHSONIAN	370	5,284	4,978	8,895	8,724	1,224	1,060	221	30,756	30,756
11	ROSSLYN	4,150	5,171	4,118	3,310	5,297	3,782	1,411	1,891	29,130	29,130
12	GALLERY PLACE	780	5,323	2,860	3,289	5,638	3,460	4,129	1,766	27,245	27,245
13	CRYSTAL CITY	3,033	5,207	3,671	2,894	5,102	3,185	940	1,358	25,390	25,390
14	PENTAGON CITY	2,453	1,343	3,744	4,156	3,294	4,690	2,398	1,722	23,800	23,800
15	FEDERAL TRIANGLE	313	6,131	2,816	3,038	6,103	677	848	127	20,053	20,053
16	ANACOSTIA	6,349	782	2,098	1,829	1,076	5,224	494	1,904	19,756	19,756
17	JUDICIARY SQUARE	418	5,533	2,906	3,138	5,229	771	807	133	18,935	18,935
18	CAPITOL SOUTH	717	3,236	2,519	3,217	3,556	1,076	770	443	15,534	15,534
19	ARCHIVES - NAVY MEMORIAL	278	3,942	1,895	2,180	4,390	583	734	150	14,152	14,152
20	FEDERAL CENTER SW	1,306	2,850	1,189	1,233	2,665	1,472	306	153	11,174	11,174
21	POTOMAC AVENUE	3,448	428	1,079	857	529	3,212	239	796	10,588	10,588
22	NATIONAL AIRPORT	885	1,160	1,890	1,905	1,341	1,614	1,099	429	10,323	10,323
23	EASTERN MARKET	1,898	665	1,146	1,077	903	1,942	402	959	8,992	8,992
24	WATERFRONT	1,378	1,247	1,211	981	1,394	1,474	464	666	8,815	8,815
25	STADIUM ARMORY	1,488	563	1,032	757	527	1,417	316	491	6,591	6,591
26	ARLINGTON CEMETERY	34	255	1,198	1,538	1,066	498	133	18	4,740	4,740
27	NAVY YARD	680	487	510	394	467	571	186	273	3,568	3,568
28	MT. VERNON SQUARE - UDC	761	193	430	371	303	653	163	342	3,216	3,216
	Total Core Stations	**60,022**	**144,163**	**88,021**	**97,161**	**151,874**	**77,496**	**44,168**	**26,866**	**689,779**	689,771
	Total Non-Core Stations	**133,962**	**35,897**	**54,805**	**45,451**	**45,562**	**117,932**	**18,202**	**49,083**	**500,886**	500,894
	Total Metrorail System	**193,984**	**180,060**	**142,826**	**142,612**	**197,436**	**195,428**	**62,370**	**75,949**	**1,190,665**	1,190,665

SOURCE: WMATA Assessment of Rush Period Rail Service Levels (April 2000)

4.1.3 INTRA-SYSTEM TRANSFERS

Transfers refer to those Metrorail riders who switch from one line to another. Transferring riders make use of the platform and the internal circulation system within a station. Transferring riders also affect the dwell time (i.e., the time that a train is stopped in a station to allow passengers to board and alight) on two trains – the trains they get off of or alight from as well as the trains they board. At transfer stations, the capacity of the station and the dwell times for boarding and alighting must accommodate not only entries and exits but also transfers between lines. There are nine transfer stations within the Metrorail System – Metro Center, L'Enfant Plaza, Gallery Place, Rosslyn, Mt. Vernon Square/UDC, Stadium-Armory, Pentagon, King St. and Fort Totten. All except King St. and Fort Totten are located within the Metrorail Core.

Exhibit 4.3: Metrorail Core Average Daily Transfer Activity (2000)

Transfer Station	Average Weekday Transfers
Metro Center	137,267
Gallery Place/Chinatown	131,455
L'Enfant Plaza	118,218
Rosslyn	15,558
Pentagon	17,642
Stadium Armory	1,970
Mt. Vernon Square/UDC	4,867
Total Core	**426,976**

Notes:
Year 2000 transfers estimated using the MinUTP computer simulation model and include the number of boardings plus the number of alightings involved in transfer moves.

WMATA does not automatically track the movement of passengers transferring from one line to another; transfers were estimated using the Mixed Integer non-linear Urban Transit Planning (MinUTP) computer simulation model. The average Core station weekday transfers within the Metrorail System is as shown above.

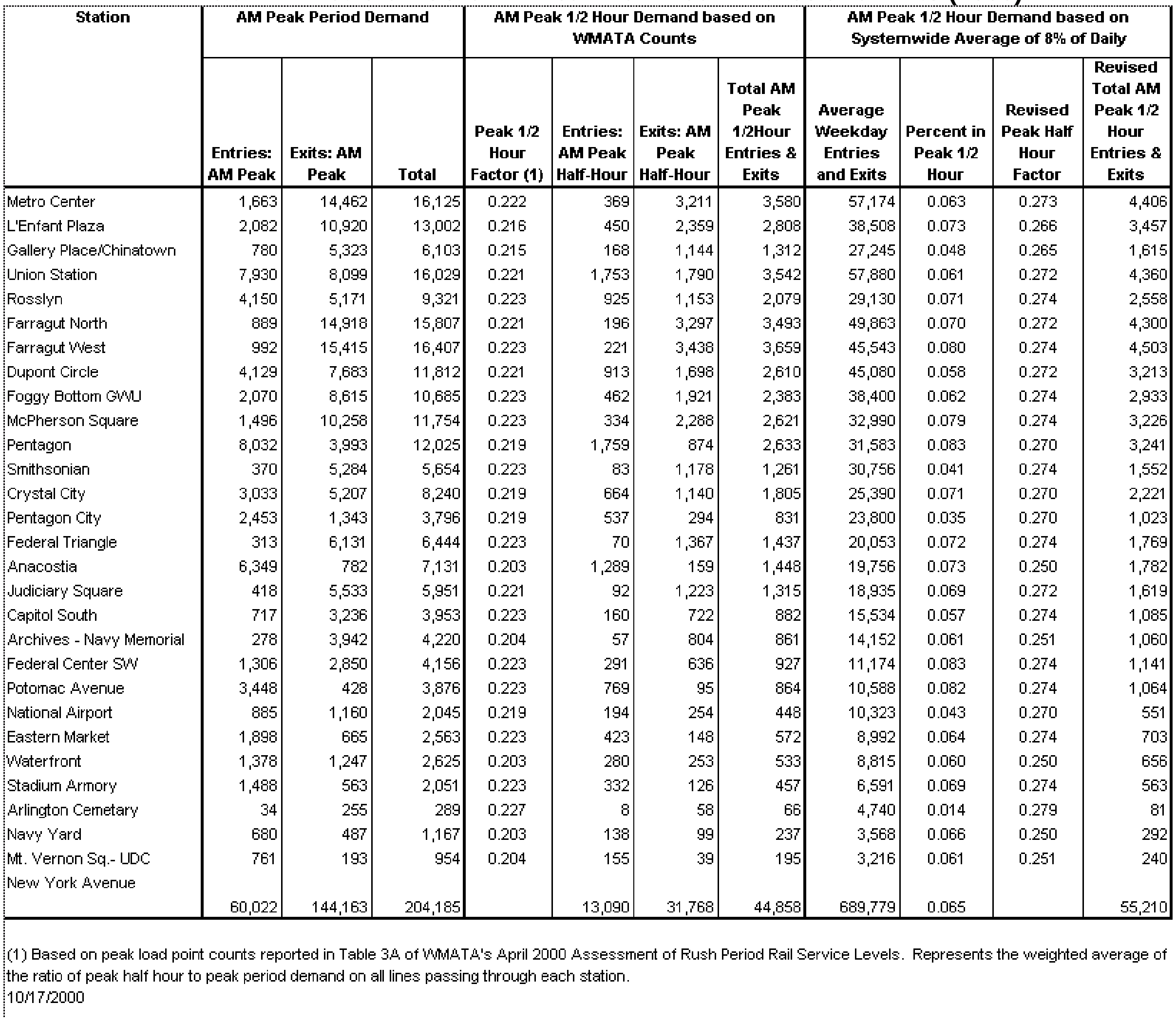
4.1.4 PEAK-HALF-HOUR TRAFFIC

The AM and PM peaks encompass the four-hour morning and evening periods where passenger entries and exits are the heaviest. Peak half-hour demand is used by WMATA in rail capacity analysis as the basis for Metrorail operations planning and architectural/engineering evaluations. This study therefore decided to use peak-half-hour (PHH) as a basis for its analysis. Between AM and PM peaks, more regular ridership patterns are observed during the AM peak. PM peak ridership, while higher than the AM peak overall, is generally distributed more evenly over the peak period.

Faregate data was used for computing PHH by applying conversion factor to the four-hour AM peak. The AM peak half-hour passenger volumes calculated using that method represent 6½% of the average daily entries and exits for the Metrorail system. As a result of discussions with WMATA, the AM peak half-hour demand was also calculated as a system-wide average of 8% of daily passenger entry and exit volumes. The results are as shown below.

The AM peak half-hour demand calculated from faregate counts does not address intra-system transfers from one line to another. In order to address that aspect of system demand, the conversion factors were also applied to the AM peak period entry and exit data and inter-line transfer moves calculated from the MinUTP simulation model to estimate the total peak half-hour demand for each Metrorail Core station. The estimated AM/AM PHH for the Core as shown below:

Exhibit 4.4: Metrorail Core AM Peak Half-Hour Entries and Exits (2000)



Station	AM Peak Period Demand			AM Peak 1/2 Hour Demand based on WMATA Counts				AM Peak 1/2 Hour Demand based on Systemwide Average of 8% of Daily			
	Entries: AM Peak	Exits: AM Peak	Total	Peak 1/2 Hour Factor (1)	Entries: AM Peak Half-Hour	Exits: AM Peak Half-Hour	Total AM Peak 1/2Hour Entries & Exits	Average Weekday Entries and Exits	Percent in Peak 1/2 Hour	Revised Peak Half Hour Factor	Revised Total AM Peak 1/2 Hour Entries & Exits
Metro Center	1,663	14,462	16,125	0.222	369	3,211	3,580	57,174	0.063	0.273	4,406
L'Enfant Plaza	2,082	10,920	13,002	0.216	450	2,359	2,808	38,508	0.073	0.266	3,457
Gallery Place/Chinatown	780	5,323	6,103	0.215	168	1,144	1,312	27,245	0.048	0.265	1,615
Union Station	7,930	8,099	16,029	0.221	1,753	1,790	3,542	57,880	0.061	0.272	4,360
Rosslyn	4,150	5,171	9,321	0.223	925	1,153	2,079	29,130	0.071	0.274	2,558
Farragut North	889	14,918	15,807	0.221	196	3,297	3,493	49,863	0.070	0.272	4,300
Farragut West	992	15,415	16,407	0.223	221	3,438	3,659	45,543	0.080	0.274	4,503
Dupont Circle	4,129	7,683	11,812	0.221	913	1,698	2,610	45,080	0.058	0.272	3,213
Foggy Bottom GWU	2,070	8,615	10,685	0.223	462	1,921	2,383	38,400	0.062	0.274	2,933
McPherson Square	1,496	10,258	11,754	0.223	334	2,288	2,621	32,990	0.079	0.274	3,226
Pentagon	8,032	3,993	12,025	0.219	1,759	874	2,633	31,583	0.083	0.270	3,241
Smithsonian	370	5,284	5,654	0.223	83	1,178	1,261	30,756	0.041	0.274	1,552
Crystal City	3,033	5,207	8,240	0.219	664	1,140	1,805	25,390	0.071	0.270	2,221
Pentagon City	2,453	1,343	3,796	0.219	537	294	831	23,800	0.035	0.270	1,023
Federal Triangle	313	6,131	6,444	0.223	70	1,367	1,437	20,053	0.072	0.274	1,769
Anacostia	6,349	782	7,131	0.203	1,289	159	1,448	19,756	0.073	0.250	1,782
Judiciary Square	418	5,533	5,951	0.221	92	1,223	1,315	18,935	0.069	0.272	1,619
Capitol South	717	3,236	3,953	0.223	160	722	882	15,534	0.057	0.274	1,085
Archives - Navy Memorial	278	3,942	4,220	0.204	57	804	861	14,152	0.061	0.251	1,060
Federal Center SW	1,306	2,850	4,156	0.223	291	636	927	11,174	0.083	0.274	1,141
Potomac Avenue	3,448	428	3,876	0.223	769	95	864	10,588	0.082	0.274	1,064
National Airport	885	1,160	2,045	0.219	194	254	448	10,323	0.043	0.270	551
Eastern Market	1,898	665	2,563	0.223	423	148	572	8,992	0.064	0.274	703
Waterfront	1,378	1,247	2,625	0.203	280	253	533	8,815	0.060	0.250	656
Stadium Armory	1,488	563	2,051	0.223	332	126	457	6,591	0.069	0.274	563
Arlington Cemetary	34	255	289	0.227	8	58	66	4,740	0.014	0.279	81
Navy Yard	680	487	1,167	0.203	138	99	237	3,568	0.066	0.250	292
Mt. Vernon Sq.- UDC	761	193	954	0.204	155	39	195	3,216	0.061	0.251	240
New York Avenue											
	60,022	144,163	204,185		13,090	31,768	44,858	689,779	0.065		55,210

(1) Based on peak load point counts reported in Table 3A of WMATA's April 2000 Assessment of Rush Period Rail Service Levels. Represents the weighted average of the ratio of peak half hour to peak period demand on all lines passing through each station.
10/17/2000

Exhibit 4.5: Metrorail Core AM Peak Transfer Activity (2000)

Station	AM Peak Transfers	AM Peak Half-Hour Transfers
Metro Center	45,298	9,984
Gallery Place/Chinatown	43,380	9,084
L'Enfant Plaza	39,012	7,990
Rosslyn	5,134	1,064
Pentagon	5,822	1,292
Stadium Armory	650	156
Mt. Vernon Sq.- UDC	1,606	316
Total Core	**140,902**	**29,886**

Notes:
Year 2000 transfers based on MinUTP computer simulation model. Transfers include the number of boardings plus the number of alightings involved in transfer moves.

4.1.5 2000 SPECIAL EVENTS

Apart from an analysis of average weekday passenger loads and Metro core capacity, it is useful to separately review Metro ridership during special events to understand its implications on system capacity. The Metro network's connectivity makes it well suited to serving numerous special events in the District throughout the year, the most famous being the fireworks and celebrations on the National Mall on the Fourth of July every year. Metrorail stations in the vicinity of the Mall, such as the Smithsonian, L'Enfant Plaza, Federal Triangle and Metro Center, experience major traffic increases on this day every year. Events held at other locations within the Core area, such as the MCI Center, located at the Gallery Place Metrorail station, also generate additional Metrorail traffic at nearby stations although to a much smaller degree than the Fourth of July celebration.
Demand data from July 4, 2000 is as shown in Exhibit 4.6. The Smithsonian station exhibits more than three-fold increase in ridership on the July 4 relative to an average weekday. The maximum traffic increases occur during the late evening as people leave the Mall after the fireworks display has finished.

Exhibit 4.6: July 4, 2000 Passenger Traffic

STATION	AM PEAK		AM OFF-PEAK		PM PEAK		PM OFF-PEAK		TOTAL		TOTAL
	ALIGHTINGS	BOARDINGS	ALIGHTINGS	BOARDINGS	ALIGHTINGS	BOARDINGS	ALIGHTINGS	BOARDINGS	ALIGHTINGS	BOARDINGS	PASSENGERS
MT. VERNON SQUARE/UDC	37	71	226	377	243	211	231	169	737	828	1,565
NAVY YARD	23	97	235	337	306	230	343	323	907	987	1,894
STADIUM ARMORY	30	75	310	320	290	335	307	353	937	1,083	2,020
POTOMAC AVENUE	44	104	347	556	348	361	477	354	1,216	1,375	2,591
WATERFRONT	116	96	637	878	1,236	512	524	1,715	2,513	3,201	5,714
ANACOSTIA	108	315	679	1,279	916	1,074	1,578	730	3,281	3,398	6,679
EASTERN MARKET	40	92	850	982	1,113	1,013	715	2,058	2,718	4,145	6,863
NATIONAL AIRPORT	191	215	1,044	1,456	815	1,309	1,000	1,320	3,050	4,300	7,350
FEDERAL CENTER SW	51	36	601	349	1,702	526	433	3,869	2,787	4,780	7,567
JUDICIARY SQUARE	41	17	890	365	1,553	544	1,152	3,310	3,636	4,236	7,872
ARLINGTON CEMETERY	180	4	2,224	1,125	2,234	1,243	1,608	3,956	6,246	6,328	12,574
PENTAGON	66	224	1,015	2,469	1,563	3,109	3,934	3,166	6,578	8,968	15,546
CRYSTAL CITY	84	417	1,379	3,258	1,691	3,283	4,402	1,304	7,556	8,262	15,818
CAPITOL SOUTH	120	47	1,894	970	4,643	1,176	1,291	5,679	7,948	7,872	15,820
MCPHERSON SQUARE	134	214	1,985	1,924	2,989	1,464	1,807	5,482	6,915	9,084	15,999
FARRAGUT WEST	76	63	1,683	1,322	3,118	1,423	3,227	6,928	8,104	9,736	17,840
FARRAGUT NORTH	145	179	2,095	1,563	4,133	1,423	2,998	9,007	9,371	12,172	21,543
PENTAGON CITY	83	254	3,686	4,144	2,851	6,077	4,538	1,869	11,158	12,344	23,502
ROSSLYN	110	398	2,002	3,682	4,644	3,613	5,892	5,510	12,648	13,203	25,851
ARCHIVES/NAVY MEMORIAL	461	45	5,421	2,478	4,539	2,432	2,434	8,685	12,855	13,640	26,495
FOGGY BOTTOM GWU	240	405	3,848	4,822	6,827	4,370	4,073	8,581	14,988	18,178	33,166
FEDERAL TRIANGLE	281	24	6,763	3,417	7,115	3,547	3,722	8,434	17,881	15,422	33,303
DUPONT CIRCLE	217	461	4,798	5,656	5,472	6,544	4,644	6,239	15,131	18,900	34,031
GALLERY PLACE	196	125	8,657	2,344	7,505	5,765	1,270	10,789	17,628	19,023	36,651
UNION STATION	367	288	7,073	4,405	10,603	6,391	3,212	14,141	21,255	25,225	46,480
L'ENFANT PLAZA	403	154	7,783	2,778	11,663	4,113	7,432	20,504	27,261	27,549	54,810
METRO CENTER	467	250	7,213	3,659	14,149	3,988	10,271	25,857	32,100	33,754	65,854
SMITHSONIAN	912	53	24,695	6,754	34,123	10,303	16,758	16,232	76,488	33,342	109,830
Total Metrorail Core	**5,223**	**4,723**	**100,033**	**63,669**	**138,384**	**76,379**	**90,273**	**176,564**	**333,893**	**321,335**	**655,228**

4.2 Passenger Demand for Year 2025

4.2.1 2025 AVERAGE WEEKDAY STATION VOLUMES

Based on factors and assumptions stated in section 4.1, it is projected that overall Mertorail System weekday ridership will more than double by year 2025. Ridership within the Metrorail Core is projected to more than double as well. The projected growth is a result of population and employment growth, and other factors such as increased highway congestion, increased Metrorail parking and increased Core parking costs and density. Projected 2025 ridership for the Core area is outlined in Exhibit 4.7 below. Projections are provided for the 28 existing Core stations as well as the proposed New York Avenue station. Union Station is the busiest station in terms of projected average weekday volume, followed by Farragut North, Gallery Place and Farragut West.

Exhibit 4.7: Metrorail Core Average Daily Entries and Exits (2000 and 2025)

Station	2000 Average Weekday Entries and Exits	2025 Average Weekday Entries and Exits	Percent Change
Metro Center	57,174	74,382	30%
Gallery Place/Chinatown	27,245	94,155	246%
L'Enfant Plaza	38,508	86,303	124%
Union Station	57,880	134,569	132%
Farragut North	49,863	97,036	95%
Farragut West	45,543	92,978	104%
Dupont Circle	45,080	79,971	77%
Rosslyn	29,130	50,971	75%
Foggy Bottom GWU	38,400	70,673	84%
McPherson Square	32,990	59,512	80%
Pentagon	31,583	63,796	102%
Smithsonian	30,756	62,424	103%
Crystal City	25,390	41,989	65%
Pentagon City	23,800	47,666	100%
Federal Triangle	20,053	42,317	111%
Anacostia	19,756	42,673	116%
Judiciary Square	18,935	45,723	141%
Capitol South	15,534	30,891	99%
Archives - Navy Memorial	14,152	29,200	106%
Federal Center SW	11,174	20,059	80%
Potomac Avenue	10,588	17,558	66%
National Airport	10,323	14,363	39%
Eastern Market	8,992	13,765	53%
Waterfront	8,815	17,490	98%
Stadium Armory	6,591	14,009	113%
Mt. Vernon Sq.- UDC	3,216	9,073	182%
Arlington Cemetary	4,740	8,185	73%
Navy Yard	3,568	35,767	902%
New York Avenue	0	14,000	
Total Core	**689,779**	**1,411,497**	**105%**

Notes:
Existing Entry and Exit Data Based on WMATA Assessment of Rush Period Service Levels (April 2000).
Year 2025 entries and exits based on 2000 existing data and application of WashCOG's Round 6.2 Population and Household Growth Factors.

While the overall Core System ridership is anticipated to double from 2000 baseline conditions, passenger traffic at some stations will grow at a much greater rate. Demand at the Navy Yard station is projected to increase by approximately 900%. Gallery Place station volumes will increase by 245% while the Mt. Vernon Square station is anticipated to see a 182% increase in passenger volume. Other stations projected to grow significantly include Judiciary Square (142% increase) and Union Station (133% increase).

4.2.2 INTRA-SYSTEM TRANSFERS

Transfer volumes at Metrorail Core stations are projected to increase more rapidly than overall Core ridership, at a rate of 125% for the average weekday demand, as more riders are destined to jobs outside the traditional downtown. Gallery Place, Metro Center and L'Enfant Plaza will see the greatest numbers of weekday transfers, as shown below, while transferring riders in 2025 are projected to account for approximately 40% of the total Core area weekday demand.

Exhibit 4.8: Metrorail Core Average Daily Transfer Activity (2000 and 2025)

Station	2000 Average Weekday Transfers	2025 Average Weekday Transfers	Percent Increase
Metro Center	137,267	268,764	96%
Gallery Place/Chinatown	131,455	291,952	122%
L'Enfant Plaza	118,218	265,479	125%
Rosslyn	15,558	36,691	136%
Pentagon	17,642	81,800	364%
Stadium Armory	1,970	5,636	186%
Mt. Vernon Sq.- UDC	4,867	12,279	152%
Total Core	**426,976**	**962,600**	**125%**

Notes:
Year 2000 and 2025 transfers based on computer simulation. Transfers include the number of boardings plus the number of alightings involved in transfer moves.

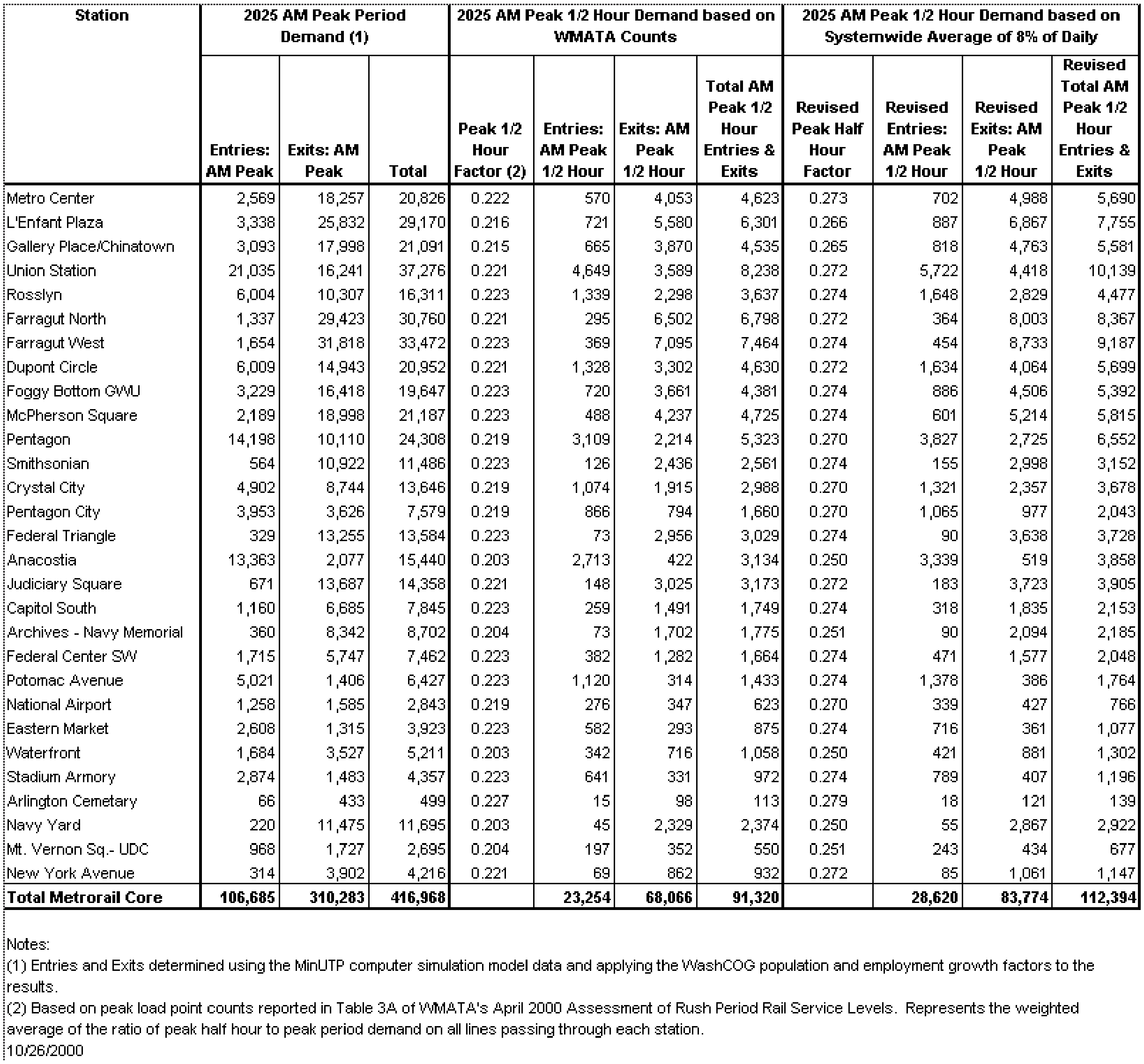
According to the model, the Pentagon station will experience the greatest percentage growth in transfers. The imprecision of the modeling forecast probably explains this change.

4.2.3 PEAK-HALF-HOUR TRAFFIC

The following table shows the AM PHH Entries and Exits for the Metrorail Core stations. The table shows demand for two scenarios: a system-wide average of 6-1/2% of daily entries and exits and as 8% of daily passenger entry and exit volumes.

AM peak half-hour entries and exists are projected double from 2000 baseline levels. The busiest stations, in terms of entries and exits, are Union Station, Farragut West and Farragut North. The greatest growth rate, however, is projected for stations outside the traditional business district including the Navy Yard (1098% increase), Gallery Place (261%), Mt. Vernon Square (172%) and Federal Triangle (167%). For the Metrorail Core as a whole, transfers during the AM peak half-hour will grow at a greater rate, 129%, than station entries and exits. Metro Center, Gallery Place and L'Enfant Plaza remain the busiest transfer stations. Total Metrorail Core peak half-hour traffic is expected to account for nearly 25% of the AM peak period Core ridership.

Exhibit 4.9: AM Peak Half Hour Entries and Exits



Station	2025 AM Peak Period Demand (1)			2025 AM Peak 1/2 Hour Demand based on WMATA Counts				2025 AM Peak 1/2 Hour Demand based on Systemwide Average of 8% of Daily			
	Entries: AM Peak	Exits: AM Peak	Total	Peak 1/2 Hour Factor (2)	Entries: AM Peak 1/2 Hour	Exits: AM Peak 1/2 Hour	Total AM Peak 1/2 Hour Entries & Exits	Revised Peak Half Hour Factor	Revised Entries: AM Peak 1/2 Hour	Revised Exits: AM Peak 1/2 Hour	Revised Total AM Peak 1/2 Hour Entries & Exits
Metro Center	2,569	18,257	20,826	0.222	570	4,053	4,623	0.273	702	4,988	5,690
L'Enfant Plaza	3,338	25,832	29,170	0.216	721	5,580	6,301	0.266	887	6,867	7,755
Gallery Place/Chinatown	3,093	17,998	21,091	0.215	665	3,870	4,535	0.265	818	4,763	5,581
Union Station	21,035	16,241	37,276	0.221	4,649	3,589	8,238	0.272	5,722	4,418	10,139
Rosslyn	6,004	10,307	16,311	0.223	1,339	2,298	3,637	0.274	1,648	2,829	4,477
Farragut North	1,337	29,423	30,760	0.221	295	6,502	6,798	0.272	364	8,003	8,367
Farragut West	1,654	31,818	33,472	0.223	369	7,095	7,464	0.274	454	8,733	9,187
Dupont Circle	6,009	14,943	20,952	0.221	1,328	3,302	4,630	0.272	1,634	4,064	5,699
Foggy Bottom GWU	3,229	16,418	19,647	0.223	720	3,661	4,381	0.274	886	4,506	5,392
McPherson Square	2,189	18,998	21,187	0.223	488	4,237	4,725	0.274	601	5,214	5,815
Pentagon	14,198	10,110	24,308	0.219	3,109	2,214	5,323	0.270	3,827	2,725	6,552
Smithsonian	564	10,922	11,486	0.223	126	2,436	2,561	0.274	155	2,998	3,152
Crystal City	4,902	8,744	13,646	0.219	1,074	1,915	2,988	0.270	1,321	2,357	3,678
Pentagon City	3,953	3,626	7,579	0.219	866	794	1,660	0.270	1,065	977	2,043
Federal Triangle	329	13,255	13,584	0.223	73	2,956	3,029	0.274	90	3,638	3,728
Anacostia	13,363	2,077	15,440	0.203	2,713	422	3,134	0.250	3,339	519	3,858
Judiciary Square	671	13,687	14,358	0.221	148	3,025	3,173	0.272	183	3,723	3,905
Capitol South	1,160	6,685	7,845	0.223	259	1,491	1,749	0.274	318	1,835	2,153
Archives - Navy Memorial	360	8,342	8,702	0.204	73	1,702	1,775	0.251	90	2,094	2,185
Federal Center SW	1,715	5,747	7,462	0.223	382	1,282	1,664	0.274	471	1,577	2,048
Potomac Avenue	5,021	1,406	6,427	0.223	1,120	314	1,433	0.274	1,378	386	1,764
National Airport	1,258	1,585	2,843	0.219	276	347	623	0.270	339	427	766
Eastern Market	2,608	1,315	3,923	0.223	582	293	875	0.274	716	361	1,077
Waterfront	1,684	3,527	5,211	0.203	342	716	1,058	0.250	421	881	1,302
Stadium Armory	2,874	1,483	4,357	0.223	641	331	972	0.274	789	407	1,196
Arlington Cemetary	66	433	499	0.227	15	98	113	0.279	18	121	139
Navy Yard	220	11,475	11,695	0.203	45	2,329	2,374	0.250	55	2,867	2,922
Mt. Vernon Sq.- UDC	968	1,727	2,695	0.204	197	352	550	0.251	243	434	677
New York Avenue	314	3,902	4,216	0.221	69	862	932	0.272	85	1,061	1,147
Total Metrorail Core	**106,685**	**310,283**	**416,968**		**23,254**	**68,066**	**91,320**		**28,620**	**83,774**	**112,394**

Notes:
(1) Entries and Exits determined using the MinUTP computer simulation model data and applying the WashCOG population and employment growth factors to the results.
(2) Based on peak load point counts reported in Table 3A of WMATA's April 2000 Assessment of Rush Period Rail Service Levels. Represents the weighted average of the ratio of peak half hour to peak period demand on all lines passing through each station.
10/26/2000

Exhibit 4.10 below compares 2000 and projected 2025 transfers for all Core area transfer stations.

Exhibit 4.10: Metrorail Core AM Peak Transfer Activity (2000 and 2025)

Station	2000 AM Peak Transfers	2025 AM Peak Transfers	Percent Increase	2000 AM Peak Half-Hour Transfers	2025 AM Peak Half-Hour Transfers	Percent Increase
Metro Center	45,298	92,692	105%	9,984	20,500	105%
Gallery Place/Chinatown	43,380	96,344	122%	9,084	20,242	123%
L'Enfant Plaza	39,012	87,608	125%	7,990	17,874	124%
Rosslyn	5,134	12,108	136%	1,064	2,504	135%
Pentagon	5,822	26,994	364%	1,292	6,080	371%
Stadium Armory	650	1,860	186%	156	444	185%
Mt. Vernon Sq.- UDC	1,606	4,052	152%	316	798	153%
Total Core	**140,902**	**321,658**	**128%**	**29,886**	**68,442**	**129%**

Notes:
Year 2000 and 2025 transfers based on computer simulation. Transfers include the number of boardings plus the number of

Whereas Exhibit 4.11 below compares 2000 AM peak half-hour entries/exits and projected 2025 conditions for all Core area stations.

Exhibit 4.11: Metrorail Core AM Peak Half-Hour Entries and Exits (2000 and 2025)

Station	2000 AM Peak Half-Hour (a)	2025 AM Peak Half-Hour (a)	Percent Change
Metro Center	3,782	4,618	22%
Gallery Place/Chinatown	1,214	4,380	261%
L'Enfant Plaza	2,963	6,131	107%
Union Station	3,566	8,231	131%
Farragut North	3,867	6,787	76%
Farragut West	4,026	7,474	86%
Dupont Circle	2,460	4,623	88%
Rosslyn	2,002	3,769	88%
Foggy Bottom GWU	2,255	4,356	93%
McPherson Square	2,888	4,725	64%
Pentagon	2,537	5,188	104%
Smithsonian	1,230	2,547	107%
Crystal City	1,795	2,867	60%
Pentagon City	813	1,578	94%
Federal Triangle	1,158	3,087	167%
Anacostia	1,271	2,965	133%
Judiciary Square	1,507	3,167	110%
Capitol South	873	1,787	105%
Archives - Navy Memorial	843	1,770	110%
Federal Center SW	977	1,665	70%
Potomac Avenue	819	1,366	67%
National Airport	408	610	50%
Eastern Market	554	839	51%
Waterfront	609	1,053	73%
Stadium Armory	444	936	111%
Mt. Vernon Sq.- UDC	201	546	172%
Arlington Cemetary	45	112	149%
Navy Yard	207	2,474	1098%
New York Avenue	0	930	
Total Core	**45,316**	**90,583**	**100%**

4.3 Train Demand for 2000 & 2025

With passenger demand known for years 2000 and 2025, the next step was to determine train demand. Train demand was used to analyze the train operations of metrorail system to identify the constraints.

Train demand is computed in terms of Maximum Link Load Volume. The Maximum Link Load Volume refers to the largest passenger volume between two successive stations on a given line in a given direction. Maximum Link Load Volumes determine the throughput required in terms of passengers per direction per a given time period. For a given headway, these volumes also determine the average carload through the maximum link on each line in each direction

Maximum Link Load Volumes and the busiest station on each line, in each direction for the peak-within-the-PHH, was determined using the ridership data for 2000 and 2025 was used to determine the busiest station on each line, in each direction, for the 30-minute peak-within-the-peak.

Exhibit 4.12: Year 2025 Maximum Link Loads and Busiest Stations
(AM Peak-Within-the-Peak 30 Minutes)

Line	Direction	Maximum Link Load		Busiest Station (Alightings + Boardings)	
		Location	Volume	Location	Volume
Red	Glenmont	Dupont Circle – Farragut North	11,500	Metro Center	7,800
	Shady Grove	Gallery Place – Metro Center	14,600	Gallery Place	8,900
Blue-Orange	Maryland	Entering Rosslyn	23,600	Metro Center	9,300
	Virginia	L'Enfant Plaza – Smithsonian	12,800	L'Enfant Plaza	8,500
Green-Yellow	North	Entering L'Enfant Plaza	15,800	L'Enfant Plaza	11,600
	South	Gallery Place – Archives	8,600	L'Enfant Plaza	6,300
Blue-Yellow	North	Leaving Pentagon	14,900	Pentagon	4,300
	South	Leaving Pentagon	4,000	Pentagon	2,200

5. ISSUES AND CONSTRAINTS

This chapter summarizes the capacity utilization analysis for all the focus issues. Train Operations and Passenger Stations are given the primary focus as they affect the passenger flow.

5.1 Train Operations

An analysis of the train operations considers the trains, the infrastructure on which they operate, and the station platforms at which passengers board and alight. Demand volumes and demand patterns for both 2000 and 2025 were compared with a range of Train Throughput Capacity estimates to quantify the extent to which Metrorail Train Throughput Capacity accommodates existing and forecasted ridership.

Train Service Capacity Utilization is defined for a given line in a given direction as the Train Throughput Demand divided by the Train Throughput Capacity. This term consists of a set of values, based on the varying ridership year, train length and service quality, measured in terms of mean car loading. If the Train Service Capacity Utilization is less than one, then Train Throughput Capacity exceeds demand. If the Train Service Capacity Utilization is greater than one, then Train Throughput Demand exceeds Capacity. The models used to determine Train Throughput Capacity and Maximum Link Load Volumes (EMME/2) are described in detail in Milestone Report 3.

For each line, Train Throughput Capacity was determined using the methodologies previously described. This capacity was compared with the Train Throughput Demand predicted by the ridership forecasts to ascertain Train Service Capacity Utilization by line in 2025. This analysis was based on the following assumptions:

- WMATA’s service quality standard for car loadings will remain 120 passenger / car which is defined as the mean number of passengers per car through the maximum link in the peak-within-the-peak 30 minutes
- Trains can run at the maximum design length of eight cars.

5.1.1 SYSTEM WIDE CONSTRAINTS

If WMATA’s car loading standard is kept at 120 passengers, CTC analysis indicates that the Governing Station Dwell Time need not exceed 40-45 seconds. With a Minimum Train Separation of approximately 70 seconds and 25 percent Operating Margin, a Minimum Sustainable Headway of 135 seconds is marginally achievable, in comparison to the 120-second headway that Metrorail schedules but is unable to attain today.

For any metro-type system to operate reliably with sustained headways of less than two minutes, dwell times need to be very short and very consistent. This is difficult to achieve even with cars designed for fast alighting and boarding, such as those in New York and London with longitudinal seating and four wide doorways per car side.

CTC’s determination of the Minimum Sustainable Headway shows that only one Metrorail line in one direction would support a headway of 130 seconds, but all other lines and directions require a 140-second headway. For trains merging onto shared tracks, the scheduled headways on all lines that merge have to be a multiple of the same basic time interval. This interval can be no less than the Minimum Sustainable Headway, which in the case of Metrorail in year 2025 is generally 140 seconds. Therefore, this capacity analysis assumes peak headway of 140 seconds on all lines. At headway of 135-140 seconds, and with 120 passengers per car and eight-car trains, the peak 30-minute capacity would be up to approximately 12,500 passengers per line per direction.

5.1.2 CONSTRAINTS BY LINE

Peak period analysis by line and direction reveals which parts of the system will be at or above capacity in year 2025. This analysis was performed utilizing current service patterns which has all lines except the Red operating on shared tracks as well as for each line by itself (see Exhibit 5.1).

The key point from Exhibit 5.1 is that passenger volume on all lines except the southbound Yellow Line will be at or above capacity in 2025. Except for the eastbound Orange Line to New Carrollton, ridership will exceed capacity on merged lines only because of the use of shared tracks over part of their routes. For example, were the Yellow and Green Lines somehow to run independently, the number of trains that could be run on each line would increase sufficiently to provide enough capacity for the forecasted ridership. The eastbound Orange Line would still be more than 140 percent of capacity even if it did not share trackage with the Blue Line.

Exhibit 5.1: Demand vs. Capacity by Line and Direction
(based on 120 passengers per car and current service patterns)

Line and Direction	Current Year 2000	Forecast Year 2025				
	Scheduled Number of Trains per Peak 30 Minutes (and Headway)	Maximum Number of Trains ❶	Minimum Sustained Headway ❷	Peak 30-Minute Max. Link Load Volume	Peak 30-Minute Train Thruput Capacity ❸	Train Service Capacity Utilization
		During Peak 30 Minutes				
Red to Shady Grove	10 (180 sec. headway)	13	140	14,600	12,500	120%
Red to Glenmont	10 (180 sec. headway)	13	140	11,500	12,500	95%
Orange to New Carrollton	10 (Alternate 120 & 240 sec. headway)	9	Alternate 140 & 280	17,500	8,650	200%
Orange to Vienna	5 (360 sec. headway)	7	280	6,600	6,700	100%
Blue to Addison Road	5 (360 sec. headway)	4	420	6,100	3,850	160%
Blue to Franconia-Springfield	5 (360 sec. headway)	6	280	6,200	5,750	110%
Yellow to Mt. Vernon Sq.	5 (360 sec. headway)	7	280	8,800	6,700	130%
Yellow to Huntington	5 (360 sec. headway)	6	280	1,900	5,750	35%
Green to Greenbelt	5 (360 sec. headway)	6	280	7,000	5,750	125%
Green to Branch Avenue	5 (360 sec. headway)	7	280	6,700	6,700	100%

NOTES:
- ❶ The maximum number of trains is the nearest integer of 1,800 (seconds per half-hour) divided by the Minimum Sustainable Headway
- ❷ The Minimum Sustainable Headways accommodate combined operation of merged lines as at present
- ❸ The Peak 30-Minute Train Throughput Capacity is the maximum number of trains multiplied by 120 (passengers per car) and eight (cars per train)

On most lines and directions, train operation at the forecast level of ridership for year 2025, using existing service patterns, is essentially impossible. The extreme numbers of people attempting to board trains would make operation completely unstable. In fact, achieving a headway of 140 seconds is possible only if the ridership demands are kept within the capacity provided; the capacity levels stated in the table above would be severely diminished at the levels of ridership that are forecast.

5.1.2 TRAIN THROUGHPUT CONSTRAINTS

Increased patronage primarily impacts train operations by (a) raising the minimum sustainable headway due to increased dwell times, and (b) causing certain station-to-station Maximum Link Load Volumes to exceed capacity. The passenger-carrying capacity of each line and direction is constrained by the Maximum Link Load Volume for that line and direction; that is, the station-to-station link that has the highest volume of ridership for any given period.

The Year 2025 patronage forecasts show the number of passengers traveling on each station-to-station link during the morning four-hour peak period. Analysis of the data described above, determines exactly where the constraint will be.

Constraining Maximum Link Load Volumes and Station Dwells

The sections within the Core that are forecast to be at or above 90 percent of train capacity in year 2025 are shown in the following table.

Exhibit 5.2: Constraining Core Sections in 2025
(based on 120 passengers per car and existing service patterns)

Section	Line	Direction	Maximum Percentage of Capacity
Woodley Park to Farragut North	Red	Glenmont	95
Gallery Place to Metro Center	Red	Shady Grove	120
Entering Rosslyn to McPherson Sq.	Blue-Orange	Maryland	180
Eastern Market to Federal Triangle	Blue-Orange	Virginia	105
King Street to Leaving Pentagon	Blue-Yellow	Northbound	120
Entering L’Enfant Plaza to Archives	Green-Yellow	Northbound	130

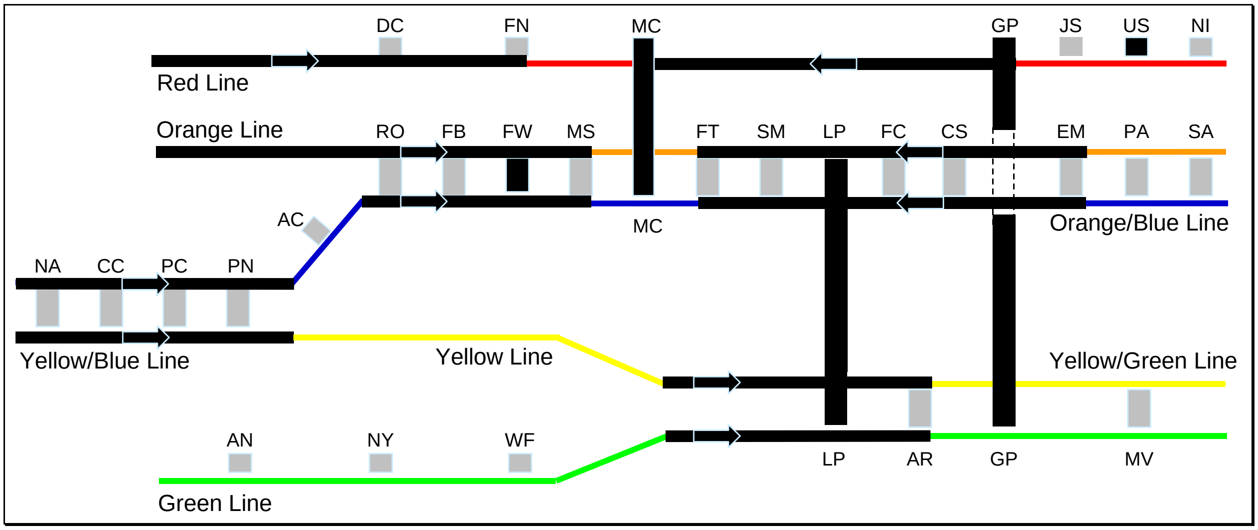
Dwell times at the Core station platforms that would be at or above 90 percent of the Governing Station Dwell Time in 2025 are indicated in Exhibit 5.3.

Exhibit 5.3: Core Stations with Constraining Dwell Times in 2025
(based on 120 passengers per car)

Station	Line	Direction
Metro Center	Red	Both
Gallery Place	Red	Shady Grove
Union Station	Red	Shady Grove
Metro Center	Blue-Orange	Maryland
Farragut West	Blue-Orange	Maryland
L'Enfant Plaza	Blue-Orange	Virginia
L'Enfant Plaza	Green-Yellow	Northbound
Gallery Place	Green-Yellow	Northbound

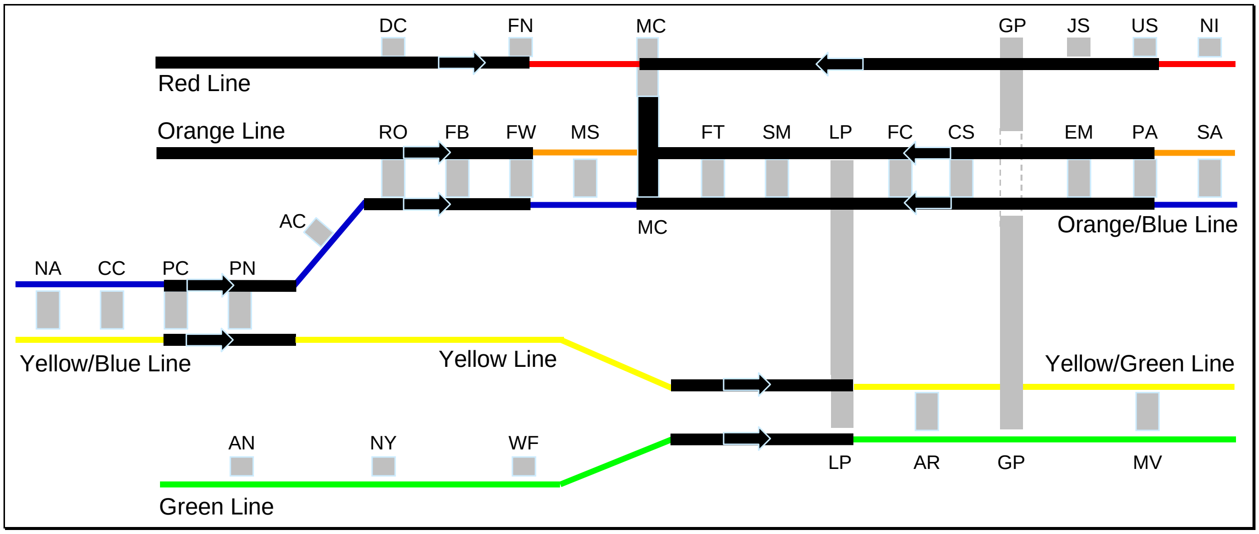
For each line and direction, the Maximum Link Load Volumes within the Core could be found in Milestone Report 3. The maximum capacity for each direction on each track is approximately 12,500 passengers per half-hour, with capacity reduced if multiple lines jointly operate over the same tracks.

Exhibit 5.4: Year 2025 Capacity Constraints
(based on 120 passengers per car, 8-car trains, Minimum Sustainable Headway)



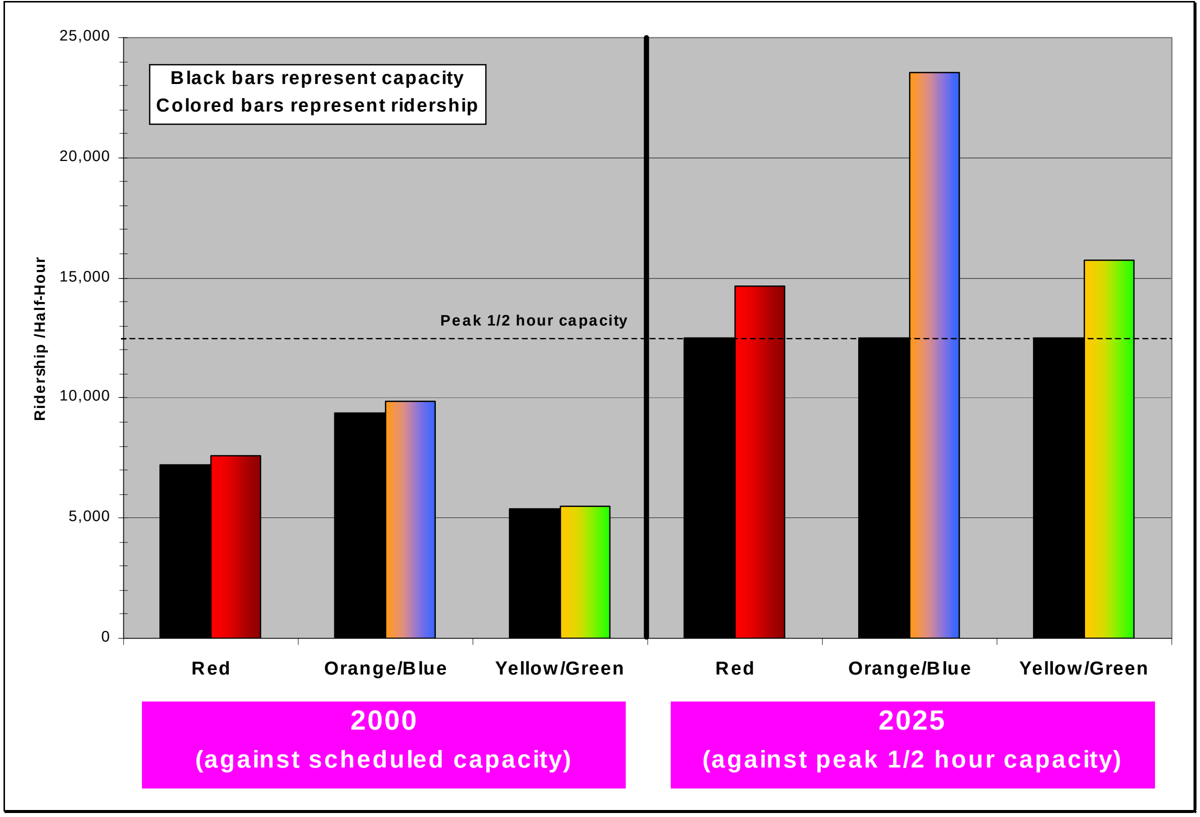
In comparison, the segments of the system that are currently (year 2000) at or above capacity, based on currently scheduled headways and train lengths, are shown below.

Exhibit 5.5: Year 2000 Capacity Constraints
(based on 120 passengers per car, currently scheduled lengths and headways)



Generally, the constraints on the Red, Orange, and Blue Lines occur for train's enroute to Metro Center. On the northbound Green-Yellow Line, the major congestion occurs as trains merge just prior to L'Enfant Plaza.

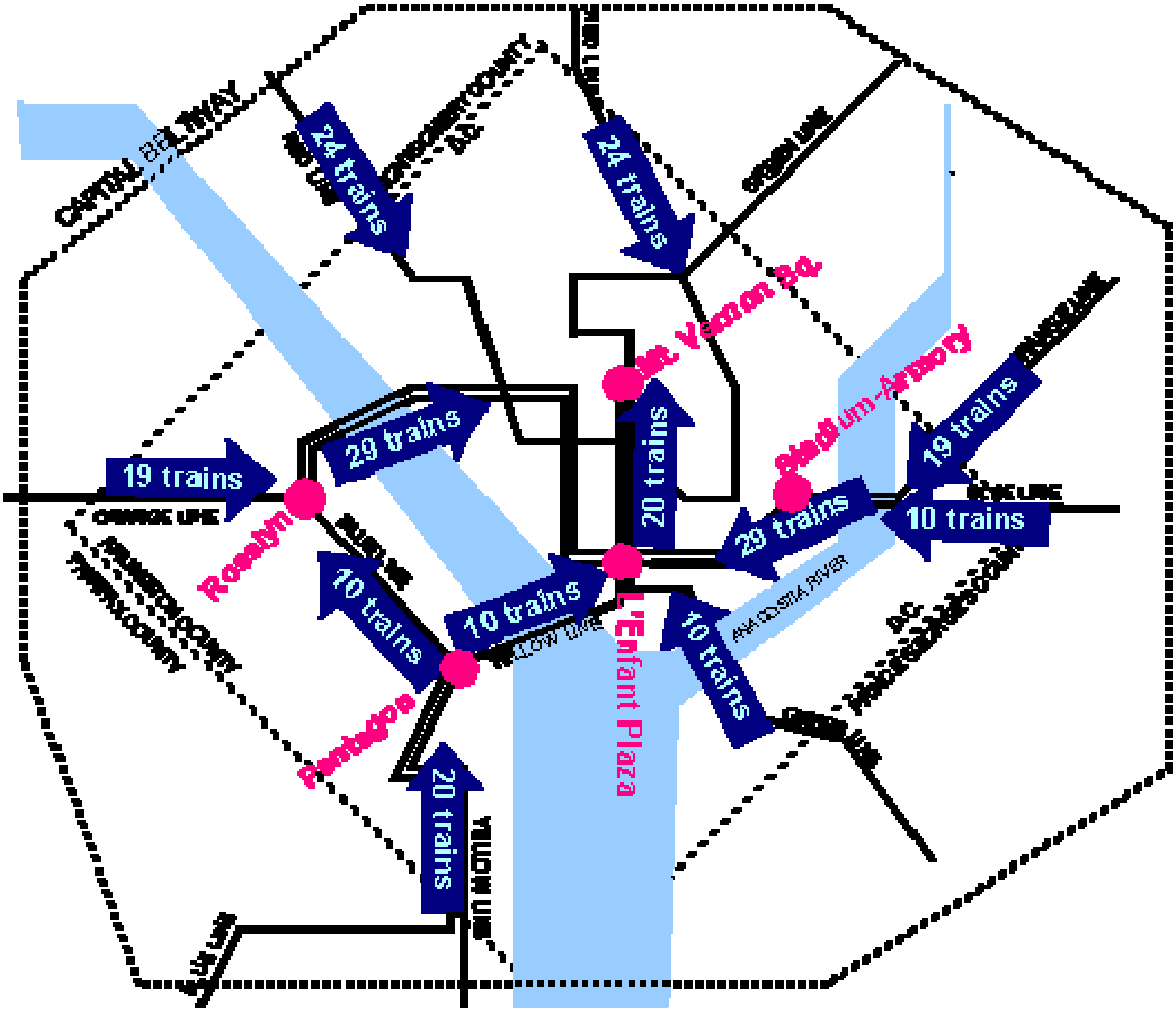
Exhibit 5.6: 2000 vs. 2025 Utilization of Capacity on Shared Tracks
(based on 120 passengers per car)



Although it appears that ridership is currently running over capacity in some locations of the system, such is the case only against currently *Scheduled* Capacity, not against the *Potential* Capacity during the peak 30 minutes that could be provided with Minimum Sustainable Headways and eight-car trains. The graph above compares year 2000 and year 2025 capacity utilization on shared tracks; note how current utilization is far below peak 30-minute Potential Capacity, and how much above that level all lines will be in 2025.

One major observation that can be made from this data is that, as ridership increases, operation of merged lines on shared track as the lines are currently configured will prevent Metrorail from carrying the projected ridership in the busier direction on any of its lines.

Exhibit 5.7: Line Portals in Metrorail System, Year 2000



5.1.3 TRAIN OPERATIONS CONSTRAINTS SUMMARY

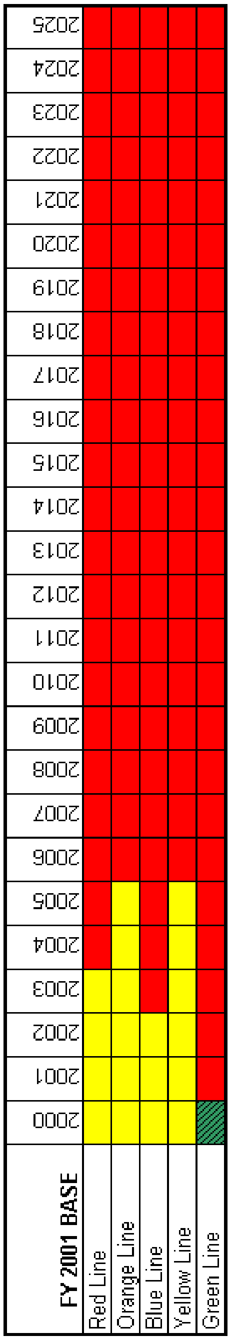
The various general categories of issues that contribute to train operation capacity constraints are shown in Exhibit 5.8. Exhibit 5.8 also outlines the general measures necessary to mitigate these constraints. Exhibit 5.9 shows the increase in Train Service Capacity Utilization (TSCU) over time for the five lines of the metrorail system. TSCU is computed using ridership at the maximum link load volume on a given line in a given direction divided by the line capacity in an hour (i.e. number of trains per hour and number of cars per train).

Exhibit 5.8: Train Operating Capacity Constraints and Potential Mitigation Measures

Item	Constraint	Mitigation	Impact*
ATC signaling system	Limits Minimum Train Separation to approximately 70 seconds; some improvement would be available with implementation of different technology	System modification	1
Station dwell	Currently varies widely at major stations; consistent dwell times would enable operation closer to optimum headway, thus improving capacity	Operating policy change	2
Vehicle interior configuration	Vestibule configuration impedes boarding and alighting, lengthening dwells on crowded cars	System modification	1
Train length uniformity	End-cars on shorter trains have excessive crowding, and on longer trains have underutilized capacity; dwells are lengthened either way	Operating policy change	2
Equipment reliability	The Operating Margin, which must be added to the interval between trains to improve operational reliability, could be reduced with better equipment reliability	Operating policy change	2
Operation on merged lines	Forces two separate lines that are already near capacity to share tracks	System expansion	4
Similar base headway on all lines (except Red)	Interlinked lines make it impossible to schedule to each line's optimum headway	Operating policy change	1
Train performance	Acceleration and braking rates are limited by passenger comfort criteria and safety concerns, and impact the separation between trains	Operating policy change	1
Car loading policy	Maximum line capacity is provided when cars are loaded to ~160 passengers, which is far in excess of quality limits; current policy is 120	Operating policy change	2

* 1 = mitigation has minimal impact
4 = mitigation has significant impact

Exhibit 5.9: Line Capacity Utilization from 2000 to 2025



FY 2001 BASE	Red Line	Orange Line	Blue Line	Yellow Line	Green Line
2000	🟨	🟨	🟨	🟨	🟩
2001	🟨	🟨	🟨	🟨	🟥
2002	🟨	🟨	🟨	🟨	🟥
2003	🟨	🟨	🟥	🟨	🟥
2004	🟥	🟨	🟥	🟨	🟥
2005	🟥	🟨	🟥	🟨	🟥
2006	🟥	🟥	🟥	🟥	🟥
2007	🟥	🟥	🟥	🟥	🟥
2008	🟥	🟥	🟥	🟥	🟥
2009	🟥	🟥	🟥	🟥	🟥
2010	🟥	🟥	🟥	🟥	🟥
2011	🟥	🟥	🟥	🟥	🟥
2012	🟥	🟥	🟥	🟥	🟥
2013	🟥	🟥	🟥	🟥	🟥
2014	🟥	🟥	🟥	🟥	🟥
2015	🟥	🟥	🟥	🟥	🟥
2016	🟥	🟥	🟥	🟥	🟥
2017	🟥	🟥	🟥	🟥	🟥
2018	🟥	🟥	🟥	🟥	🟥
2019	🟥	🟥	🟥	🟥	🟥
2020	🟥	🟥	🟥	🟥	🟥
2021	🟥	🟥	🟥	🟥	🟥
2022	🟥	🟥	🟥	🟥	🟥
2023	🟥	🟥	🟥	🟥	🟥
2024	🟥	🟥	🟥	🟥	🟥
2025	🟥	🟥	🟥	🟥	🟥

LEGEND:

Red – TSCU is greater than 1.6
Orange – TSCU is between 1.0 and 1.6
Green – TSCU is 1.0 or less

Note: Train Service Capacity Utilization (TSCU) = Train Throughput Demand (Maximum Link Load Volume) / Train Throughput Capacity

5.1.4 ROLLING STOCK

Rolling stock impacts and constrains the station dwell-time. Identifying the constraints imposed by the configuration of rolling stock could lead to possibly improved or reduced constraints.

In a separate task, the rolling stock constraints were identified as:

- Passenger Flow is adversely affected by the current configuration of the seats, windscreens, and stanchions inside the existing WMATA rail cars.
- Current information regarding station stops, directions, etc. occasionally confuses some riders, resulting in a further slowing of passenger traffic.
- Current platform management results in inefficient passenger flow.

5.1.5 TRACTION POWER

As a result of the increased ridership and increased metro car throughput in the core area, the traction power distribution system will require upgrading to accommodate the increased power demands.

A review of the current traction power capacity and its capability to meet the future demand was complied in a Power Master Plan (PMP). The PMP conducted in 1995, identified which substations would require upgrades during the 2000-2025 time period. As identified in the table below, all of the stations within the Core would require upgrade.

Exhibit 5.10: Traction Power Constraints within the Core

Substation Name	Address	Existing Capacity	Capacity Utilization
		MW	
National Airport	C10	4	Deficient
18th & Fern Street	C09	4	Deficient
Shirley Highway	C08	4	Deficient
Washington Boulevard	C06	4	Deficient
Watergate	C04	4	Deficient
Metro Center	C01	6	Deficient
Smithsonian	D02	4	Deficient
Federal Center	D04	4	Deficient
Seward Square	D06	4	Deficient
Potomac Avenue	D07	6	Deficient
Stadium Armory	D08	4	Deficient
Belmont	A03	4	Deficient
Gallery Place	B01	6	Deficient
Union Station	B03	4	Deficient
Rhode Island	B04	6	Deficient

U Street	E03	4	Deficient
Mt. Vernon Square	E01	4	Deficient
Pennsylvania Avenue	F02	4	Deficient
Maine Avenue	F04	4	Deficient
Navy Yard	F05	4	Deficient
Anacostia	F06	4	Deficient

Failure to upgrade the system would manifest itself as overloading of wayside equipment and as insufficient operating voltage at trains. The first effect (overloading) would result in successive "domino" failures of wayside traction power equipment, possibly with ultimate total breakdown of the traction power system in selected areas. The second effect (insufficient voltage at trains) would result in dropout of under-voltage relays on-board the vehicles, with "jerky" motion and significant passenger discomfort. Throughput could definitely be affected, although to an unknown extent.

To determine whether the existing system will support 8-car trains at a specific headway, additional simulations may be required. However, based on our analysis, 8 car trains at 120-second headway cannot be supported without traction power upgrades.

5.1.6 TRAIN CONTROL

The current automatic train control system (ATC) is also known as “fixed block system”. Fixed-block, at WMATA, means the running rails are electrically shorted together at periodic intervals creating separate and distinct electric circuits known as “track circuits”. WMATA’s track circuits average about 400 feet and varying in length from 60 to nearly 2000 feet.

As do virtually all fixed-block track circuit systems, WMATA’s train control system trades off performance against cost and reliability. Increasing the number of track circuits and thereby improving position resolution or increasing the number of speed commands and thereby providing finer speed control permit shorter headways and increase performance. But increasing the number of fixed-block track circuits beyond a certain limit results in diminishing returns. This is because with fixed-block technology performance gains improve slowly while costs increase significantly.

Another constraint is that additional track circuit equipment also means lower reliability because there are more parts to fail. As this equipment ages, the number of failure increase. In most high-capacity fixed-block systems virtually any component failure – if not immediately repaired – can quickly result in significant and possibly unrecoverable line delays. Mitigating this problem requires maintaining large number of signal crews on the lines thereby further increasing maintenance costs.

To ensure safe operation, traditional ATP components must be constructed from high quality materials, carefully assembled and tested, and periodically and properly maintained. As a consequence, and in contrast with trends in the computer and communications industries towards the use of commercial-off-the-shelf components, traditional ATP, and its highly specialized low-volume electro-mechanical equipment, remains costly.

In the hierarchy of a modern transit train control system, Automatic Train Supervision (ATS) is at the top. Unlike ATP, ATS is normally not intended to primarily provide safety. Rather ATS is the means by which scheduled revenue service trains are controlled and optimized. In large, high performance short-headway systems such as NYCT, WMATA, MARTA, and BART the ability to precisely schedule trains is critically important.

WMATA uses automated scheduling software as so does BART and MARTA. A properly designed ATS system continuously adjusts recovery times by controlling vehicle door open times at stations and modifying each train's acceleration and top speed, as it leaves a station. On WMATA's ATS computers CTC observed that they are not performing their tasks as well as they should, are unable to schedule train arrivals to a resolution below one minute. BART's ATS computers are able to control schedule with a one-second resolution.

5.1.7 OPERATIONS CONTROL CENTER

Operation of the trains is generally fully automatic (Constraints imposed by the ATC signaling system itself are not discussed), and neither the OCC equipment nor the Line Controllers technically impose any significant limitations on train or passenger throughput until an incident occurs that requires their intervention. However, OCC equipment and personnel have a significant effect on the smoothness and efficiency of the operation, and on the overall impact of any incidents. Their involvement can range from eliminating bunching after a minor station hold to implementing single-tracking and mid-line turn backs to mitigate a line blockage, all with the goal of maximizing passenger throughput.

OCC Equipment
- Metrorail's current control system is capable of regulating traffic but it has never worked properly and has been disabled. *(must incorporate sophisticated schedule maintenance algorithms that adjust station dwells, performance levels, merges, and dispatch times to provide the necessary capacity.)*
- The current system dispatches trains into service, when the Train Operator presses the "ATO Start" button. This in turn has a potential effect on the timely dispatch of the trains.

OCC Personnel
- The competency of the OCC controllers is critical.

A total shutdown of the OCC can result from only a few scenarios, such as fire, explosion, terrorism, or water or gas leak. However, there is a very real possibility of such an occurrence. Such an event did occur in 2000 when the OCC's halon system was accidentally activated and the room was virtually evacuated. Therefore, contingencies should be in place to prevent such a situation from causing a complete interruption of metrorail service for what could be an extended period of time.

It is widely acknowledged that Metro's continuing increase in patronage is taxing the entire infrastructure, making it far more difficult for the OCC to maintain the published train schedules and runtimes. With trains already scheduled close to capacity during rush hours on certain core parts of the system, the problems caused by increased patronage will only be exacerbated as Metro attracts more and more riders over the next few years. An added complication that cannot be ignored is the need for the OCC to react to lowered reliability caused by the aging of the system. (For example, the Monthly Delay and Offload Report for August, 1999 shows that the rate of passenger offloads due to vehicle failures is roughly twice as high for the older Rohr cars compared to the newer Breda vehicles.)

5.1.8 TRACK & WAY

Track configuration refers more to any excessively tight curves, steep grades, or other track design features such as crossovers, sidings and pocket-tracks that would have an impact on the line's capacity. Track configuration could directly or indirectly affect the line’s capacity either in terms of additional track or by offering more flexibility & failure management.

In its examination of the Core area, CTC identified the following as potential constraints;

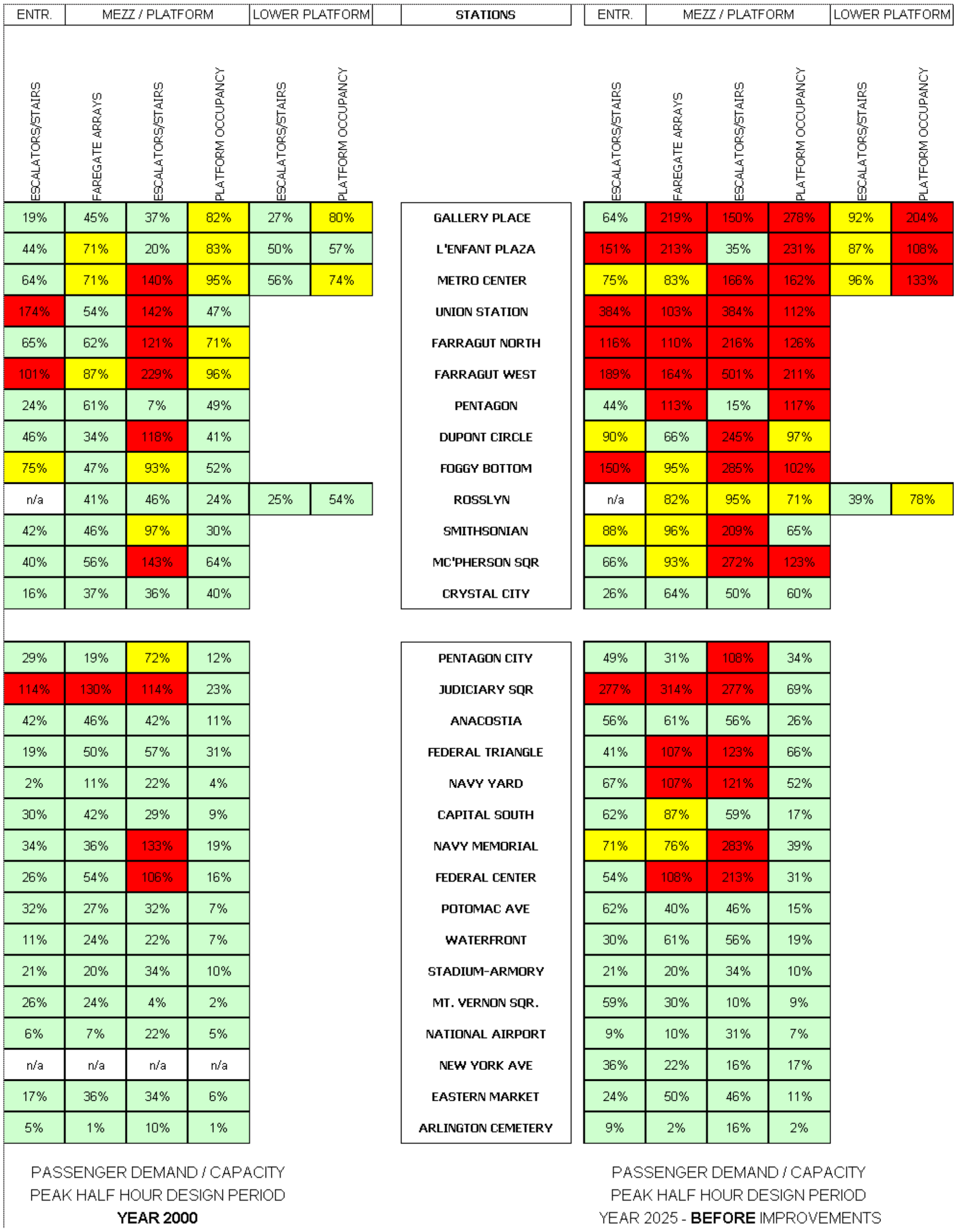
- Although most areas of Metrorail have a sufficient number of crossovers, there are areas where their excessive spacing can exacerbate problems during abnormal or emergency situations. The two worst areas are on the Yellow Line between Pentagon City and L’Enfant Plaza, and the Orange/Blue lines between Foggy Bottom and Clarendon/Arlington Cemetery.
- Diverging movements through mid-line crossovers are usually made when there is a delay event in progress; therefore geometry of the crossovers should allow speeds as high as possible to prevent exacerbating the impact of the delay. At present, the existing crossovers are not able to sustain high speeds and therefore pose potential to exacerbating the impact in the event of a delay.
- “Pocket tracks” are located between the mainline tracks at various locations to allow scheduled mid-line turnbacks. Only three of Metrorail’s seven pocket tracks are currently used for scheduled turnbacks, at Silver Spring and Grosvenor on the Red Line (both of which are located outside the Core), and at Mt. Vernon Square on the Yellow Line. Discussions with OCC personnel indicated that congestion is currently a frequent problem at the three turnback pocket tracks, and that increased service could exacerbate the problem.
- Glenmont-bound trains on the Red Line frequently stop at Brentwood Yard to pick up or drop off WMATA personnel. The impact of these stops during peak periods should be evaluated, especially considering that the track circuit configuration in that area is probably designed for higher average speeds.

5.2 Passenger Stations

Identifying issues and constraints at passenger stations involves steps as outlined in sections 2.4 and 2.6 of chapter 2. The various station elements considered are Escalators and Stairs (together as vertical circulation), Faregate Arrays and Platform Occupancy. With relevant data in hand and using the Passenger Flow Model (covered in detail in Appendix C) the constraints were identified and quantified.

A summary of the capacity utilization of elements in all stations within the Core (scored as acceptable, marginal, or deficient) is shown in Exhibit 5.11. Those with yellow color indicate marginally acceptable capacity utilization and those with red color show over capacity.

Exhibit 5.11: Summary of Constraints for Key Station Elements, Year 2000 and 2025

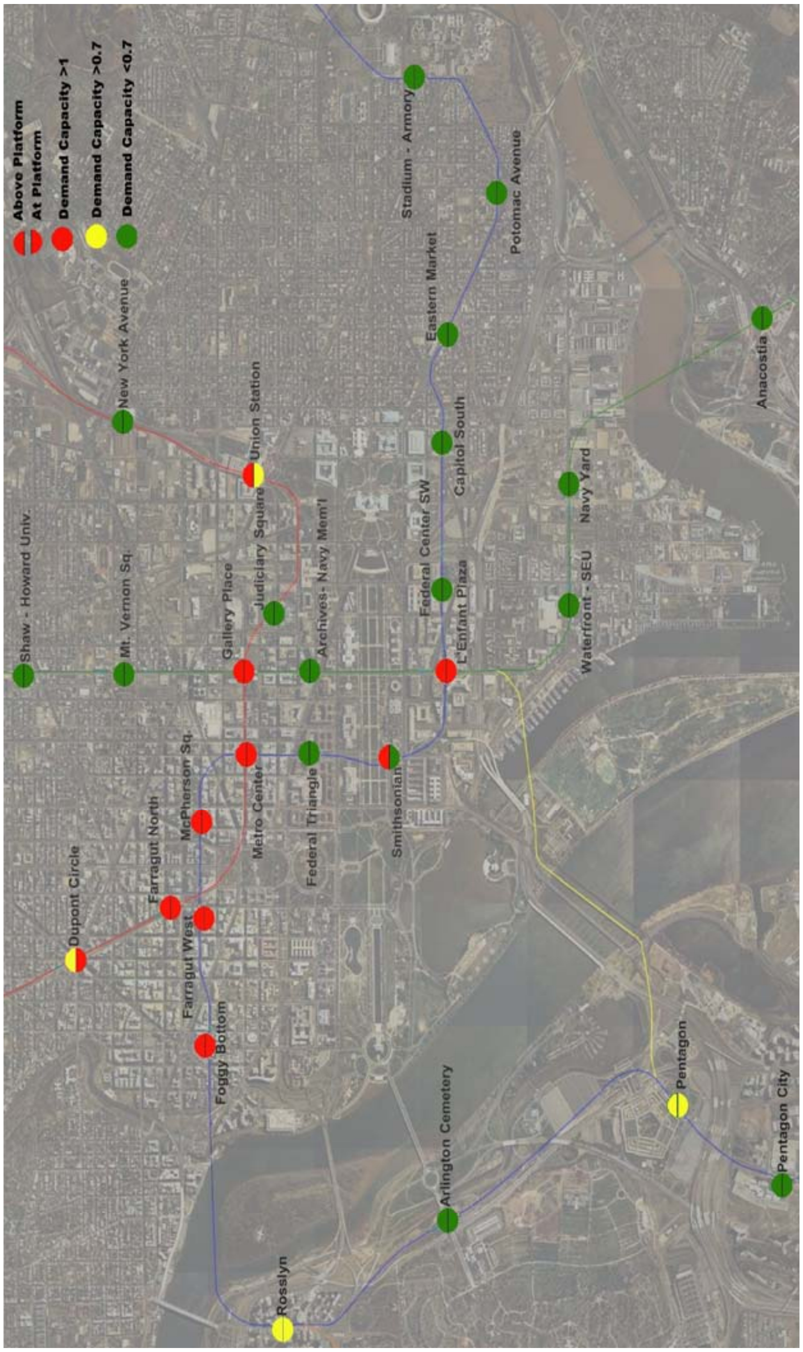


ENTR.	MEZZ / PLATFORM			LOWER PLATFORM		STATIONS	ENTR.	MEZZ / PLATFORM			LOWER PLATFORM	
ESCALATORS/STAIRS	FAREGATE ARRAYS	ESCALATORS/STAIRS	PLATFORM OCCUPANCY	ESCALATORS/STAIRS	PLATFORM OCCUPANCY		ESCALATORS/STAIRS	FAREGATE ARRAYS	ESCALATORS/STAIRS	PLATFORM OCCUPANCY	ESCALATORS/STAIRS	PLATFORM OCCUPANCY
19%	45%	37%	82%	27%	80%	GALLERY PLACE	64%	219%	150%	278%	92%	204%
44%	71%	20%	83%	50%	57%	L'ENFANT PLAZA	151%	213%	35%	231%	87%	108%
64%	71%	140%	95%	56%	74%	METRO CENTER	75%	83%	166%	162%	96%	133%
174%	54%	142%	47%			UNION STATION	384%	103%	384%	112%		
65%	62%	121%	71%			FARRAGUT NORTH	116%	110%	216%	126%		
101%	87%	229%	96%			FARRAGUT WEST	189%	164%	501%	211%		
24%	61%	7%	49%			PENTAGON	44%	113%	15%	117%		
46%	34%	118%	41%			DUPONT CIRCLE	90%	66%	245%	97%		
75%	47%	93%	52%			FOGGY BOTTOM	150%	95%	285%	102%		
n/a	41%	46%	24%	25%	54%	ROSSLYN	n/a	82%	95%	71%	39%	78%
42%	46%	97%	30%			SMITHSONIAN	88%	96%	209%	65%		
40%	56%	143%	64%			MC'PHERSON SQR	66%	93%	272%	123%		
16%	37%	36%	40%			CRYSTAL CITY	26%	64%	50%	60%		
29%	19%	72%	12%			PENTAGON CITY	49%	31%	108%	34%		
114%	130%	114%	23%			JUDICIARY SQR	277%	314%	277%	69%		
42%	46%	42%	11%			ANACOSTIA	56%	61%	56%	26%		
19%	50%	57%	31%			FEDERAL TRIANGLE	41%	107%	123%	66%		
2%	11%	22%	4%			NAVY YARD	67%	107%	121%	52%		
30%	42%	29%	9%			CAPITAL SOUTH	62%	87%	59%	17%		
34%	36%	133%	19%			NAVY MEMORIAL	71%	76%	283%	39%		
26%	54%	106%	16%			FEDERAL CENTER	54%	108%	213%	31%		
32%	27%	32%	7%			POTOMAC AVE	62%	40%	46%	15%		
11%	24%	22%	7%			WATERFRONT	30%	61%	56%	19%		
21%	20%	34%	10%			STADIUM-ARMORY	21%	20%	34%	10%		
26%	24%	4%	2%			MT. VERNON SQR.	59%	30%	10%	9%		
6%	7%	22%	5%			NATIONAL AIRPORT	9%	10%	31%	7%		
n/a	n/a	n/a	n/a			NEW YORK AVE	36%	22%	16%	17%		
17%	36%	34%	6%			EASTERN MARKET	24%	50%	46%	11%		
5%	1%	10%	1%			ARLINGTON CEMETERY	9%	2%	16%	2%		

PASSENGER DEMAND / CAPACITY
PEAK HALF HOUR DESIGN PERIOD
YEAR 2000

PASSENGER DEMAND / CAPACITY
PEAK HALF HOUR DESIGN PERIOD
YEAR 2025 - **BEFORE** IMPROVEMENTS

Exhibit 5.12: System Map Showing Station Constraints



5.3 Other Vital Systems

5.3.1 MAINTENANCE / STORAGE

The existing rail yards are not adequate to accommodate the Metrorail fleet required by 2025. The total capacity of some of the yards is too small, and the shortfall on some individual Metrorail lines including Brentwood and New Carrollton is significant.

Maintenance shop capacity will be inadequate throughout the Metrorail system. The current 126 total available maintenance shop spaces is less than the minimum required standard of 15% spaces (142). Shop capacity for the 600 series rail cars (156) does not exist. Non-revenue vehicle parking will need to be expanded at selected yards.

The adequacy of the rail yards is determined not only by their capacity but also by their location. Rail cars should be stored as near as possible to where they enter service to reduce the distance they must travel when out of service. This out-of-service travel is called deadheading. If yard capacity is available but in the wrong location, a rail system may be able to function, but it will suffer from higher operating costs because of additional deadheading.

Another constraint is the time factor. Yard capacity cannot be expanded quickly.

5.3.2 HVAC

The HVAC system components that are constrained and need an upgrade are as follows:

- The existing 350 ton / station AC capacity provides a satisfactory public area environment for current conditions. However it will fall short with the doubling of ridership by 2025. If the current AC capacity is not increased to meet future demand, the current station design temperature of 85^{o} F could rise to above outdoor ambient temperature of 96^{o} F by year 2025.
- Existing air conditioning units will require replacement. In cases where new mezzanines are proposed, additional air conditioning units and mechanical room space are also required. At both Farragut West and Union Station, the existing mechanical rooms can accommodate the new air conditioning units.
- The tunnel ventilation fans are reversible and provided in accordance with existing standards flow rate, type, accessories, motor control and controls. Standby ventilating equipment is not provided.
- Existing chilled water and condenser water piping systems will require replacement to accommodate the increased water flow rate associated with the required increase in cooling capacity. An increase in flow rate will also necessitate chilled water and condenser water pump replacement.
- Both at Farragut West and Union Station, the existing mechanical spaces can accommodate larger equipment. However, additional space may be required to accommodate larger chillers and cooling towers in other locations. This is potentially a problem in cases where cooling towers are located on the property of others.
- Ducts will require enlargement to accommodate increased airflow rates. Identifying the necessary space is a potential problem, especially in the case of side platform stations where embedded ducts are utilized.

- Miscellaneous items such as the chilled water plant ventilation system and the water treatment system capacities will also be affected and will require retrofits or replacement.

These observations are made based on Farragut West and Union Station and given the uniformity of the extent of equipment provided for each station, it would be safe to say these observations can be applied to all 29 stations within the Core.

5.3.3 COMMUNICATIONS

The issues that need consideration for communications within the core of the metrorail system are summarized below.

Automatic Public Address Announcement System (APAAS)

As custom manufactured unit's parts become old, obsolete and incompatible with current technology, they will become hard to find in the future. The life expectancy of current APAAS equipment is 15 years.

Carrier Transmission System (CTS)

The D, G and K routes are limited by the number of copper cable pair's availability. The B, C, E and inter F routes are limited by the maximum capacity of the fiber optic system.

The WMATA system uses various models of T-1 multiplex equipment to Bellcore standards. The limitation to the life expectancy of this equipment is 20 years.

Closed-Circuit Television System (CCTV)

The current "black & white" closed-circuit television systems, while filing their original intended purpose, do not take advantage of modern technology. The systems were originally specified considering the limited technology available at the time of installation. Since the images can only be viewed from the Kiosk, the use of these images is very limited.

Fiber-Optic System (FOS)

The Harris DVL44 FO system is limited to a maximum of 28 DS-1s and to a minimum drop of 4 DS-1 at the terminal. The Harris DVL44 FO system is also a proprietary system and cannot be connected to any of the other WMATA FO systems and cannot operate as a self-healing ring. The life expectancy of this equipment is 20 years and would need a replacement by 2008.

Kiosk System

Any additional equipment or expansion may require reorganization of the existing equipment and/or replacement of the monitoring equipment into a much more concise configuration to accommodate expansion within the Kiosk.

No risk is foreseen to the WMATA communications systems by the Kiosk.

Mobile Radio System (MR)

The limitation of single communications channels can prohibit necessary communications between field radio units and the Operations Centers when more than one emergency situation arises. Similarly, the mobile equipment on the BUS system is well past its useful life. Parts are no longer available from the manufacturer and can only be obtained from units removed from WMATA retired WMATA buses. Reliability is a serious issue for all systems.

Furthermore the current systems are limited to growth due to the expected volume of voice radio traffic and the lack of adequate radio channels to support growth. MTPD's future needs for mobile data terminals (MDT) cannot be supported by the existing radio system.

Public Address System (PA)

The old PA system may no longer have replacement parts due to their age and the non-existence of some of the customized components. However the new PA system uses current technology that may guarantee the availability of component replacement.

Passenger Emergency Reporting System (PERS)

PERS equipment models are nearing the end of there life expectancy of 20 years and pose a major risk that they have become obsolete with hard to find part. For example, a terrorist attack involving the release of chemical or biological agent would require immediate communication using the most readily accessible PERS system, the system better work or loss of life could result.

Passenger Information Display System (PIDS)

The Customer Information Sign (CIS) can only display one message at a time coming from a source server. The system has a design life expectancy of 15 years.

Telephone System

The most important limitation of the current equipment is its ability to expand. Generally, the current telephone system is reaching the limit of its capacity. As WMATA service expands, it will be impossible to provide fully integrated telephone service to new facilities.

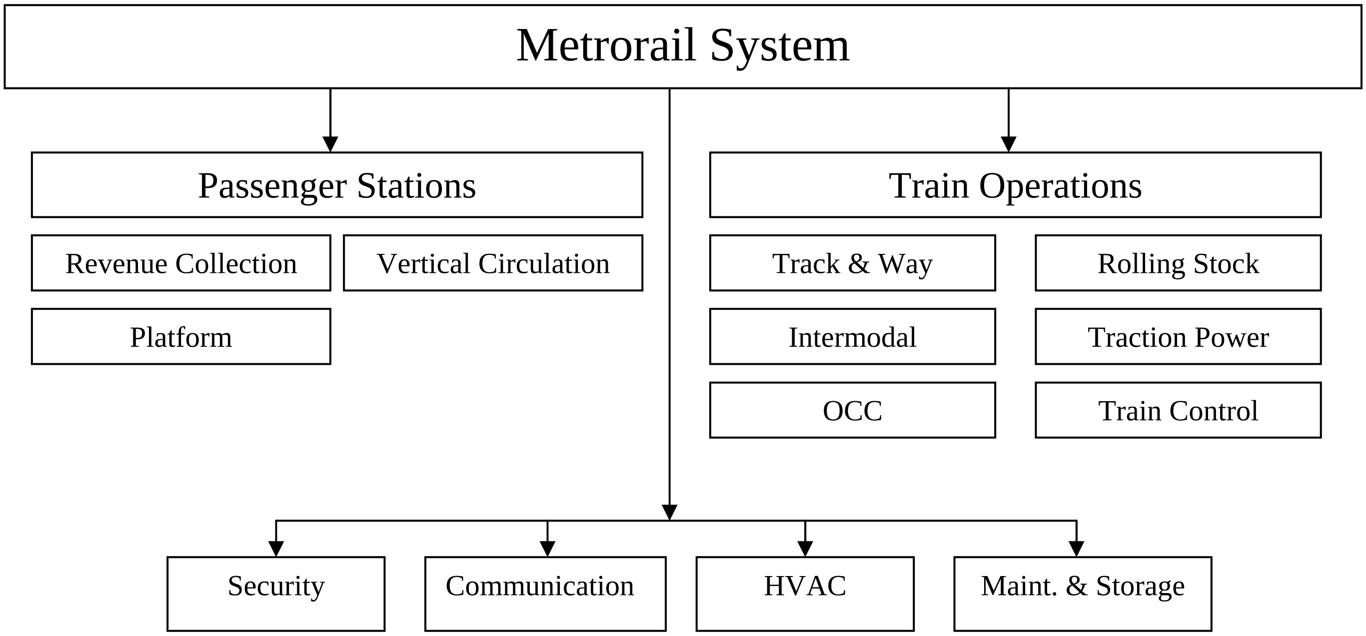
A second limitation is the ability to maintain a system that hasn't been in production for more than 15 years. As new technologies are introduced into the telephone market, it will become increasingly difficult to operate and maintain this obsolete equipment.

Inefficiencies / lack of total integration in to the WMATA telephone system can realistically be absorbed without having a detrimental affect on the CORE Capacity of the rail system.

5.4 Inter-relationship

The various operating systems of the WMATA metrorail are interrelated to each other. Understanding these interrelationship would help better evaluate the passenger handling capacity and train handling capacity as discussed in Chapter 5. The relation between various metro-system elements are shown in Exhibit 5.13:

Exhibit 5.13: Inter-relationship between Metrorail's various systems



6.0 CAPACITY ENHANCEMENTS

6.1 Line Improvement Projects

Improvements providing additional tracks and lines are seen as significant in terms of the benefits they could offer to alleviate crowding, to enhance passenger transfers between lines, and to increase operational flexibility for the Metrorail system. The recommended enhancements include connections between existing lines, new pocket tracks for additional storage and new bypass lines to relieve stress on existing lines.

The benefits offered by each representative enhancement are summarized below:

Line Connections

- Offer greater flexibility in train operations
- Provide direct service in certain regions (e.g. Rosslyn Orange/Blue Line connection would provide direct service connection between Dulles Airport and National Airport).
- Improve failure management flexibility.

Pocket Tracks

- Provide efficient movement of extra trains to meeting train needs within the Core
- Avoid costly and time-consuming movement of trains from satellite train-storage yards.
- Reduce delays to system operations caused by disabled trains in or near the Core.

New Bypass Lines

- Reduce the ridership demand on the line being bypassed
- Reduce passenger demand at the transfer stations
- Improve operational and emergency flexibility

Brief descriptions for the proposed line enhancements are provided below. Additional details on each line improvement project can be found in Milestone Report 4.

6.1.1 PROJECT 1
ORANGE LINE VIRGINIA EXPRESS TRACK

6.1.1.1 Description:

The project would be a single-track line running between West Falls Church and Rosslyn. This new track would be constructed largely alongside the existing Orange Line tracks in the Interstate I-66 median, beginning east of the West Falls Church Station; at the planned connection to the Dulles Corridor Rapid Transit Project (DCRTP), and ending at Rosslyn. At the west end the project would include track connections to existing Inbound and Outbound Orange Line tracks, that would allow routing of express trains to/from either the existing Orange Line or the future Dulles RTP. At the east end the project would include a connection to the existing Blue Line between Rosslyn and Arlington Cemetery Station on the west side of the Potomac River, including track connections to both outbound and inbound tracks on the Blue Line. The project location and route is illustrated on the attached drawing

The east end of the project would include a new station near the existing Rosslyn Station to allow passengers that did not want to continue traveling to/from the Metro System Core to get on/off there. The new station at Rosslyn would be on aerial structure east of the existing station, situated between Interstate I-66 and Arlington Ridge Road. It would be designed to include easy passenger connections between the new and existing stations. No other new stations would be constructed, but the design of the track would accommodate future connection to East Falls Church Station and future stations constructed by Improvement Project 18.

The connections to existing tracks at both ends of the project would be at-grade connections using no. 15 turnouts, to allow high-speed operations.

Between West Falls Church and the existing tunnel portal west of Ballston Station the new line would share the Interstate I-66 median with the existing Orange Line. In this section the line would run at-grade alongside the existing Orange Line where space allows. However, for some of this section there is not enough room for at-grade construction of both the Express Track and the future fourth track. In those stretches, the track would be constructed on aerial structure. The aerial structure would be designed to allow later construction of the fourth track with minimal impacts to operations on either the existing Orange Lines or the Express Track.

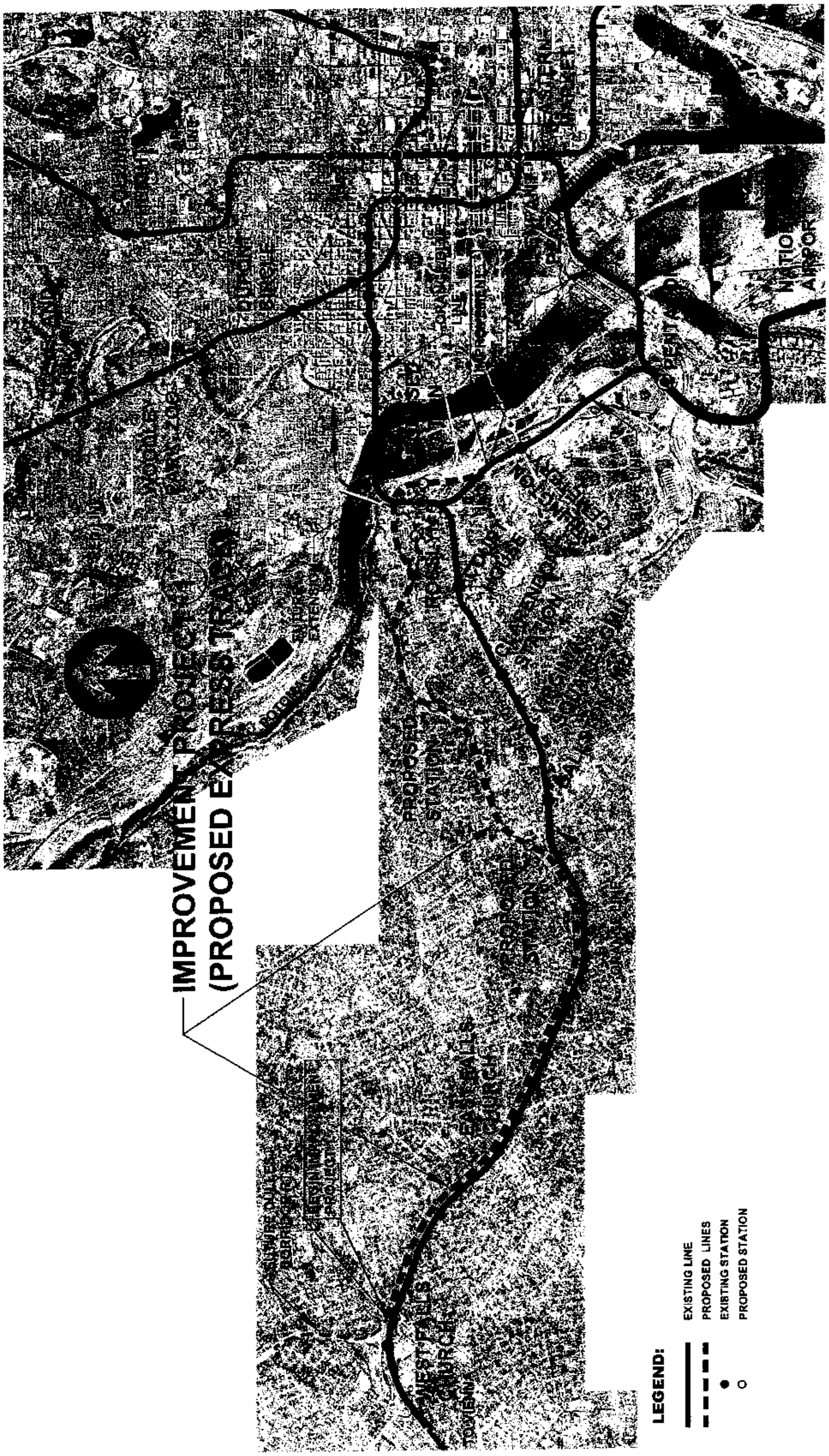
Crossovers between the Orange Line tracks and the new Express Track will be located near the existing tunnel portal west of Ballston Station, where the Express Track would separate from the existing Orange Line corridor and continue in the Interstate I-66 right-of-way. Depending on the right-of-way and optimum track alignment constraints, some of the line would be in the center of Interstate I-66 and some of it would run along the side of Interstate I-66. The track in this section would continue on aerial structure into Rosslyn until descending to its at-grade connection with the existing Blue Line north of Arlington Cemetery Station. A stub-out would be constructed off the aerial structure in Rosslyn for a future connection to the Orange Line Bypass into the District of Colombia (Improvement Project 18).

6.1.1.2 Length of Project and Breakdowns by Construction Types

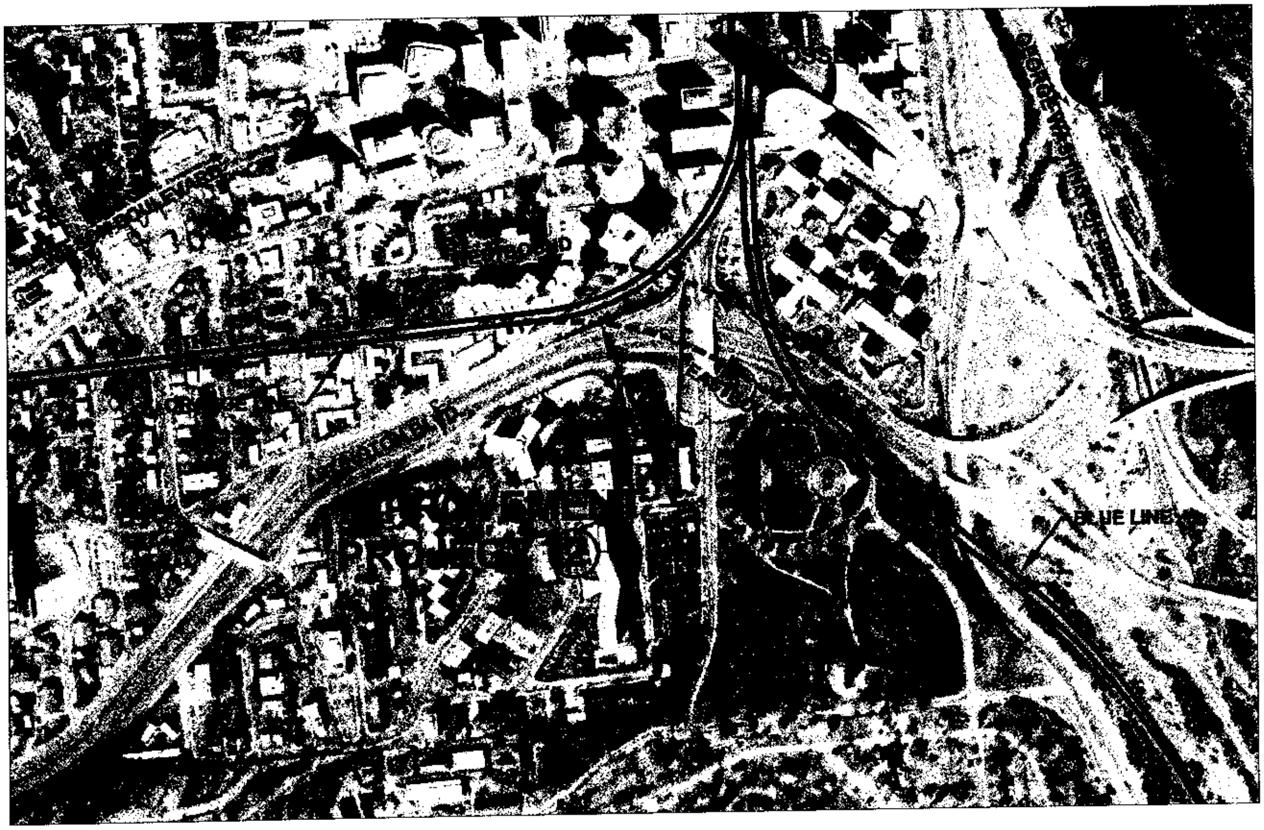
At-grade track	14,300	track feet	(2.71 miles)
Aerial track	25,900	track feet	(4.91 miles)
Aerial station	800	track feet	(0.15 miles)
At-grade to tunnel transition, single-track	1,600	track feet	(0.30 miles)
Cut-and-cover tunnel, single-track	1,100	track feet	(0.21 miles)
Total length of track	43,700	track feet	(8.28 miles)

6.1.1.3 Estimated Project Cost $ 525 million

6.1.1.4 Total Project Duration 110 months


IMPROVEMENT PROJECT
(PROPOSED EXPRESS TRACK)
PROPOSED STATION
PROPOSED STATION
WEST FALLS CHURCH
EAST FALLS CHURCH
WOODLEY PARK-ZOO
NATIONAL AIRPORT
LEGEND:
EXISTING LINE
PROPOSED LINES
EXISTING STATION
PROPOSED STATION

6.1.2 PROJECT NUMBER 2
ROSSLYN ORANGE/BLUE LINE CONNECTION



6.1.2.1 Description

The project would be a two-track line running between the Orange Line west of Rosslyn Station and the Blue Line south of Rosslyn Station. The two tracks would provide revenue operations in both inbound and outbound directions, thus allowing alternative routing for either Orange Line or Blue Line trains in/out of the Metro System Core, and also would improve failure management flexibility. The project location and route is illustrated above.

Both tracks would be in subway. The inbound subway would connect at its west end to the Inbound Track of the Orange Line under 16th Street, east of the intersection with Pierce Street. It would not cross over/under any other Metro tunnel on its way to its east end connection to the Blue Line near the Iwo Jima Memorial.

The outbound subway would connect at its east end to the Blue Line near the Iwo Jima Memorial. It would cross over both the Blue Line and Orange Line subways and connect with the Orange Line tunnel under 16th Street, west of the intersection with Queen Street.

There would be no stations in the project. The outbound subway would require mid-alignment subway ventilation. Since the alignment would run very close to the existing Orange Line ventilation structure near the intersection of Wilson Boulevard and Fort Myer Drive, the existing ventilation structure could be reconstructed and modified to provide ventilation for both the existing tunnels and the new outbound subway of this project. The inbound subway for this project would be short enough that no additional ventilation is anticipated at this time. This will be verified during final design.

The track connections to existing tracks at both ends of both new subways would use either no. 15 or no. 20 turnouts, to allow unrestricted speed operations.

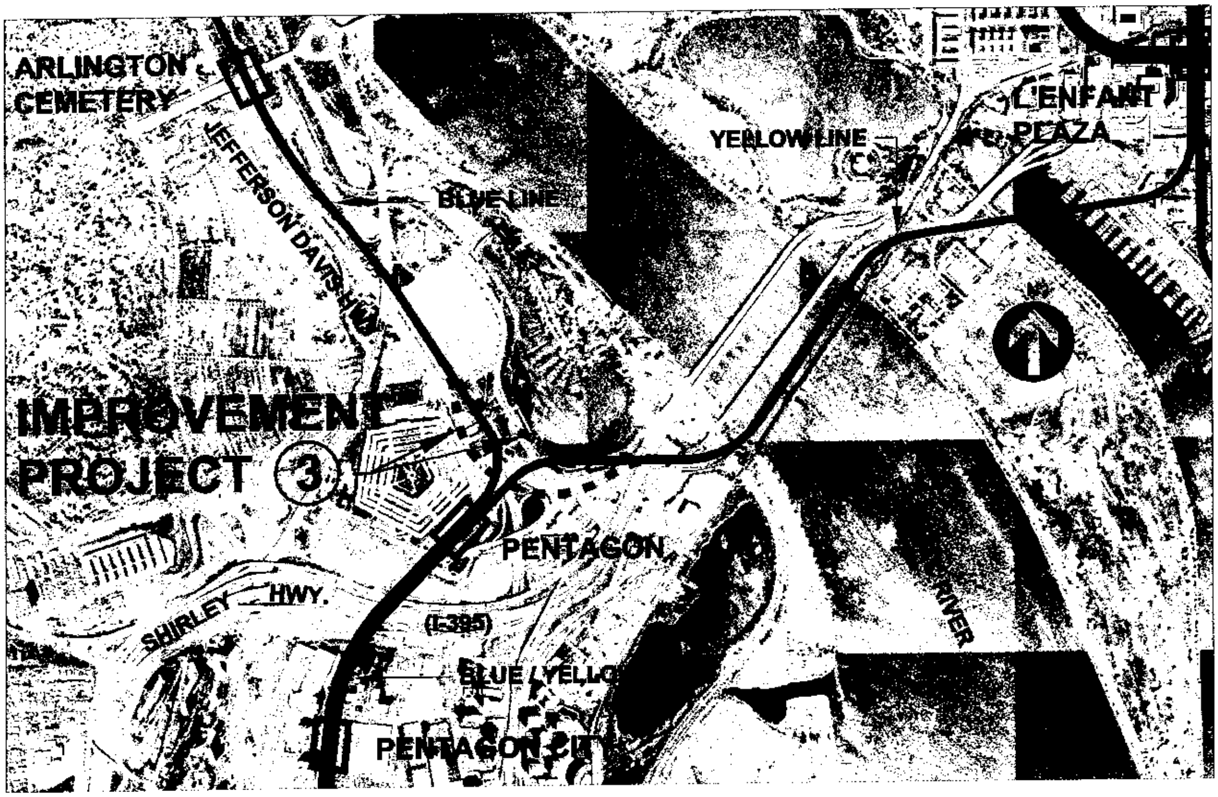
6.1.2.2 Length of Project and Breakdowns by Construction Types

Cut-and-cover subway connection structure	1500 track feet	(0.28 miles)
Special mined connection structure, including building underpinning	500 track feet	(0.09 miles)
Minded tunnel, single track	3256 track feet	(0.62 miles)
Total length of track	5256 track feet	(1.00 miles)

6.1.2.3 Estimated Project Costs $ 125 million

6.1.2.4 Total Project Duration 74 months

6.1.3 PROJECT NUMBER 3
PENTAGON BLUE/YELLOW LINES CONNECTION



6.1.3.1 Description

The project would be a two-track line running between the Blue Line north of Pentagon Station and the Yellow Line east of Pentagon Station. The two tracks would provide revenue operations in both inbound and outbound directions, thus allowing alternative routing for either Blue Line or Yellow Line trains into/out of the Metro System Core (together with Improvement Project 1 and also would improve failure management flexibility. The project location and route is illustrated above.

Both tracks would be in subway. Both track tunnels would connect at their north ends to the Blue Line in the Pentagon North Parking Area on the east side of Jefferson Davis Highway (Virginia Route 110), south of the intersection with Virginia Route 27). Both track tunnels would connect at their south ends to the Yellow Line in the median space between the Express Lanes and the northbound lanes of Shirley Highway (Interstate I-395).

The outbound tunnel would not cross over/under any other Metro tunnel, but it would cross under Boundary Channel Drive and Shirley Highway. The inbound tunnel would cross under the Blue Line and Yellow Line tunnels, as well as both Boundary Channel Drive and Shirley Highway.

There would be no stations in the project. However, the new tunnels would be long enough that mid-alignment ventilation structures would be required.

The track connections to existing tracks at both ends of both new tunnels would use no. 15 turnouts, to allow unrestricted operations.

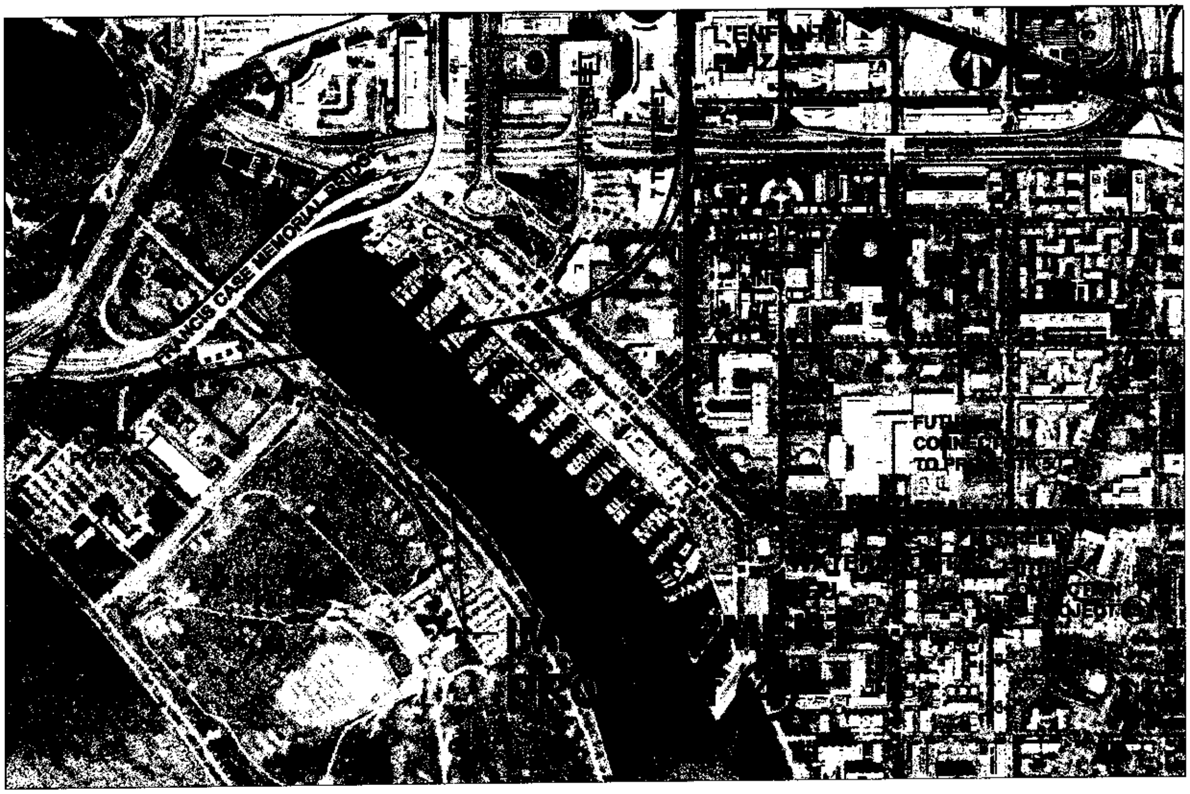
6.1.3.2 Length of Project and Breakdowns by Construction Types

Cut-and-cover subway connection structures (4-turnouts)	1400 track feet	(0.27 miles)
Special mined structures under Shirley Highway (2)	600 track feet	(0.11 miles)
Mined tunnel, single track	4552 track feet	(0.86 miles)
Total length of track	6552 track feet	(1.24 miles)

6.1.3.3 Estimated Project Cost $150 million

6.1.3.4 Total Project Duration 74 months

6.1.4 PROJECT NUMBER 4
WATERFRONT YELLOW/GREEN LINES CONNECTION



6.1.4.1 Description

The project would be a two-track subway connection in the District of Columbia running between the Yellow Line in East Potomac Park and the Blue Line near Waterfront Station. The two tracks would provide revenue operations in both inbound and outbound directions. The project location and route is illustrated above.

Both tracks would connect at their west end to the Yellow Line east of the tunnel portal near the railroad bridge over Interstate 395 in East Potomac Park and at their east end to the Green Line under M Street SW, east of Waterfront Station, near the intersection of M Street with Delaware Avenue.

From its west end connection, the inbound tunnel would curve away from the Yellow Line in a southeasterly direction, continue under the Washington Channel, run under the parking lot on the south side of Pier Seven Restaurant, continue east to run parallel to the Green Line on its south side, and reconnect with the Green Line as described above.

The outbound tunnel would run west from the above-described east-end connection at the Green Line, continue parallel to and on the north side of the Green Line in M Street, turn north in 7th Street SW along the east side of the Green Line, curve west near the intersection of 7th Street and I Street SW, run underneath the Green Line tunnels and Yellow Line tunnels, continue curving in a southwesterly direction under Benjamin Banneker Park, run under Maine Avenue and in-between Capt. White's Seafood market and Phillips Flagship Restaurant, run under Washington Channel, and connect with the Yellow Line as described above.

There would be no new stations in the project. In addition to the two main tunnels, the project would also include two cut and cover stub-outs for future connection to Improvement Project 5 tunnels, and vent structures where required. The construction of these stub-outs is recommended to allow construction of the future tunnels without causing service disruptions on the already constructed lines. One of the stub-outs would extend off the inbound track of this project on the north side of Waterfront Station. The second stub-out would extend off the outbound track of this project. These stub-outs are on the west side of Waterfront Station.

The track connections to existing tracks at both ends of both new tunnels would be use no. 15 turnouts, to allow high-speed operations.

6.1.4.2 Length of Project and Breakdowns by Construction Types

Cut-and-cover subway connection structure	1,620 track feet (0.31 miles)
Circular tunnel subway single-track structure	8,119 track feet (1.54 miles)
Total length of track:	9,739 track feet (1.84miles)

6.1.4.3 Estimated Project Costs $215 million

6.1.4.4 Total Project Duration 86 months

6.1.5 PROJECT NUMBER 5
NAVY YARD TO UNION STATION CONNECTION

6.1.5.1 Description

The project would be a two-track connection primarily under 2nd Street NE/SE, providing both northbound and southbound revenue service from the Green Line in the Waterfront section of the District of Columbia to a temporary terminus at a new transfer station at Union Station. The two tracks would provide revenue operations in both inbound and outbound directions. In addition to the two main tracks, two other short tracks would connect to the Yellow Line Connector constructed by Improvement Project 4. The project location and route are illustrated on the attached drawing. All of both tracks would be in subway.

The northbound track would have two legs at the south end. One northbound leg would connect to the Green Line west of Navy yard Station, with the turnout at approximately the intersection of M Street and South Capital Street SW. This track would carry inbound trains on the Green Line from Branch Avenue to go north to Union Station. From its connection to the Green Line, this track would curve north and cross under the Blue/Orange Line at 2nd Street / D Street SE, continue north under 2nd Street, and curve west to run under Massachusetts Ave. NE. The subway would run under the existing Amtrak/VRE passenger train tunnel under 1st Street NE, run under the Red Line at the south end of Union Station Metro Station, run through a new transfer station at Union Station, and terminate at the end of a temporary tail track at the west end of the new station. The end of the project would be under Massachusetts Avenue near the intersection with 3rd Street NW.

The other northbound leg would begin at a connection with the Yellow Line stub-out already constructed by Improvement Project 4. This track would carry inbound trains off the Yellow Line from Huntington to Union Station. The turnout for this leg would be under M Street near the intersection with 6th Street SW and would bypass, the Waterfront Station. From this connection point, the track would run east along the south side of the Green Line, curve north near the intersection with Delaware Avenue, and connect with the other northbound track constructed in this project, described above, under 1st Street near the intersection with I Street SW.

The southbound track would share the same alignment as the northbound track described above, from the northern terminus as far south as the Southwest Freeway and runs south on 3rd street. From there, the southbound track would split into two legs. One leg would curve east to make a connection with the Green Line west of Navy Yard Station near the intersection of M Street and South Capitol Street. Southbound trains on this track would run from Union Station onto the outbound Green Line toward Branch Avenue.

The other southbound leg would connect with the first southbound leg described above under 3rd Street near the intersection with I Street SW. From there, this track would curve west to connect with the Yellow Line stub-out that was already constructed by Improvement Project 4. The connection point with the Yellow Line Connection would be on the north side of M Street next to Waterfront Station and would bypass the Waterfront Station

Included in this project would be three stations. All these stations would be in subway. One station would be at the intersection of 2nd Street and /D Street SE. The south end of the new station platform would be immediately north of the intersection of 2nd Street with D Street SE. The station would include a pedestrian tunnel (approximately 320 feet length) to connect this station with Capitol South Station on the Orange/Blue Line running under D Street

Another station would be at the intersection of 2nd Street and East Capitol Street. The station would include a pedestrian tunnel to connect this station with the new underground Capitol Visitors Center.

The third station in the project would be under Massachusetts Ave. at the intersection with North Capitol Street. The station would be designed for tracks at two levels. The south end of the station would connect with the Metro Station at Union Station, forming an "L-shaped" transfer station (the east side of this station connecting with the south end of Union Station).

Also included in the project would be a tail track and double crossover constructed on the west side of the new station at Union Station, which would accommodate temporary terminus operations at Union Station.

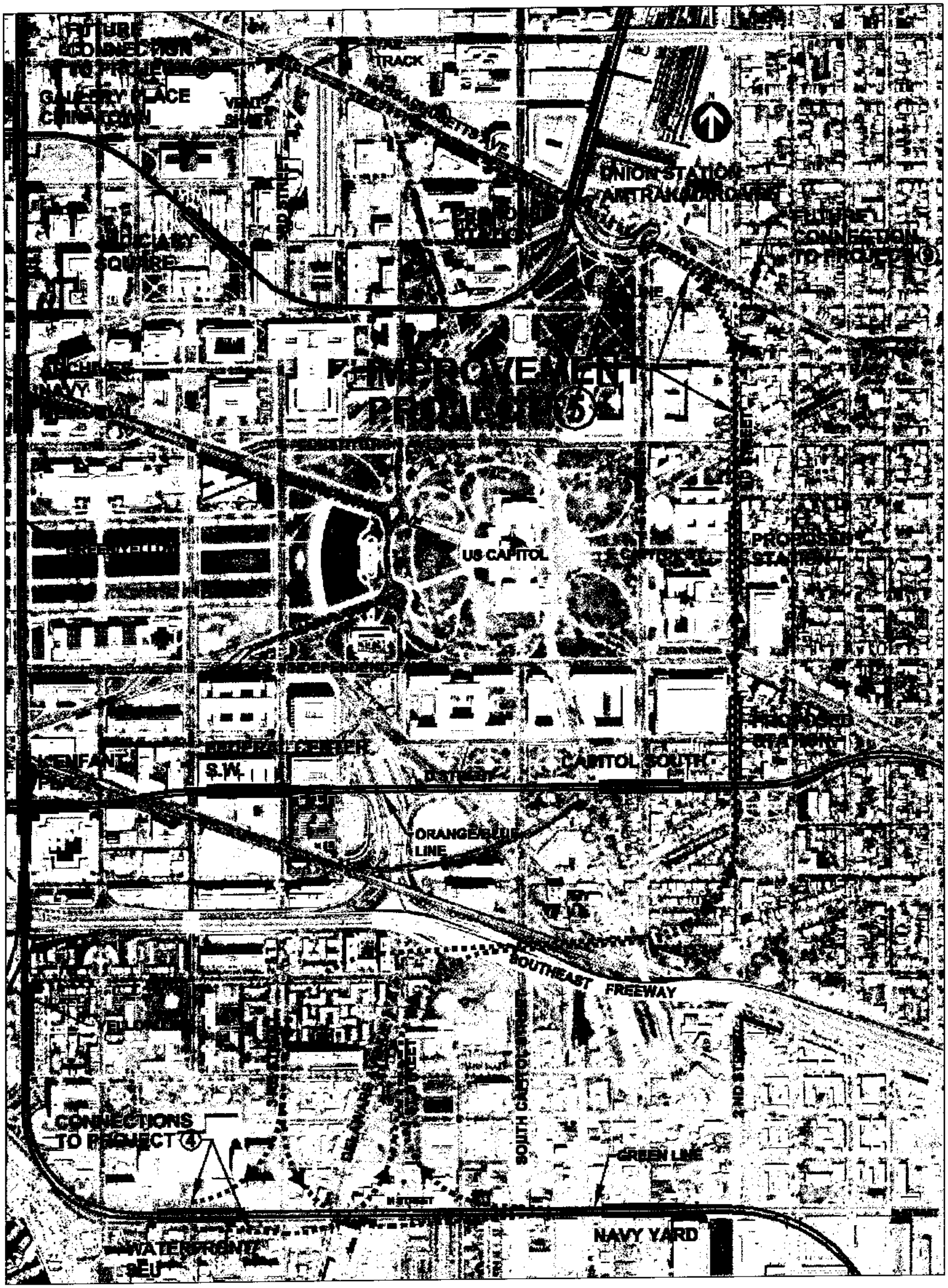
Most of the track connections to existing tracks at both ends of both new tunnels would be use no. 15 turnouts, to allow high-speed operations. Only the two turnouts for the southbound leg's connection to the Yellow Line Connection would be no. 10 turnouts, because there is not enough room in the alignment for no. 15 turnouts there.

6.1.5.2 Length of Project and Breakdowns by Construction Types.

Cut-and-cover subway connection structure	2,950	track feet (0.55 miles)
Cut-and-cover subway double-box structure	4,540	track feet (0.85 miles)
Cut-and-cover subway stub-out structure	2,400	track feet (0.45 miles)
Cut-and-cover subway station (3)	4,800	track feet (0.90 miles)
Special mined box structure under Red Line	120	track feet (0.02 miles)
Circular tunnel subway	18,940	track feet (3.60 miles)
Total length of track:	33,750	track feet (6.40 miles)

6.1.5.3 Estimated Project Cost $1,050 million

6.1.5.4 Proposed Construction Schedule And Duration 110 months


FUTURE CONNECTION TO PROJECT
TRACK
GALLERY PLACE CHINATOWN
MASSACHUSETTS AVE
N
UNION STATION AMTRAK/MARC/VRE
FUTURE CONNECTION TO PROJECT ⑤
JUDICIARY SQUARE
3RD STREET
IMPROVEMENT PROJECT ⑤
NAVY
US CAPITOL
PROPOSED STATION
INDEPENDENCE
PROPOSED STATION
FEDERAL CENTER S.W.
CAPITOL SOUTH
L'ENFANT PLAZA
D STREET
ORANGE/BLUE LINE
SOUTHEAST FREEWAY
CONNECTIONS TO PROJECT ④
SOUTH CAPITOL STREET
2ND STREET
GREEN LINE
M STREET
NAVY YARD
WATERFRONT/SEU

6.1.6 PROJECT NUMBER 6
NEW YORK AVENUE BLUE-ORANGE/BRENTWOOD YARD CONNECTION

6.1.6.1 Description

The project location and route are illustrated on the attached drawing. The project includes a number of interconnected segments, some of which can be removed from the project without detriment to the other segments. The segments include:

a) Subway along New York Avenue from McPherson Square Station to Brentwood Yard.
b) Connection from New Convention Center Station to New York Avenue.
c) Connection from New York Avenue at Old Convention Center to Yellow/Green Line.
d) Station at Old Convention Center under New York Avenue.
e) Station at New Convention Center under Massachusetts Avenue.
f) Station at New York Avenue / North Capitol Street.
g) Train storage yard at Old Convention Center.
h) Eckington train storage yard.

Most of the tracks would be in subway, except where the tracks would go up to at-grade in Brentwood Yard and Eckington Yard.

The primary line segment of the project is the subway primarily running under New York Avenue. This would be a two-track route providing both eastbound and westbound revenue service from the Blue/Orange Line east of McPherson Square Station to Brentwood Yard. At the west end both tracks would connect with the Blue/Orange Line with no. 10 turnouts. Because the existing track profile of the Blue/Orange Line has a vertical curve that runs right up to the station platform, the new turnouts would have to be located partially in the vertical curve. From the turnout connections, the eastbound track would curve northeast toward New York Avenue, run on top of the existing Blue/Orange Line tunnels, continue east under New York Avenue and above the westbound track, in a stacked arrangement, run through a stacked station, then run under the Carnegie Library at the intersection of New York Avenue and Massachusetts Avenue, then run under the existing Green/Yellow Line tunnels in 7th Street NW, and continue running east under New York Avenue, including running under the future depressed roadway with both tracks returning to the same level somewhat east of 7th street. The track would slope up to at-grade east of Florida Avenue and end at at-grade connections in both Brentwood Yard and the proposed new Eckington train storage yard described below.

The west bound track of the primary line segment of the New York Avenue connection would begin at at-grade connections in both Brentwood Yard and the proposed Eckington Yard, would turn west to run parallel to the eastbound track under New York Avenue, then run under the Green/Yellow Line and below the eastbound track, in a stacked arrangement, then run under the Carnegie Library at the intersection of New York Avenue and Massachusetts Avenue, run through a stacked station, continue under New York Avenue until 11th Street, turn northwest and run along the north side of the westbound track of the Blue/Orange Line without crossing it, run west under the south side of Franklin Square, and end at a connection with the Blue/Orange Line immediately east of the platform of McPherson Square Station.

Another line segment included in the project would be a subway connection from the New York Avenue segment described above to the New Convention Center. This segment would be a two-track connection providing revenue service in both directions. The west end of both eastbound and westbound tracks would be at the east end of the New Convention Center Station, under Massachusetts Avenue at the intersection with 9th Street with all four tracks in stacked pairs to facilitate the connection. The east ends of both tracks would use no. 15 turnouts to connect to the New York Avenue segment under Massachusetts Avenue east of the intersection with 7th Street NW after passing below the Green Line tunnels on 7th Street. In between the ends of this segment, both tracks would curve and run under the north side of Carnegie Library.

The third line segment included in the project would be a single-track non-revenue subway connection from the primary line segment in New York Avenue to the Yellow/Green Line in 7th Street NW from the lower level westbound track. This connection would allow movement of trains from the proposed train storage yard at the Old Convention Center site to the southbound track of the Green Line. In addition, since together with the New York Avenue Connection track described above, it would allow movement of trains from the Blue/Orange Line to the Yellow/Green Line. No. 8 turnouts would be used for track connections at both ends of this segment. The alignment of this segment would begin at a connection with the New York Avenue Connection immediately east of the platform of the proposed Old Convention Center Station in New York Avenue, at the intersection with 9th Street NW. From there, the track would curve east under Mt. Vernon Place, continue curving south to run south along the west side of the southbound track of the Yellow/Green Line in 7th Street, and end with a connection to the Yellow/Green Line at the intersection of 7th Street and H Street NW.

Three new stations would be included in this project. All these stations would be in subway. One station would adjoin the old Convention Center, under New York Avenue at the intersection with 10th Street NW. The station would be designed for tracks at two levels, with the eastbound track running overtop the westbound track. The platforms for both tracks would be on the north side of the tracks, which would enable unobstructed track access to the adjoining underground rail storage yard at the site of the old Convention Center, as described below. The station would also have a pedestrian tunnel connection to the new station at the New Convention Center. Refer to Improvement Project 12 in Milestone Report 5 for further information.

The second station would adjoin the new Convention Center, under Massachusetts Avenue at the intersection with 10th Street NW. This station would be designed for four tracks at three levels, and in the future would be a transfer station allowing passengers to transfer between the New York Avenue subway and the proposed Orange Line Bypass. The lower track would be a platform similar to Rosslyn with the westbound track that would connect with the westbound track under New York Avenue. The track at the second level would be the eastbound track that would connect with the eastbound track under New York Avenue. This station would also include an 800 feet long tail track structure for short-term storage of trains while this station serves as a temporary terminus station. At the top level would be both eastbound and westbound tracks running under Massachusetts Avenue that would connect in the future with Improvement Project 8 to carry passengers to/from Union Station. This station would also include a stub-out section of tunnel on the east side of the station to allow future extension of the line under Massachusetts Avenue toward Union Station. This stub-out structure would be a two-track structure that would be mined under the Carnegie Library, pass over the Yellow/Green Line in 7th Street, ending on the west side of the intersection of 7th Street and Massachusetts Avenue. The station would have an entrance into the New Convention Center, as well as connection to the aforementioned pedestrian tunnel connection with the new station at the Old Convention Center.

The third station would be under New York Avenue at the intersection with North Capitol Street.

Two new train storage yards would also be included in this project. The first yard would be in subway at the site of the Old Convention Center. The lead track for this yard would connect with the westbound (lower) track of the New York Avenue Connection at a no. 8 turnout on the east side of the station platform. The yard would provide storage for seven 8-car trains (56 cars).

The second train storage yard proposed for this project would be at the site of the old Baltimore and Ohio Railroad Eckington train yard. The old train yard has been abandoned and the property is still vacant, but would have to be purchased or leased by WMATA. This property is bordered on the south by New York Avenue, on the east by WMATA Red Line to Glenmont, on the north by Franklin Street, and on the west by a number of properties. Depending on how much of the site is used, it would allow storage for at least twelve 8-car trains or more. This yard would be designed for train access from the proposed New York Avenue Connection, the Red Line, and Brentwood Yard.

6.1.6.2 Length of Project and Breakdowns by Construction Types

Underpin buildings	0 track feet	(0 miles)
Reconstruct vent structure at McPherson Sq. Station	0 track feet	(0 miles)
Cut-and-cover subway station	1600 track feet	(0.30 miles)
Cut-and-cover subway station, deep 2-level type	1600 track feet	(0.30 miles)
Cut-and-cover subway station, deep 3-level type	3,200 track feet	(0.61 miles)
Cut-and-cover line connection structure	760 track feet	(0.14 miles)
Cut-and-cover subway single box structure	2,020 track feet	(0.38 miles)
Cut-and-cover subway double-box structure	9,820 track feet	(1.86 miles)
Cut-and-cover subway double box with 3rd track stub-out	900 track feet	(0.17 miles)
Cut-and-cover subway 3-track box structure	3,300 track feet	(0.63 miles)
Cut-and-cover subway 4-track box structure	5,000 track feet	(0.95 miles)
Cut-and-cover subway train yard (Old Conv. Cntr.)	6,800 track feet	(1.29 miles)
Special mined line connection structure	340 track feet	(0.06 miles)
Special mined single-track tunnel	1,600 track feet	(0.30 miles)
Special mined double-track tunnel	2,960 track feet	(0.56 miles)
Eckington Train Yard (at-grade)	10,000 track feet	(1.89 miles)
Track connections to Brentwood Yard	1,000 track feet	(0.19 miles)
Total length of track	50,900 track feet	(9.64 miles)

6.1.6.3 Estimated Project Cost $1545 million

6.1.6.4 Total Project Duration 116 months


BRENTWOOD YARD
NEW YORK AVE STATION
UNION STATION AMTRAK/MARC/VRE
PROPOSED ECKINGTON STORAGE YARD
PROPOSED STATION
RED LINE
NORTH CAPITOL
IMPROVEMENT PROJECT 6
7TH STREET
HOWARD UNIV
GREEN/YELLOW LINE
CONVENTION CENTER
OLD CONVENTION CENTER
PROP. TRAIN STORAGE YARD
GALLERY PLACE CHINATOWN
11TH STREET
14TH STREET
LIMIT OF IMPROVEMENT

6.1.7 PROJECT NUMBER 7
NORTH TRACK CONNECTION FROM YELLOW/GREEN LINE TO NEW YORK AVENUE CONNECTION

6.1.7.1 Description

The project would be a single-track connection, providing northbound non-revenue service from the New York Avenue Connection and Brentwood Yard to the Green Line to Greenbelt. The project location and route is illustrated above

All of the track would be in subway. At the south end of the project, the new track would connect to the inbound track of the proposed New York Avenue Connection under New York Avenue near the intersection with M Street NW. From there the project track would turn to run west under M Street, and curve northwest toward the Green Line. The project's north end would be a connection with the outbound track of the Green Line under 7th Street NW at the intersection with P Street NW.

The track connections to existing tracks at both ends of the new tunnel would use no. 10 turnouts.

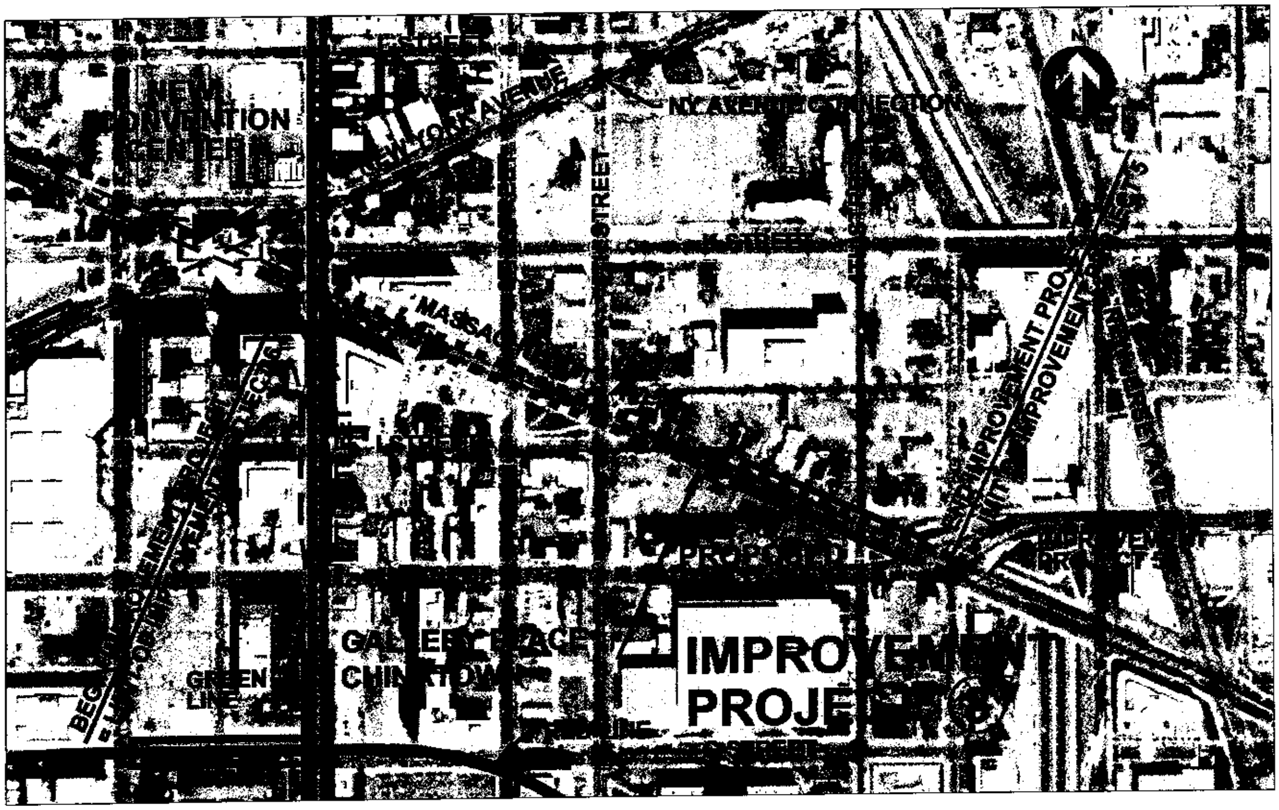
6.1.7.2 Length of Project and of Breakdowns by Construction Types

Cut-and-cover subway connection structure	720	track feet	(0.1 miles)
Circular tunnel subway	2780	track feet	(0.5 miles)
Total length of track	3500	track feet	(0.7 miles)

6.1.7.3 Estimated Project Cost $ 70 million

6.1.7.4 Total Project Duration 74 months

6.1.8 PROJECT NUMBER 8
TRACK CONNECTION FROM NEW CONVENTION CENTER TO UNION STATION



6.1.8.1 Description

The project would be a two-track revenue subway running under Massachusetts Avenue NW, providing both eastbound and westbound revenue service in the District of Columbia from the future metro station at the new convention center, completed by Improvement Project 6, to the future transfer station at Union Station completed by Improvement Project 5. Both of the tracks in this project would also cross over the Green Line tunnels. The project location and route is illustrated above.

At the west end of the project, the two tracks would both start at their connection with the already completed segment of subway at the intersection of Massachusetts Avenue and 7th Street NW, which was already constructed under the Carnegie Library by Improvement Project 6.

At the east end of the project, the two tracks would end at their connection with the already completed tail track west of the future transfer station at Union Station. The terminus point would be approximately at the intersection of Massachusetts Avenue and 3rd Street NW.

The project would also include construction of a future station at the intersection of Massachusetts

Avenue and 4th Street NW.

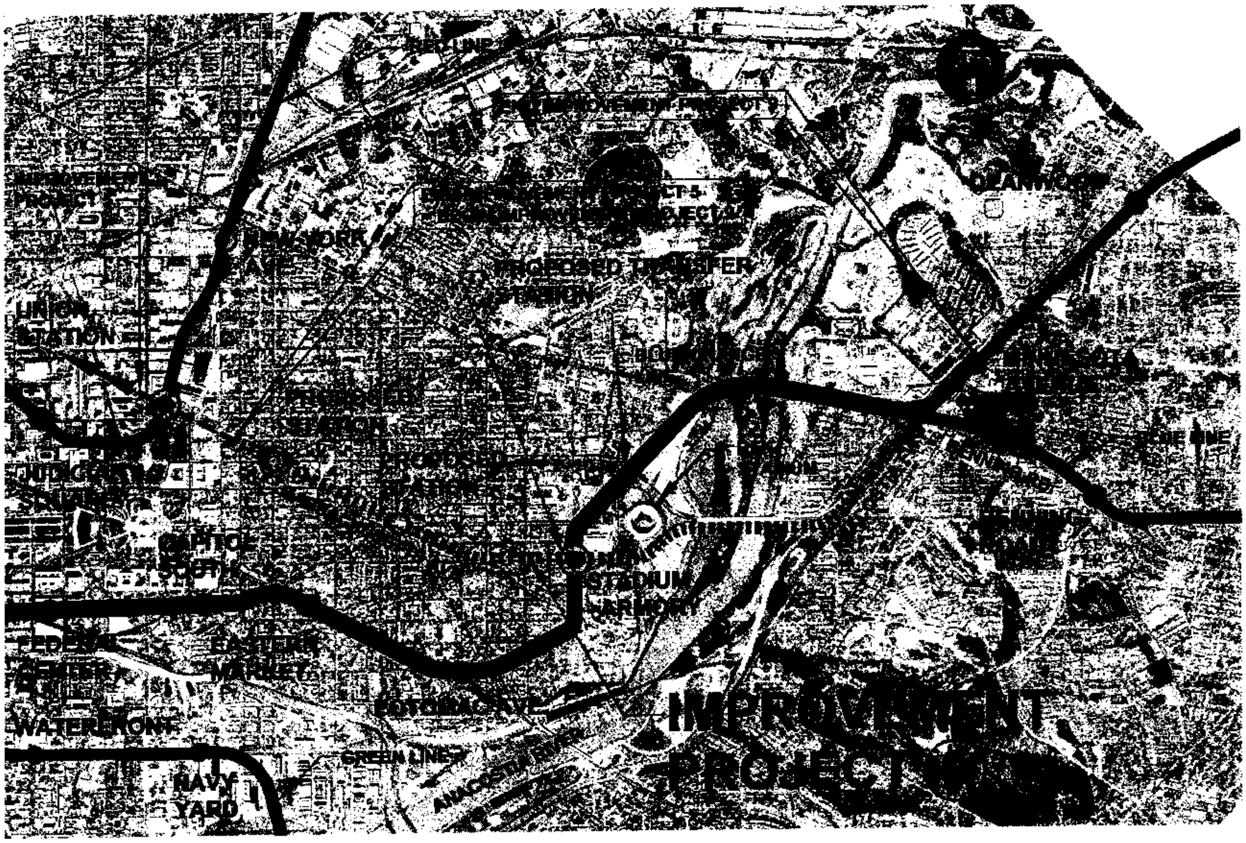
6.1.8.2 Length of Project and Breakdowns by Construction Types.

Cut-and-cover subway double-box structure:	2800 track feet	(0.5 miles)
Cut-and-cover subway station:	1600 track feet	(0.3 miles)
Total length of track:	4400 track feet	(0.8 miles)

6.1.8.3 Estimated Project Cost $ 175 million

6.1.8.4 Total Project Duration 74 months

6.1.9 PROJECT NUMBER 9
UNION STATION TO MINNESOTA AVENUE CONNECTION



6.1.9.1 Description

The project would be a two-track connection providing inbound and outbound revenue service between Union Station at its west end and Minnesota Avenue Station at its east end. The project location and route are illustrated above.

The western half of the connection would be in subway, while the eastern half of the connection would be on aerial structure.

At the west end of the project both tracks would connect with the end of the existing stub-out structure constructed under Improvement Project 5, under Massachusetts Avenue at the intersection of 2nd Street NE. From there, the subway would run in parallel tunnels east under Massachusetts Avenue as far as Independence Avenue, curve east and run under Independence Avenue, run under the Blue/Orange Line at Stadium-Armory Station, ascend to a portal and up to aerial structure east of 19th Street SE, run on a new bridge across the Anacostia River on the south side of Whitney Young Memorial Bridge (East Capitol Street), curve north over the top of the Anacostia Freeway and Norfolk Southern Corporation mainline, continue north on the east side of Anacostia Freeway, go over Benning Road, and connect with the Orange Line at Minnesota Avenue Station.

Three new stations would be included in this project. All three stations would be in subway. One station would be under Stanton Park, at the intersection of Massachusetts Avenue and Maryland Avenue NE. The station would be a two-level station, designed as a transfer station for future connection to Improvement Project 15 and the Red Line Bypass. The track for Improvement Project 9 would run over the future track for Improvement Project 15. All of the Massachusetts Avenue part of the station would be constructed in this project, as well as the portion serving the tracks for Improvement Project 15 that is in Massachusetts Avenue. The remainder of the station serving Improvement Project 15, outside Massachusetts Avenue, would be completed later under that contract, to minimize impacts and cost to Project 9.

The second station in this project would be under Lincoln Park, at the intersection of Massachusetts Avenue and North Carolina Avenue.

The third station in this project would be a transfer station connecting with the existing Stadium Armory Station at the intersection of Independence Avenue and 19th Street SE. The new station constructed in this project would be lower than the existing station, to allow the new tracks to pass under the Blue/Orange Line. The new station would be constructed on the west side of the existing station, forming a "T-shaped" transfer station, and would include a direct pedestrian passageway between the two platforms.

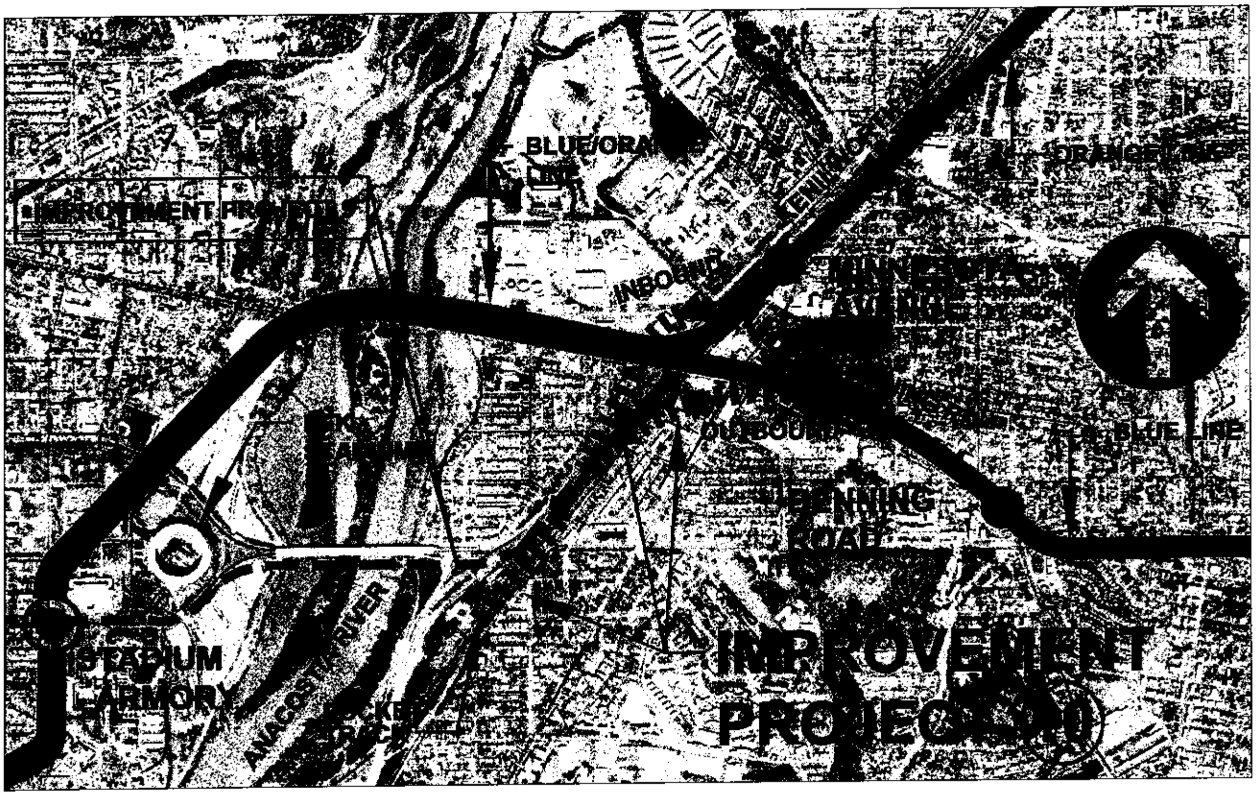
6.1.9.2 Length of Project and Breakdowns by Construction Types

Circular tunnel subway	16,800	track feet (3.18 miles)
Subway-to-aerial transition structure	1,800	track feet (0.34 miles)
Anacostia River Bridge	4,400	track feet (0.83 miles)
Aerial Structure	11,800	track feet (2.23 miles)
Cut-and-cover stations (3)	4,800	track feet (0.91 miles)
Total length of track	39,600	track feet (7.50 miles)

6.1.9.3 Estimated Project Cost $ 990 million

6.1.9.4 Total Project Duration 110 months

6.1.10 PROJECT NUMBER 10
TRACK CONNECTION FROM THE BLUE LINE TO IMPROVEMENT PROJECT 9 AND BENNING YARD POCKET TRACKS



6.1.10.1 Description

The project includes three segments. One segment would be a single-track connection providing inbound revenue service from the Blue Line west of Benning Road Station to Improvement Project 9 south of Benning Road. The second segment would be a single-track connection providing outbound revenue service from Improvement Project 9 south of Benning Road to the Blue Line west of Benning Road Station. The third segment would be train storage pocket tracks connecting with Improvement Project 9 south of Benning Road. The project location and route is illustrated above.

The first and second segments of the project would each be partially in subways and partially on aerial structures. At the east end of the project the new inbound track would have a subway connection to the inbound track of the Blue Line approximately 1000 feet east of the intersection of Benning Road and Minnesota Avenue. It would run in subway west alongside the north side of the Blue Line, run under Minnesota Avenue, run under the CSX and Norfolk Southern railroad tracks, curve south and run under Kenilworth Avenue and Benning Road, ascend to a portal and slope up to aerial structure on the west side of Anacostia Freeway, curve east and run over the Anacostia Freeway and connect with the outbound track of Improvement Project 9, north of East Capitol Street on aerial structure.

The second segment of the project would connect to the outbound track of Improvement Project 9 on aerial structure north of East Capitol Street, in between Anacostia Freeway and the Norfolk Southern tracks. From there it would run north and descend to a tunnel portal south of Benning Road, curve east and run in subway under both the Norfolk Southern and CSX tracks run under Benning Road and Minnesota Avenue, run east alongside the outbound track of the Blue Line, and connect with the Blue Line outbound track in subway, approximately 1000 feet east of Minnesota Avenue.

Both inbound and outbound tracks would be designed for revenue operation standards, using high-speed no. 15 turnouts at all connections for high-speed operations.

The third segment of the project would be pocket tracks for train storage in the old Benning Railroad Yard on the east side of Anacostia River, with connection to Improvement Project 9 north of the intersection of East Capitol Street with Anacostia Freeway (Route 295). The pocket tracks would be parallel to and immediately east of Improvement Project 9. The two-track pocket would provide storage for two 8-car trains (16 cars).

6.1.10.2 Length of Project and Breakdowns by Construction Types

Aerial structure, single track	1270 track feet	(0.24 miles)
Aerial structure, double track	1830 track feet	(0.35 miles)
Aerial-to-subway transition structure, single track	1800 track feet	(0.34 miles)
Circular tunnel subway, single track	3715 track feet	(0.70 miles)
Cut-and-cover subway connection structure	1000 track feet	(0.19 miles)
Total length of track	9615 track feet	(1.82 miles)

6.1.10.3 Estimated Project Cost $155 million

6.1.10.4 Total Project Duration 74 months

6.1.11 PROJECT NUMBER 11
PENTAGON STUB POCKET TRACKS

6.1.11.1 Description

The project would be a two-track pocket track with connection at one end only to the Blue / Yellow Line immediately south of Pentagon Station. The project would provide train storage close to the Metro System Core for 40 cars and a crew office structure within a new vent shaft. The project location and route is illustrated above.

Both tracks would be in subway. No special connection structure to the existing tunnels would be required since others have already constructed the stub-outs. These stub-outs were constructed for the future Metrorail Columbia Pike extension. For this project only the special track and systems for the connections would have to be installed. No. 15 turnouts would be installed for the track connections with the Blue/Yellow Line. The existing stub-out structure to be used for this project was designed and constructed for the use of an at-grade track crossing diamond. The signal system would have to be designed to allow safe at-grade crossing of trains at this point.

After the connection, the pocket tracks would follow approximately parallel alignments to the end of track, sharing the same structure at 14 feet track centers. The track connections to existing tracks at both ends of both new tunnels would use no. 15 turnouts, to allow high-speed operations. From the connection, the alignment would curve west on the south side of the Pentagon South Parking Area, until ending at a fan shaft on the west side of Washington Boulevard (Virginia Route 27), inside the interchange with Colombia Pike (Virginia Route 244).

The pocket tracks would provide storage for 40 cars and would also include a double crossover.

6.1.11.2 Length of Project and Breakdowns by Construction Types

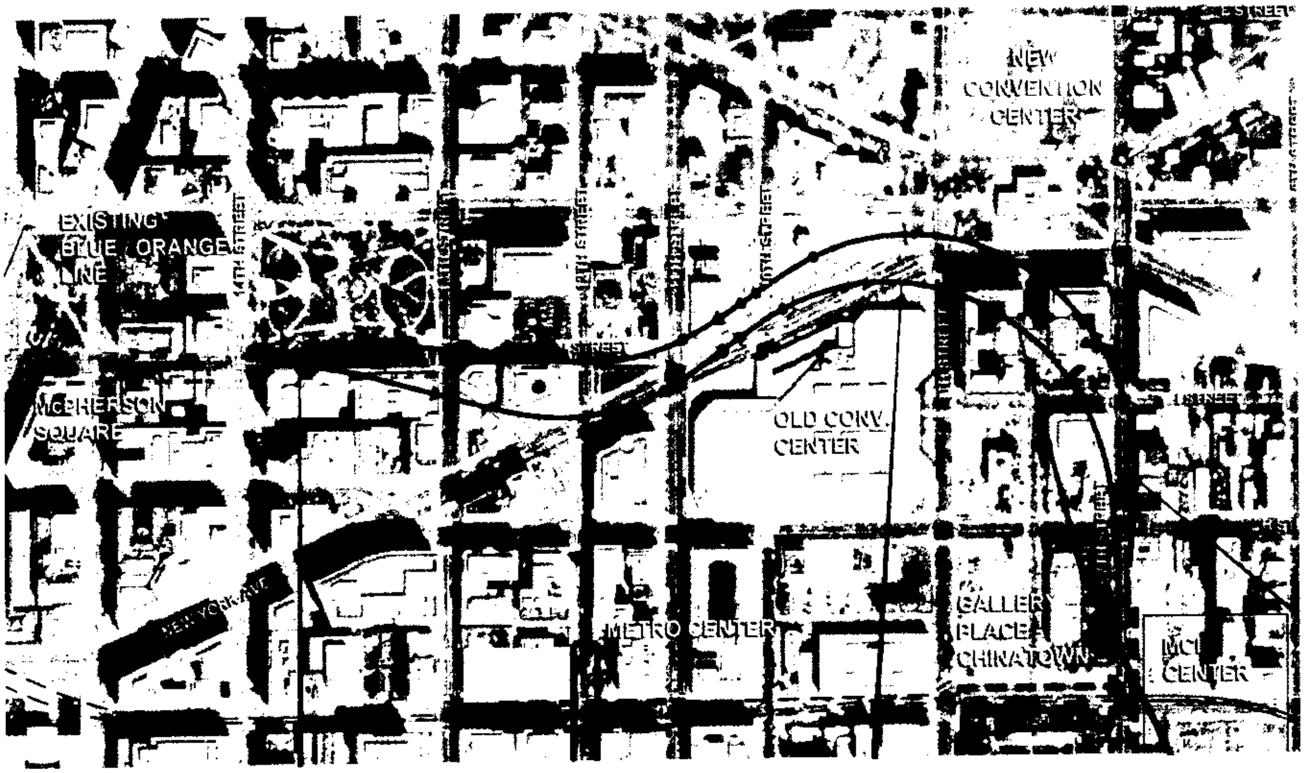
Cut-and-cover double-track structure 2700 track feet (0.5 miles)

6.1.11.3 Estimated Project Cost $ 90 million

6.1.11.4 Total Project Duration 68 months

6.1.12 PROJECT NUMBER 12

BLUE/ORANGE TO YELLOW/GREEN LINE CONNECTION BETWEEN GALLERYPLACE-CHINATOWN & McPHERSON SQUARE



6.1.12.1 Description

The project would be a two-track connection from the Blue/Orange Line east of McPherson Square to the Yellow/Green Line north of Gallery Place. The two tracks would provide revenue operations in both directions. The project location and route is illustrated above.

Both tracks would be in subway. Both tunnels would connect at their north ends to the Blue/Orange Line, east of McPherson Square Station at the intersection of 14th and I Streets. Both new tunnels would connect at their south ends to the Yellow/Green Line north of Gallery Place Station under 7th Street, south of the intersection with H Street

The southbound tunnel of this project would dive down and run southeasterly from its connection to the outbound Blue/Orange Line track east of McPherson Square, at approximately 14th and I Streets, curving southwesterly under private property and buildings to New York Avenue at 12th Street, running northeasterly on New York Avenue, turning southeasterly at 9th Street and curving under private property and buildings at 9th Street through to 7th Street, south of H Street, to the aforementioned connection with the inbound track of the Yellow/Green Line.

From its south end connection to the outbound track of the Yellow/Green Line, North of Gallery Place Station, the northbound tunnel of this project would dive down and curve northeasterly under private property and buildings south of H Street, curve northwesterly under the Yellow/Green Line tunnels, curve under private property and buildings between 7th and 9th Streets at I Street, curve northwesterly into private property and under buildings at the north side of New York Avenue west of 9th Street, continuing to curve southwesterly under private property and buildings and emerging into I Street west of 11th Street, curving northwesterly on I Street and partly under private property and buildings on the south side of I Street at 12th Street, continuing to curve northwesterly on I Street and running partly under the McPherson Square Park on the north side of I Street at 13th Street and curving westerly to connect to the Blue/Orange Line directly east of the McPherson Square Station at 14th Street.

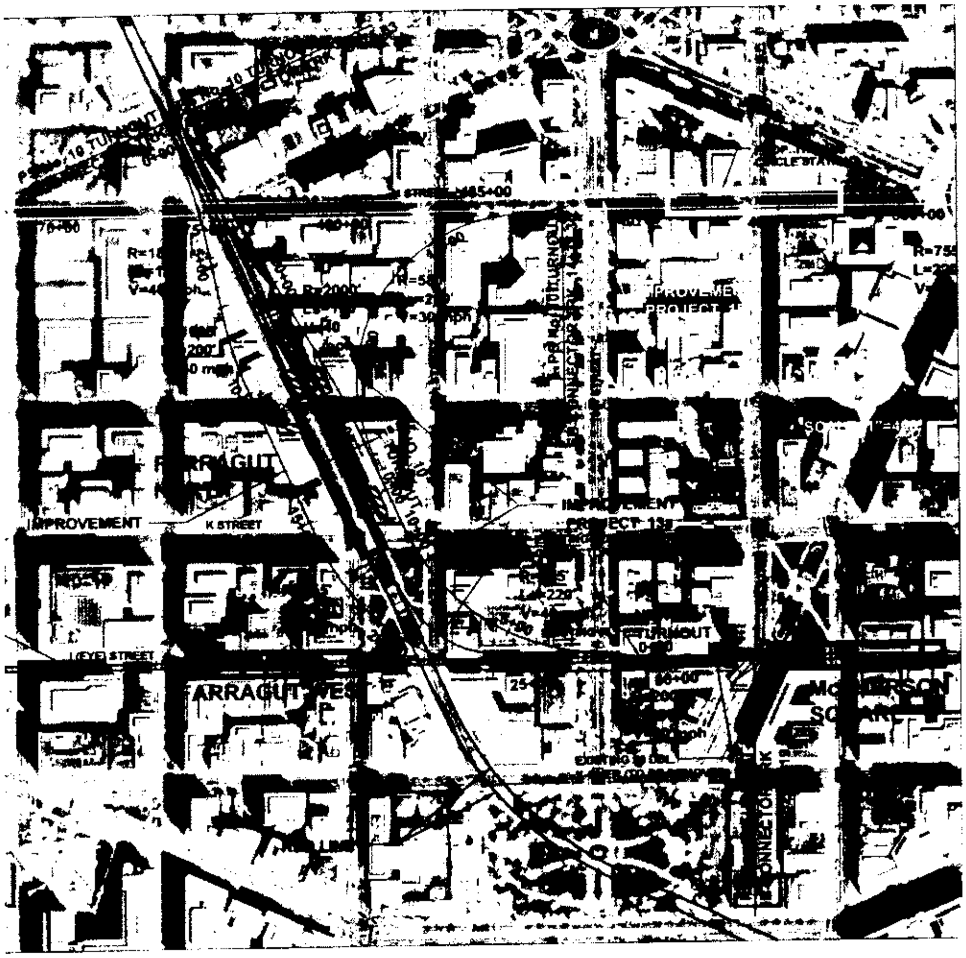
6.1.12.2 Length of Project and Breakdowns by Construction Types

Cut-and-cover subway connection structure	900	track feet (0.17	miles)
Mined sections of line connection structure	1,100	track feet (0.21	miles)
Circular tunnel subway, single track	5,375	track feet (1.02	miles)
Total length of track	7,375	track feet (1.41	miles)

6.1.12.3 Estimated Project Cost $195 million

6.1.12.4 Total Project Duration 80 months

6.1.13 PROJECT NUMBER 13a
RED TO BLUE/ORANGE LINE CONNECTION AT FARRAGUT NORTH & McPHERSON SQUARE



6.1.13.1 Description

The project would be a two-track connection between the Red Line North of Farragut North Station and the Blue/Orange line west of McPherson Square Station. The two tracks would provide emergency operations between the two lines, in both directions. The project location and route is illustrated above.

Both tracks would be in subway. The southbound tunnel of this project, would run southwesterly under private property from its connection to the inbound Red Line track north of Farragut North Station, bypass the Farragut North Station, curve southwesterly and run below the Red Line tracks, curve west under private property on the south side of EYE Street, near the intersection of 17th, run under private property and end at the aforementioned connection with the outbound track of the Blue/Yellow Line.

From its south end connection to the inbound track of the Blue/Orange Line, the northbound tunnel of this project would curve away from Blue/Orange Line in a northeasterly direction, curve north and run under private buildings, bypassing the existing Red Line north of Farragut North Station, and ending at a connection with the outbound track of the Red Line, north of M Street.

The track connections to existing tracks at both ends would use no. 10 turnouts, to allow high-speed operations

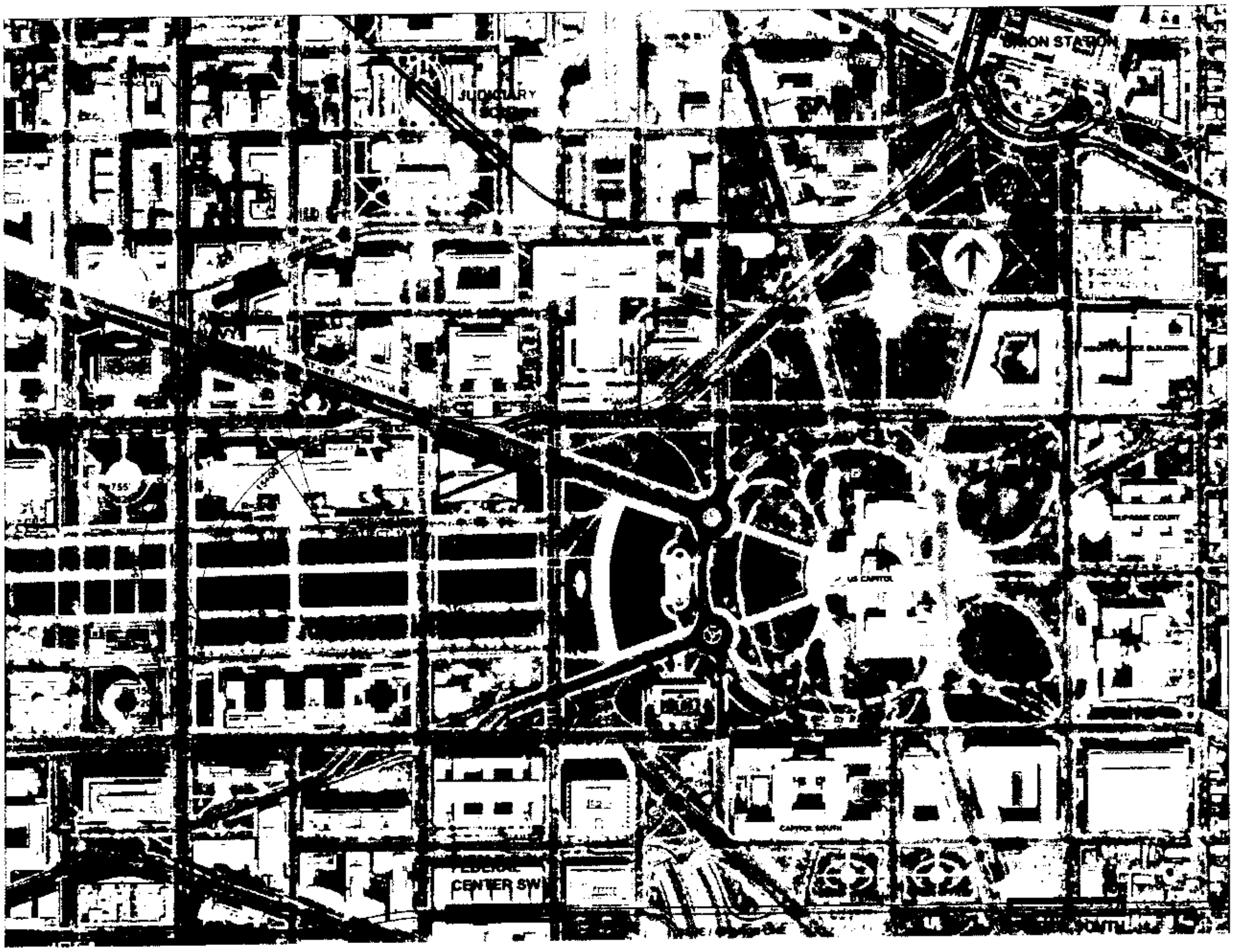
6.1.13.2 Length of Project and Breakdowns by Construction Types

Cut-and-cover subway connection structure	2,000	track feet	(0.38	miles)
Circular tunnel subway	3,950	track feet	(0.75	miles)
Total length of track	5,950	track feet	(1.13	miles)

6.1.13.3 Estimated Project Cost $180 million

6.1.13.4 Total Project Duration 80 months

6.1.14 PROJECT NUMBER 14 L'ENFANT-TO-UNION STATION (YELLOW-GREEN LINE TO RED LINE) CONNECTION



6.1.14.1 Description

The project would be a two-track connection between the Yellow/Green Line in the National Mall and the Red Line at Union Station. The two tracks would provide revenue operations in both directions. The project location and route is illustrated above.

Both tracks would be in subway. Both new tunnels would connect at their south ends to the Yellow/Green Line north of L'Enfant Plaza Station under 7th Street south of the intersection with Independence Avenue. Both tunnels would connect at their north ends to the Red Line south of Union Station at the intersection of Massachusetts Avenue and Columbus Circle.

From its south end connection to the inbound Track of the Yellow/Green Line, the northbound tunnel of this project, would curve away from the Yellow/Green Line in a northeasterly direction, curve east and run under Constitution Avenue, curve north under Union Station Plaza, and end at a connection with the outbound track of the Red Line south of Union Station.

The southbound tunnel of this project would run southwest from its connection to the inbound Red Line south of Union Station, curve west and run beside the Red Line, curve southwest under D Street near the intersection with North Capitol Street and run under the Red Line, curve west and run under Constitution Avenue, curve south at the intersection of Constitution Avenue and 7th Street NW, run under the Yellow/Green Line tunnels, run under the National Mall on the west side of 7th Street NW, and end at the aforementioned connection with the outbound track of the Yellow/Green Line.

In addition to the two main tunnels, the project would also include four subway stub-outs, for future connections to subways of Improvement Projects 15 and 19 under Constitution Avenue. The construction of these stub-outs is recommended to allow construction of the future subways without causing service disruptions on the already constructed lines. Two of the stub-outs would extend off the west side of the alignment before the beginning of the curves for the connections to the yellow/green line. The other two stub-outs would extend off the east side of the alignment at the beginning of the curves running northerly into Louisiana Avenue.

The track connections to existing tracks at both ends would be use no. 15 turnouts, to allow high-speed operations. The other two track connections would use no. 10 turnouts, as no. 15 turnouts will not fit into workable track alignments.

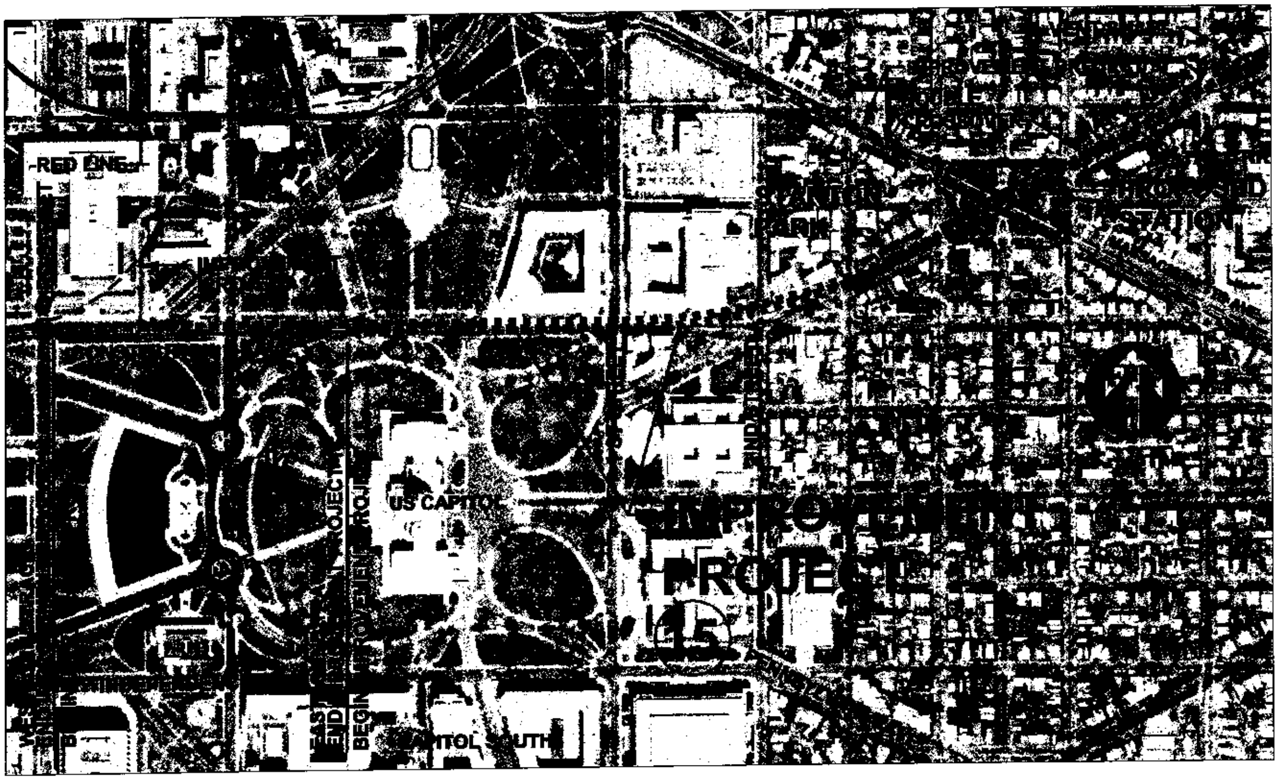
6.1.14.2 Length of Project and Breakdowns by Construction Types

Cut-and-cover subway connection structure	2,000	track feet (0.38 miles)
Cut-and-cover subway double crossover structure	1,000	track feet (0.19 miles)
Cut-and-cover structure, single track	480	track feet (0.09 miles)
Circular tunnel subway	9,258	track feet (1.75 miles)
Total length of track	12,738	track feet (2.41miles)

6.1.14.3 Estimated Project Cost $ 224 million

6.1.14.4 Total Project Duration 92 months

6.1.15 PROJECT NUMBER 15
SMITHSONIAN TO STANTON PARK CONNECTION



6.1.15.1 Description

The project would be a two-track connection between the stub-out of Improvement Project 14 in Constitution Avenue and a new transfer station at Stanton Park in Maryland Avenue. The two tracks would provide revenue operations in both directions. The project location and route is illustrated above.

Both tracks would be in subway. The eastbound track in this project would connect to the stub-out constructed by Improvement Project 14, under Constitution Avenue near the intersection with 1st Street NW. From there, the new track would run east under Constitution Avenue, run under the Senate Subway people mover, run under the Amtrak passenger railroad tunnel under 1st Street NE, run under Improvement Project 5 tunnels in 2nd Street NE, curve northeast and run under Maryland Avenue, run through the new station at Stanton Park below the existing tracks of Improvement Project 8, and end at the end of a tail track approximately 1400 feet past the intersection of Massachusetts Avenue and Maryland Avenue.

The westbound track would begin at the same point that the eastbound track ends, as described above. From there, it would follow the same route as the eastbound track except in reverse. However, the westbound track would also cross under the northbound tunnel of Improvement Project 14, and would connect to its respective Improvement 14 stub-out structure a couple of blocks farther west than the eastbound track, under Constitution Avenue near the intersection with 3rd Street.

No special connection structure to the existing tunnels of Improvement Project 14 would be required since others have already constructed the stub-outs. Only the special track and systems for the connections would have to be installed. No. 15 turnouts would be installed for the track connections.

The new transfer station at Stanton Park that would be partially constructed by Improvement Project 8 would be completed in this project. This station would be under Stanton Park, at the intersection of Maryland Avenue and Massachusetts Avenue. The portion of the station that would be already completed by Improvement Project 8 would be the central section, roughly within the right of way of Massachusetts Avenue. Improvement Project 15 would construct both ends of the station running under Maryland Avenue, outside of the central section.

The project would also include a tail track and double crossover constructed on the east side of the new station, which would accommodate temporary terminus operations at Union Station.

6.1.15.2 Length of Project and Breakdowns by Construction Types

Cut-and-cover subway double-box structure	3,000	track feet	(0.6 miles)
Cut-and-cover subway station	1,100	track feet	(0.2 miles)
Circular tunnel subway	6,200	track feet	(1.2 miles
Total length of track	10,300	track feet	(2.0 miles)

6.1.15.3 Estimated Project Cost

$ 305 million

6.1.15.4 Total Project Duration

92 months

6.1.16 PROJECT NUMBER 16
ADAMS MORGAN (RED LINE TO GREEN LINE) CONNECTION

6.1.16.1 Description

The project would be a two-track revenue subway connecting the west leg of the Red Line (to Shady Grove), between Woodley Park-Zoo Station and Dupont Circle Station, to the Green Line, between Colombia Heights Station and U-Street-Cardozo Station. The two tracks of the new connection would provide revenue operations in both eastbound and westbound directions. Track alignments at each end of the connection would be designed to allow trains from the Green Line to continue either north or south onto the Red Line, and to allow trains from the Red Line to continue either north or south onto the Green Line. Except for the curved connections at either end, the connection would primarily run under Biltmore and Euclid Streets. The project location and route is illustrated above.

The project would also include a subway station near the intersection of Biltmore Street and Cliffbourne Street NW. The station would be a cut-and-cover structure. At one end of the station box would be a double crossover to allow emergency movements of trains between the two tracks.

6.1.16.2 Length of Project and Breakdowns by Construction Types.

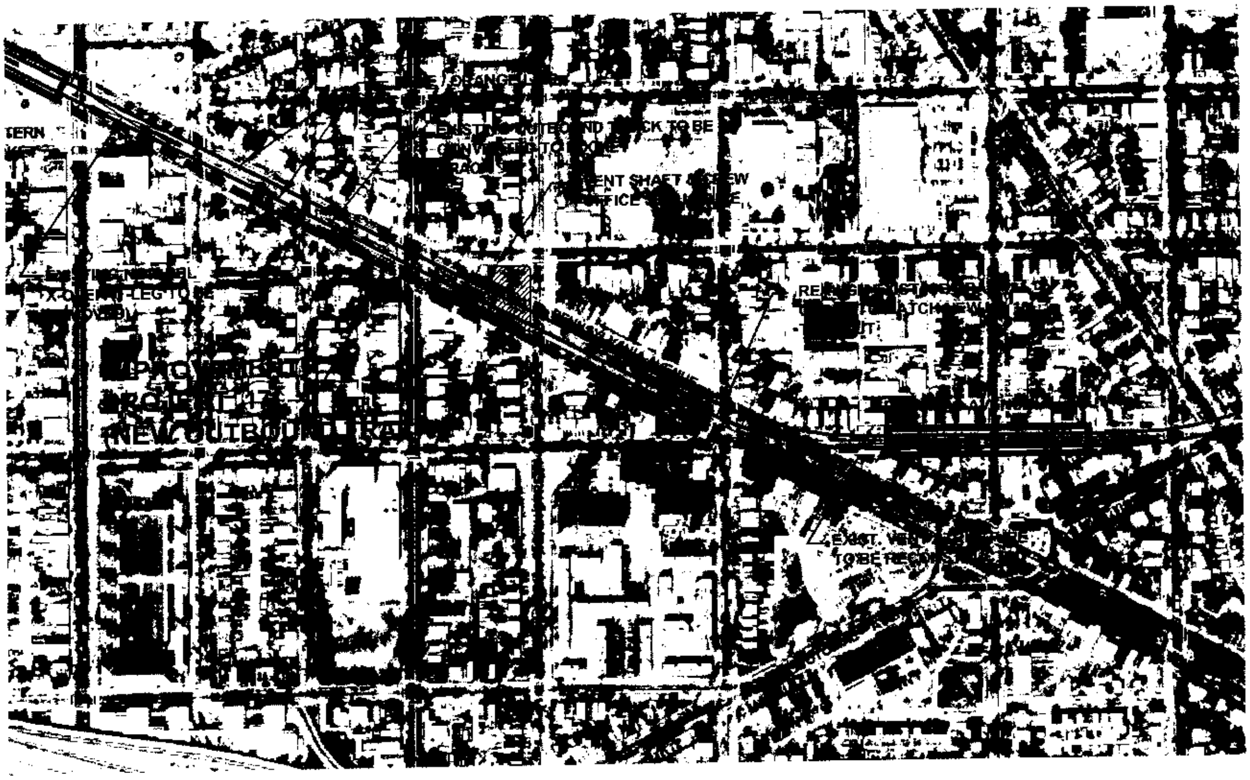
Cut-and-cover subway connection structure:	8,000 track feet	(1.52 miles
Cut-and-cover station and crossover box structure	2,400 track feet	(0.45 miles)

Circular tunnel, double track	4,000 track feet	(0.76 miles)
Circular tunnel, single track	18,000 track feet	(3.41 miles)
Total length of track	32,400 track feet	(6.14 miles)

6.1.16.3 Estimated Project Cost $ 780 million

6.1.16.4 Total Project Duration 92 months

6.1.17 PROJECT NUMBER 17
POTOMAC AVENUE/ PENNSYLVANIA AVENUE SE POCKET TRACK



6.1.17.1 Description

The Project would be a new single-track revenue subway constructed in Pennsylvania Avenue SE between Eastern Market Station and Potomac Avenue Station. The new subway would run roughly parallel to the existing outbound track in that section of the Metrorail system. After completion of the new subway, outbound mainline trains would be rerouted through the new subway and the existing outbound track in that section would be converted to a center pocket train storage track. The project location and route is illustrated above.

The project would provide train storage close to the Metro System Core for 28 Metrorail vehicles.

At the west end of the project the new subway would connect to the outbound track of the Blue/Orange Line immediately south of Eastern Market Station. A no. 15 turnout would be used for this connection to allow unrestricted speeds through the turnout. From the initial connection, the new subway would run southeast and parallel to the existing outbound tunnel under the south side of Pennsylvania Avenue, then turn east under G Street SE, and reconnect to the existing outbound track at the west end of Potomac Avenue Station. Since the existing track alignment is in a curve at this point, a special no. 10 turnout would be used for this connection. The turnout would be aligned so that after conversion of the new subway to the outbound track, the mainline track would use the straight leg of the new turnout and the diverging leg of the turnout would be designed for a best fit into the existing curve.

One leg of the existing double crossover that is east of Eastern Market Station would be removed because of conflict with the new subway alignment.

6.1.17.2 Length of Project and Breakdowns by Construction Types

Cut-and-cover single track structure 4200 track feet (0.80 miles)

6.1.17.3 Estimated Project Cost $ 80 million

6.1.17.4 Total Project Duration 74 months

6.1.18 PROJECT NUMBER 18 ORANGE LINE BYPASS

18.1 Description

The project would be a revenue line running east and west between West Falls Church, Virginia and the west end of Improvement Project 6 in the District of Columbia. The project location and route is illustrated on the attached sheet.

The segment of the project in Virginia from West Falls Church to the west side of Rosslyn would be a single-track line running parallel to the Orange Line Virginia Express Track that was constructed by Improvement Project 1. Taken together, these two tracks would provide bi-directional operations complementing the existing Orange Line now running in Interstate 66 between West Falls Church and Rosslyn. From the west side of Rosslyn, the project would split from the Orange Line Virginia Express Track, run through Rosslyn, and cross the Potomac River to continue east through the District of Columbia. From the west side of Rosslyn to its east end in the District of Columbia, the project would be a two-track line providing bi-directional operations.

West of Rosslyn the Virginia segment of the project would mostly be on aerial structure, with some short at-grade stretches where the track runs inside the Interstate 66 median. The Rosslyn and District of Columbia segments of the project would all be in subway, including the Potomac River crossing.

The Virginia segment would begin at its connection with the west-end of the Orange Line Virginia Bypass Track east of West Falls Church Station. From there, the track would share the Interstate 66 median with the existing Orange Line. In this section the line would run at-grade alongside the existing Orange Line, where space allows. However, for some of this section there is not enough room for at-grade construction of this new track and the other three tracks in the interstate median. In those stretches, the track would be constructed on aerial structure. Near the existing tunnel portal west of Ballston Station, the new track would separate from the existing Orange Line corridor and continue in the Interstate 66 right-of-way parallel to the Orange Line Virginia Express Track. Depending on the right-of-way and optimum track alignment constraints, some of the line would be in the center of Interstate 66 and some of it would run along the side of Interstate 66. The track in this section, would continue east on aerial structure until the intersection of Interstate 66 and Spout Run Parkway. From there, two new tracks would separate from the Express Track alignment, descend into subway, turn south and east to run under Key Boulevard in Rosslyn, and continue north before crossing the Potomac River in subway.

After crossing the Potomac River, both tracks would follow parallel alignments through the District of Columbia all the way to the east end of the project. The tracks would cross under the Potomac River on the east side of Key Bridge, turn east and run under M Street NW through Georgetown, continue east under M Street until reaching Massachusetts Avenue, where they would turn southeast and run under Massachusetts for a short distance until ending at the connection with the tail track of the New Convention Center Station, that was already constructed by Improvement Project 6.

Included in the project would be seven stations. One of these stations would be an expansion of the existing East Falls Church Station to accommodate the two new tracks of this project and Improvement Project 1. The other six stations in the project would be completely new. Three of the new stations would be in Virginia and three would be in the District of Columbia.

One of the new stations in Virginia would be in the median of Interstate 66 at the intersection of Washington Boulevard. The second station in Virginia would be in the right-of-way of Interstate 66 at the intersection of Lee Highway. The third station in Virginia would be in Rosslyn under Key Boulevard at the intersection with Oak Street.

The first station in the District of Columbia would be in Georgetown at the intersection of M Street and Wisconsin Avenue. The second station in the District of Columbia would be in M Street at the intersection of New Hampshire Avenue. The third station in the District of Columbia would be in M Street west of the intersection of Massachusetts Avenue.

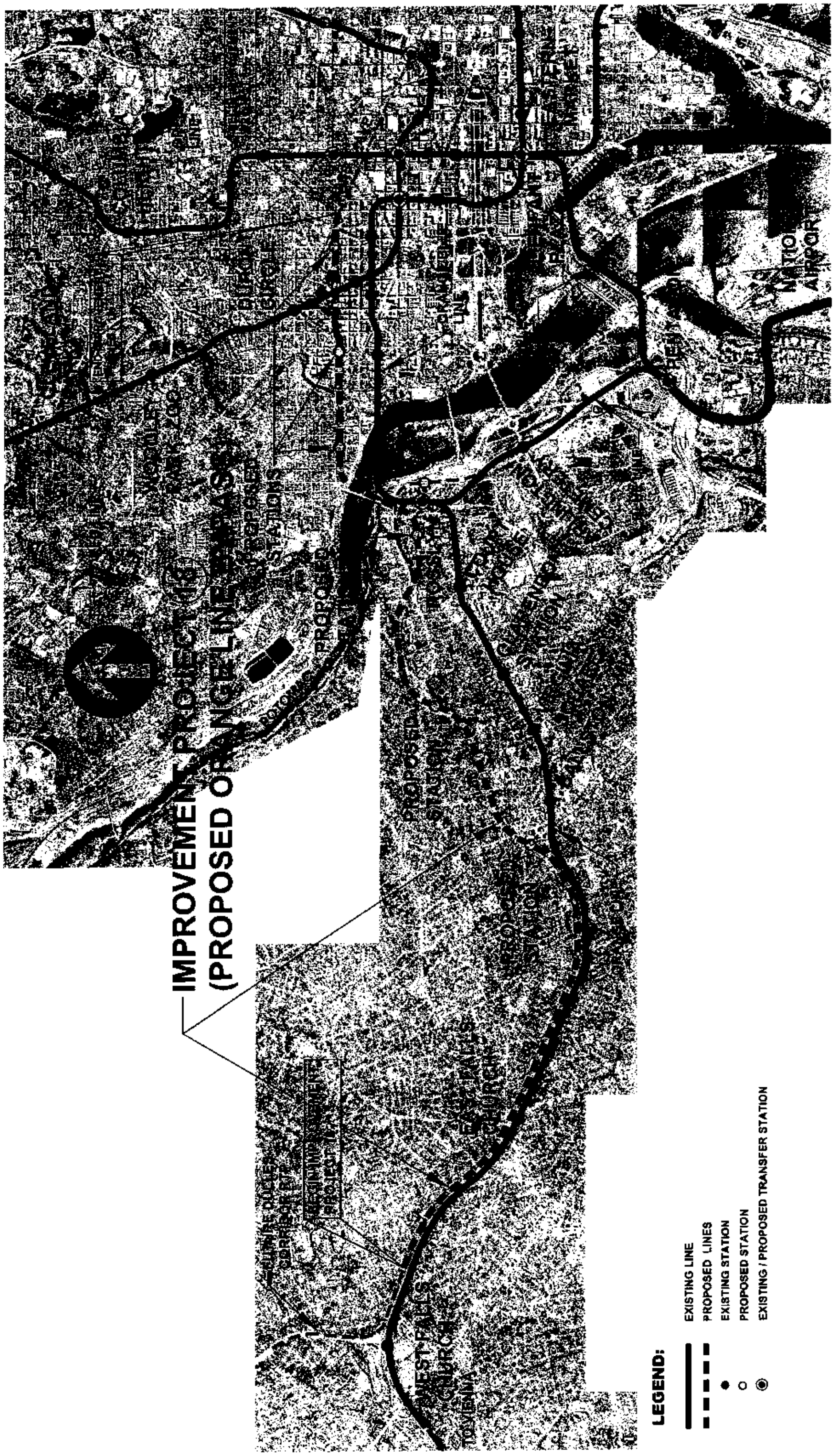
Also included in the project would be two subway connections from this project to existing Metro lines. These connections would be single-track connections between the proposed Orange Line Bypass and the Red Line to Shady Grove. Both tracks would be designed for non-revenue and emergency (failure management) use. The first track would be located west of the intersection of Connecticut Ave. and M Street NW, and the second track would be located east of the intersection of Connecticut Ave. and M Street NW.

6.1.18.2 Length of Project and Breakdowns by Construction Types

At-grade, single-track	6,800 track feet	(1.29 miles)
Aerial track (sgl. trk. on exist. columns/supports for dbl-trk. structure)	18,600 track feet	(3.52 miles)
East Falls Church Station Reconstruction (aerial)	800 track feet	(0.15 miles)
Aerial stations in Interstate 66 (2)	1,600 track feet	(0.30 miles)
Aerial-to-tunnel transition structure (two-tracks)	2,000 track feet	(0.38 miles)
Cut-and-cover line connection structures	2,400 track feet	(0.45 miles)
Cut-and-cover stations (4)	6,400 track feet	(1.21 miles)
Circular tunnel, single-track	7,100 track feet	(1.34 miles)
Circular tunnel, double-track	30,400 track feet	(5.76 miles)
Total length of track	76,100 track feet	(14.41 miles)

6.1.18.3 Estimated Project Cost $ 1,840 million

6.1.18.4 Total Project Duration 110 months



6.1.19
PROJECT

NUMBER 19
RED LINE BYPASS

6.1.19.1 Description

The project would be a two-track revenue line consisting of two segments. The west segment would begin at a temporary terminus in the District of Columbia, at its west end near Washington National Cathedral, and would end at its connection to Improvement Project 14, at the National Mall. The east segment would begin at a connection with the east end of Improvement Project 15, east of Stanton Park Station, and would end at its connection to the Orange Line, west of Cheverly Station in Maryland. The project location and route is illustrated on the attached sheet.

The west segment of the project would all be in subway. Both track tunnels would follow parallel alignments. The project would begin at a new station at the intersection of Wisconsin Avenue / Massachusetts Avenue. From there, the project would run south under Wisconsin Avenue through Georgetown as far as K Street, turn southeast to run under the north side of the Potomac river, continue south under Virginia Avenue, turn east to run under Constitution Avenue, and connect with the already completed Improvement Project 14 near the intersection of Constitution Ave. and 7th Street NW. Since connection stub-out structures for this connection would already be completed by Improvement Project 14, the construction of the connection to the existing subway could be made with a lot fewer impacts to existing Metro operations.

The east segment of the project would partially be in subway, partially at-grade, and partially on aerial structure. The west end of the segment would connect to the end of the tail track already completed in Project 15, east of Stanton Park Station. From there the line would run east in subway under Maryland Avenue, turn north and run in subway under Bladensburg Road, and turn east at New York Avenue. After turning and running alongside New York Avenue, the line would come up out of the ground and run on aerial structure. It would continue east on aerial structure, go over the Amtrak Northeast Corridor, then cross over the Anacostia River on a new bridge, continue through Anacostia River Park and over Kenilworth Avenue, curve south and cross back over Amtrak Northeast Corridor and the CSX Washington Branch, and slope down to connect with the Orange Line west of Cheverly Station. Track connections to both Orange Line tracks in both inbound and outbound direction would be provided, for maximum operational flexibility.

There would be eleven stations in the project, including the following:

1. National Cathedral: Underground station at the intersection of Wisconsin Avenue and Massachusetts Avenue. It would include an 800 feet long tail track at its north end for storage of trains at this temporary terminus station, and. A cut-and-cover type double crossover at its south end.

2. US Naval Observatory: Underground station at the intersection of Wisconsin Avenue and W Place NW.

3. Georgetown North: Underground station at the intersection of Wisconsin Avenue and 33rd Street NW.

4. Georgetown: Underground station at the intersection of Wisconsin Avenue and M Street NW. This would be a two-level transfer station for the Red Line Bypass with the Orange Line Bypass. Improvement Project 18 will construct the central portion of this station, approximately within the right-of-way of M Street. The outer ends of the section of the station serving the Red Line Bypass would be constructed under this project.

5. Watergate: Underground station in the Watergate section of the District of Columbia near the Kennedy Center, at the intersection of Virginia Avenue / New Hampshire Avenue.

6. Federal West: Underground station at the intersection of Virginia Avenue / 20th Street NW

7. Federal Triangle: Underground station immediately west of the intersection of Constitution Avenue and 12th Street NW, with its east end near the south end of the existing Federal Triangle Station. It would include a short pedestrian tunnel to the existing Federal Triangle Station, to allow easy pedestrian transfers between the two lines.

8. Kingman Park: Underground station near the intersection of Maryland Avenue / Bladensburg Road / Florida Avenue.

9. National Arboretum: Underground station near the intersection of Bladensburg Road / Mount Olivet Road.

10. Gateway / Fort Lincoln: At-grade or aerial station along New York Avenue somewhere in the vicinity of the intersection with South Dakota Avenue. Further planning studies are required to determine the exact location of this station, and whether it would be at-grade or on aerial structure.

11. Coakley Terrace: Aerial station along John Hanson Highway somewhere in the vicinity of the intersection with Kenilworth Avenue. Further planning studies are required to determine the exact location of this station.

Also included in the project would be three subway connections from this project to existing Metro lines. Two of these connections would be single-track connections between this project and the proposed Orange Line Bypass. Both of these connection tracks would be designed for non-revenue and emergency (failure management) use. The first track would be located west of the intersection of Wisconsin Ave. and M Street NW, and the second track would be located east of the intersection of Wisconsin Ave. and M Street NW.

The third connection would be a double-track connection between this project and the Orange Line, between Cheverly Station and Deanwood Station. The two tracks would be designed to allow revenue and operations in both directions. They would be mostly on aerial structure, including bridges over three railroad mainlines and Beaverdam Creek. The track connections to this project would be on aerial structure, while the track connections to the Orange Line would be at-grade.

6.1.19.2 Length of Project and Breakdowns by Construction Types

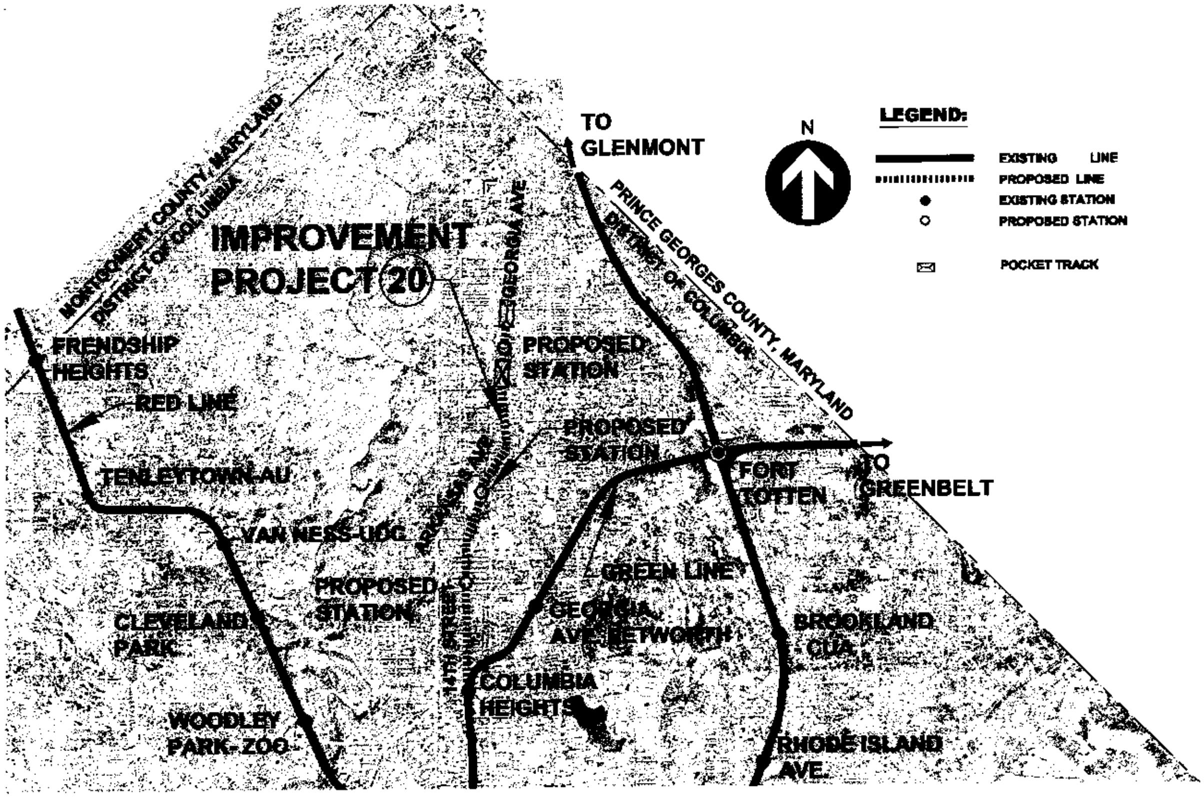
At-grade, single-track	800 track feet	(0.15 miles)
At-grade to aerial transition, single-track	3,200 track feet	(0.61 miles)
Aerial structure, single-track	12,800 track feet	(2.42 miles)
Aerial structure, double-track	23,800 track feet	(4.51 miles)
Aerial stations (2)	3,200 track feet	(0.61 miles)
Aerial-to-tunnel transition (double-track)	2,400 track feet	(0.45 miles)
Circular tunnel, double-track	51,400 track feet	(9.73 miles)
Cut-and-cover stations (9)	14,400 track feet	(2.73 miles)
Cut-and-cover triple-box (pocket track)	5,400 track feet	(1.02 miles)
Cut-and-cover double-box (tail track and crossover)	5,000 track feet	(0.95 miles)
Total length of track	122,400 track feet	(23.2 miles)

6.1.19.3 Estimated Project Cost $ 3205 million

6.1.19.4 Total Project Duration 110 months


PROVEMENT PROJECT ⑲
POSED RED LINE BYPASS)
N
TO NEW CARROLLTON
CHEVERLY
PROPOSED STATION
PRINCE GEORGES COUNTY, MARYLAND
ADDISON ROAD

6.1.20 PROJECT NUMBER 20
YELLOW/GREEN LINE NORTH EXTENSION



6.1.20.1 Description

This project would be a two-track revenue line that would all be in subway. Except for where tracks would separate to make their respective connections with the Green Line, both tracks would run in parallel alignments. The project location and route is illustrated above.

The project would begin at the south end, with connections to the Green Line near the intersection of 14th Street and Park Road. From there, the tracks would run north under 14th Street, turn northeast and run under Arkansas Avenue, turn north and run under Georgia Avenue, and end at the end of a tail track north of the terminus station at Brightwood.

There would be three stations in the project, including the following:

12. Crestwood: Underground station near the intersection of 14th Street and Spring Road NW.
13. Arkansas / Iowa: Underground station at the intersection of Arkansas Avenue and Iowa Avenue.
14. Brightwood: Underground station that would serve as the temporary terminus of the project and would be at the intersection of Georgia Avenue and Military Road. The contract would include an 800 feet long tail track at its north end for storage of trains at this temporary terminus station and a double crossover at its south end.

6.1.20.2 Length of Project and Breakdowns by Construction Types

Cut-and-cover subway tunnel connection structure	1,000	track feet	(0.2 miles)
Cut-and-cover subway station	4,800	track feet	(0.9 miles)
Cut-and-cover double box structure	2,200	track feet	(0.4 miles)
Circular tunnel subway	15,400	track feet	(2.9 miles)
Total length of track	23,400	track feet	(4.4 miles)

6.1.20.3 Estimated Project Cost $ 750 million

6.1.20.4 Total Project Duration 98 months

6.2 Station Improvement Projects

The stations experience capacity constraints primarily at the escalators/stair vertical circulation elements, at faregate arrays and at the platform level. The constraints could be eliminated by providing additional escalators/stairs and additional faregates. The constraints at the platform, however, require a more complex solution.

To address the constraints faced by several of the Core stations, an Architectural Design Charrette was organized to arrive at the best possible solutions. The Charrette was focused on three stations, (Union Station, Farragut West and Metro Center station). These three stations were chosen because each of these stations represented both system-wide similarities, as well as local idiosyncrasies. Considering that the architecture of interventions within the system should have the same strength of concept as the original "signature design", the Charrette made the following recommendations:

- Connector mezzanines connecting existing opposite mezzanines at transfer stations would divert considerable passenger flow from the platforms as well as from the escalators/stairs.
- Vertical and horizontal circulation could be improved by incremental actions immediately within and outside the "vault" structure by careful and individual analysis of each station.
- Architectural interventions will not resolve the current and projected ridership demands without some restructuring of the Core area system (line connection, station connections, new stations, etc.)

The Core Study team incorporated these recommendations while proposing solutions for the Core stations. In addition to providing additional capacity for the key station elements, new entrances were added at stations where there was potential to serve additional markets and improve level of service.

The benefits offered by various improvements could be broadly outlined as follows:

Revenue Collection Equipment
- Increased passenger handling capacity.
- Improved patron flow through reconfiguration of faregate arrays at certain stations.
- Increased Smartrip card usage could reduce faregate array requirement.

Vertical Circulation (Escalators/Stairs)
- Increased vertical circulation capacity.
- Improved distribution of passengers along platforms.
- Expanded options for movement between levels.
- Improved ability to evacuate platforms.
- Increased queuing capacity.

Widened Platforms and Mezzanines
- Increased platform carrying capacity.
- Increased area for horizontal movement.
- Improved passageway rate of flow.
- Relieve congestion at junctures of side platforms and North and South Mezzanines.
- Increased floor area for additional fare gates.

For the transfer stations (namely Metro Center, Gallery Place and L'Enfant Plaza) the following enhancements could improve passenger handling capacity:

Connector Mezzanine

- Improved transfer movement between the upper and lower platforms.
- Reduced transfer movement on the side platforms.
- Improved passageway rate of flow.
- Added queuing buffer capability as side platforms reach capacity.
- Movement alternatives to compensate for direction miscues.
- Increased platform capacity.

Pedestrian Interconnector Between Stations

- Enable transfers between the different lines without having to proceed through one or more stations to reach the transfer station, eliminating transfer backtracking and resulting in added convenience and possible reductions in trip time for passengers.
- Provide more direct and convenient routes for passengers to reach existing and new commercial development.
- Reduce demand on existing station entrances by providing more options for entering and leaving the system.
- Provide joint development opportunities due to the multitude of new connections made possible by the Interconnector. When combined with the mezzanine connectors proposed for the Metro Center and Gallery Place Stations, passengers would be able to walk for a distance of more than five city blocks, through paid and free areas.
- Enable existing underground entrances and connections to be put to their best use.
- Provide secure, climate-controlled access to hotels and other commercial uses during Metro's extended nighttime operating hours.
- Provide in-station (free side) retail revenue-enhancement opportunities.
- Provide opportunities for improved and increased access for persons with disabilities.
- Provide additional routes for emergency exiting.

A summary of the reduction of constraints after the proposed enhancements are implemented is shown in Exhibit 6.4. Brief descriptions of the station enhancements are provided below. Additional details for each station improvement project can be found in Milestone Report 5.

Exhibit 6.4: Summary of Station Constraints after Improvements

ENTR.	MEZZ / PLATFORM			LOWER PLATFORM		STATIONS	ENTR.	MEZZ / PLATFORM			LOWER PLATFORM	
ESCALATORS/STAIRS	FAREGATE ARRAYS	ESCALATORS/STAIRS	PLATFORM OCCUPANCY	ESCALATORS/STAIRS	PLATFORM OCCUPANCY		ESCALATORS/STAIRS	FAREGATE ARRAYS	ESCALATORS/STAIRS	PLATFORM OCCUPANCY	ESCALATORS/STAIRS	PLATFORM OCCUPANCY
64%	■	■	■	92%	■	GALLERY PLACE	64%	72%	60%	■	55%	■
■	■	35%	■	87%	■	L'ENFANT PLAZA	74%	71%	98%	■	45%	100%
75%	83%	■	■	96%	■	METRO CENTER	75%	62%	80%	■	71%	■
■	■	■	■			UNION STATION	32%	35%	67%	■		
■	■	■	■			FARRAGUT NORTH	75%	64%	51%	■		
■	■	■	■			FARRAGUT WEST	74%	69%	67%	■		
44%	■	15%	■			PENTAGON	44%	72%	15%	95%		
90%	66%	■	97%			DUPONT CIRCLE	46%	66%	77%	80%		
■	95%	■	■			FOGGY BOTTOM	59%	47%	32%	■		
n/a	82%	95%	71%	39%	78%	ROSSLYN	n/a	62%	75%	71%	20%	78%
88%	96%	■	65%			SMITHSONIAN	57%	65%	66%	65%		
66%	93%	■	■			MC'PHERSON SQR	66%	71%	67%	100%		
26%	64%	50%	60%			CRYSTAL CITY	26%	64%	50%	60%		
49%	31%	■	34%			PENTAGON CITY	49%	31%	51%	34%		
■	■	■	69%			JUDICIARY SQR	71%	62%	71%	69%		
56%	61%	56%	26%			ANACOSTIA	56%	61%	56%	26%		
41%	■	■	66%			FEDERAL TRIANGLE	41%	67%	67%	66%		
67%	■	■	52%			NAVY YARD	67%	61%	72%	52%		
62%	87%	59%	17%			CAPITAL SOUTH	62%	66%	59%	17%		
71%	76%	■	39%			NAVY MEMORIAL	71%	61%	52%	39%		
54%	■	■	31%			FEDERAL CENTER	54%	57%	66%	31%		
62%	40%	46%	15%			POTOMAC AVE	46%	40%	46%	15%		
30%	61%	56%	19%			WATERFRONT	30%	61%	56%	19%		
21%	20%	34%	10%			STADIUM-ARMORY	21%	20%	34%	10%		
59%	30%	10%	9%			MT. VERNON SQR.	59%	30%	10%	9%		
9%	10%	31%	7%			NATIONAL AIRPORT	9%	10%	0%	7%		
36%	22%	16%	17%			NEW YORK AVE	36%	22%	16%	17%		
24%	50%	46%	11%			EASTERN MARKET	24%	50%	46%	11%		
9%	2%	16%	2%			ARLINGTON CEMETERY	9%	2%	16%	2%		

PASSENGER DEMAND / CAPACITY
PEAK HALF HOUR DESIGN PERIOD
YEAR 2025 - **BEFORE** IMPROVEMENTS

PASSENGER DEMAND / CAPACITY
PEAK HALF HOUR DESIGN PERIOD
YEAR 2025 - **AFTER** IMPROVEMENTS

LEGEND:

Acceptable	
Marginal	
Deficient	■

6.2.1 PROJECT NUMBER 21
METRO CENTER STATION ENHANCEMENTS

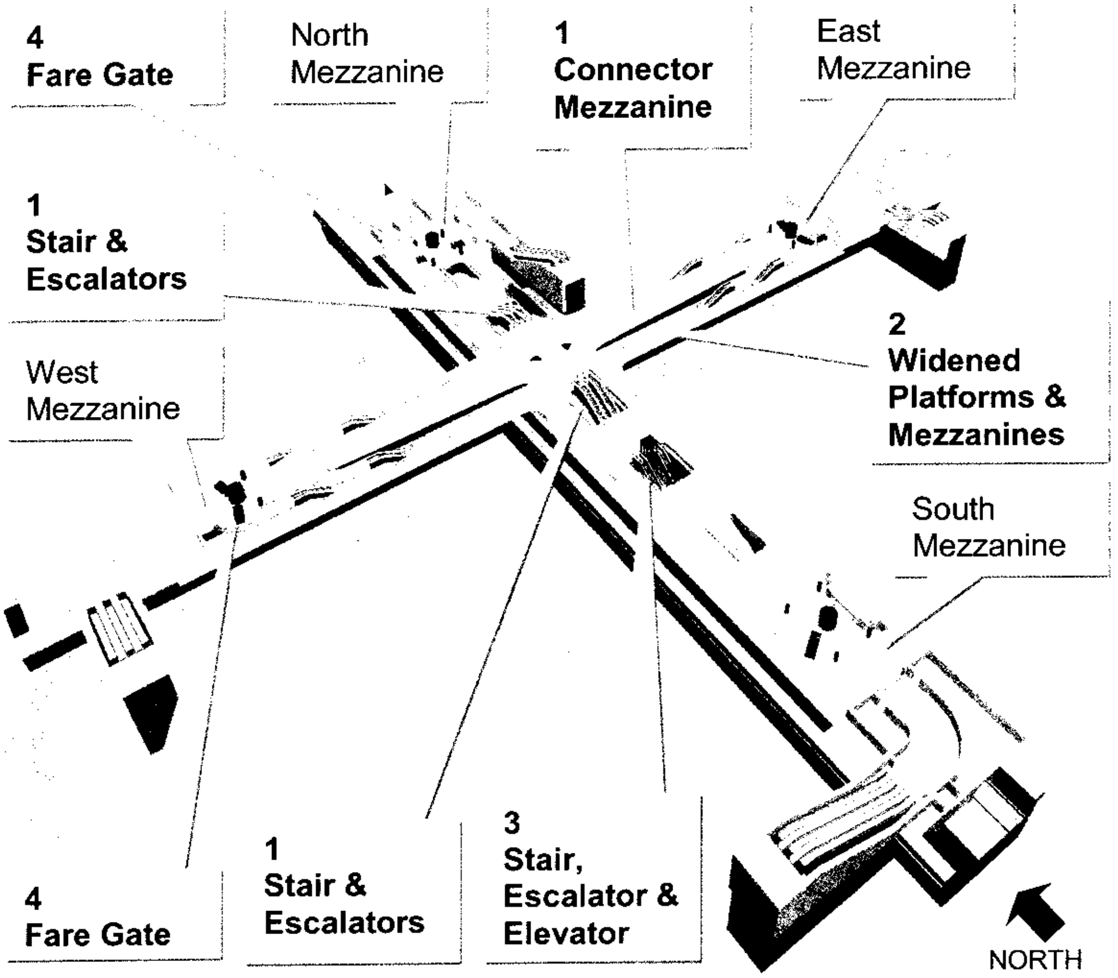


Figure 21 METRO CENTER STATION

6.2.1.1 Station Capacity Constraints

A **ESCALATORS BETWEEN EAST AND WEST MEZZANINES AND UPPER PLATFORM**

- Queuing time and headway-effect levels of service are deficient for Year 2000, and are projected to be deficient by greater percentages by Year 2025.

B **UPPER PLATFORM CAPACITY**

- The ability of the side platforms to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is marginal for Year 2000, and is projected to be deficient by Year 2025.

- The side platforms accommodate patron flow consisting of both Upper Platform entry and exit, and access to the Lower Platform from the East and West Mezzanines.
- The side platforms also accommodate transfer flow between the Red, Blue and Orange Lines.

C LOWER PLATFORM CAPACITY

- The ability of the center platform to accommodate passenger flow, to provide queuing space for stairs, escalators and the elevator, and to hold patrons waiting for trains is marginal for Year 2000, and is projected to be deficient by Year 2025.
- The center platform accommodates entry and exit flow between the Lower Platform and all mezzanines.
- The center platform accommodates transfer flow between the Red, Blue and Orange Lines.

D ESCALATORS AND STAIRS BETWEEN UPPER PLATFORM AND LOWER PLATFORM

- Queuing time and headway-effect levels of service are acceptable for Year 2000, but are projected to be deficient by Year 2025.

E MEZZANINE FAREGATES

- Queuing time level of service is marginal for Year 2000, and is projected to worsen yet remain marginal by Year 2025.

6.2.1.2 Station Enhancements

The following station enhancements are referenced to their locations as shown in Figure 21.

1 CONNECTOR MEZZANINE, WITH STAIRS AND ESCALATORS

Responds to Capacity Constraints **A, B, C** and **D**

- Continuous, same level connection provided between the East and West Mezzanines. The Connector is elevated on a single row of new columns located between the Upper Platform tracks.
- One stair and escalator pair provided from the center of the Connector Mezzanine to each of the North and South Mezzanines.
- Existing escalators on the North and South Mezzanines beneath the new Connector Mezzanine removed and replaced with a new stair and escalator pair rotated 180-degrees from the existing escalator direction.

2 STAIR, ESCALATOR & ELEVATOR

Responds to Capacity Constraints **C** and **D**

- One stair, one escalator and one elevator provided within the existing floor opening on the South Mezzanine.

3 WIDENED PLATFORMS AND MEZZANINES

Responds to Capacity Constraint **B**

- Upper Level side platforms and portions of the North and South Mezzanines increased in width by approximately three feet. The increase in width extends along the full length of both side platforms.
- The North and South Mezzanines widened along the vault sides for a distance of approximately 80-feet from the side platforms

4 FARE GATES

Responds to Capacity Constraint **E**

- One fare gate added to the south array on the West Mezzanine.
- One fare gate added to the west array on the North Mezzanine.

6.2.1.3 Length of Project

CONNECTOR MEZZANINE: Approximately 420 feet in length, varying in width from 8 to 90 feet; approximately 12,500 square feet.

WIDENED PLATFORMS AND MEZZANINES: Approximately 1,400 linear feet, approximately 3 feet in width; approximately 4,200 square feet.

6.2.1.4 Estimated Cost $60 Million

6.2.1.5 Total Project Duration 48 Months

6.2.2 PROJECT NUMBER 22
GALLERY PLACE STATION ENHANCEMENTS

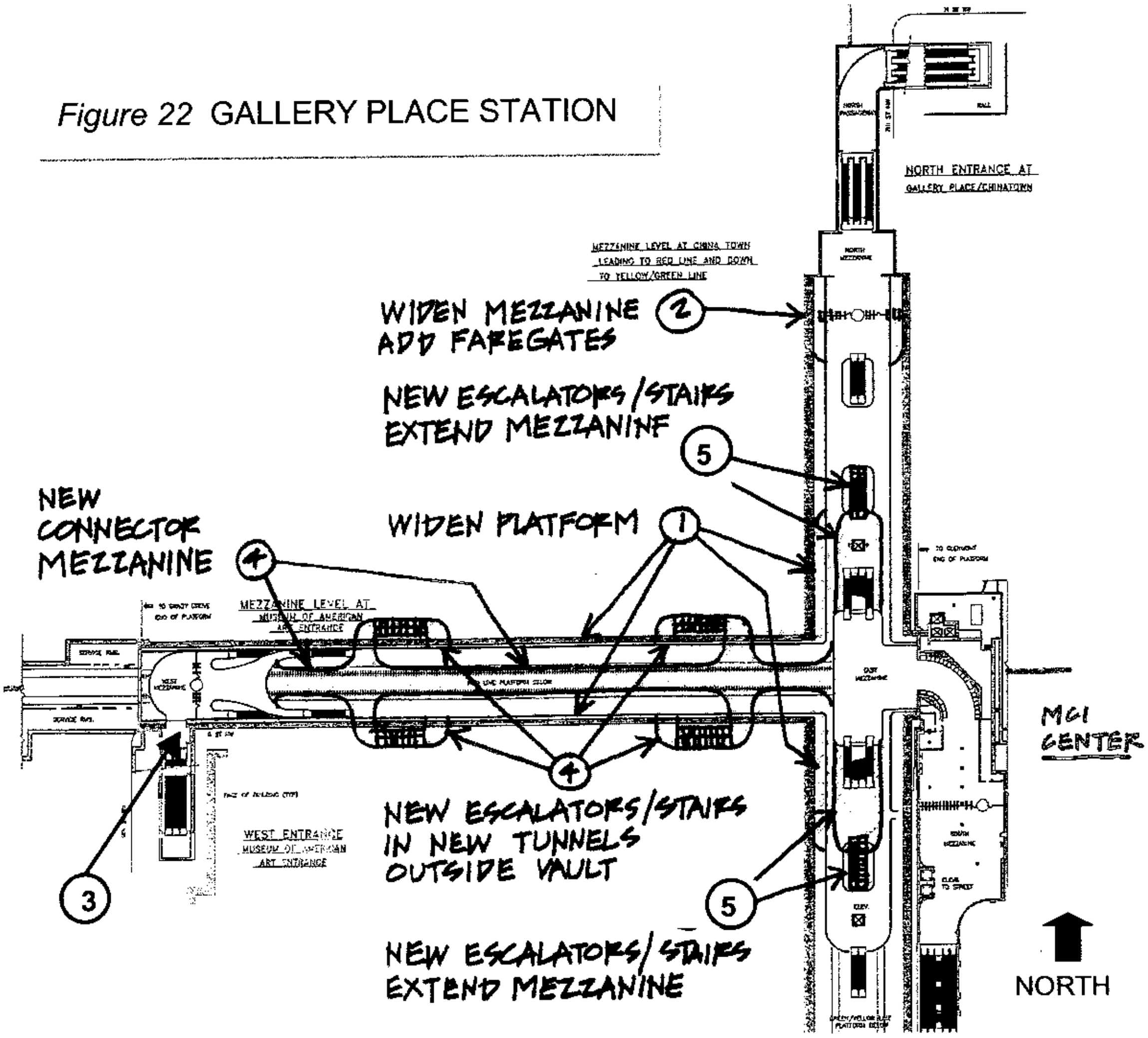


Figure 22 GALLERY PLACE STATION

6.2.2.1 Station Capacity Constraints

A UPPER PLATFORM CAPACITY

- The ability of the side platforms to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is marginal for Year 2000, and is projected to be deficient by Year 2025.
- The side platforms accommodate patron flow consisting of both Upper Platform entry and exit, and access to the Lower Platform from the East and West Mezzanines.
- The side platforms also accommodate transfer flow between the Red, Green and Yellow Lines.
- Flow is severely restricted at the junction of the side platforms and the North and South Mezzanines.

B MEZZANINE FAREGATES

- Queuing time level of service is acceptable for Year 2000, but is projected to be deficient by Year 2025.

C LOWER PLATFORM CAPACITY

- The ability of the center platform to accommodate passenger flow, to provide queuing space for stairs, escalators and the elevator, and to hold patrons waiting for trains is marginal for Year 2000, and is projected to be deficient by Year 2025.
- The center platform accommodates entry and exit flow between the Lower Platform and all mezzanines.
- The center platform accommodates transfer flow between the Red, Green and Yellow Lines.

D ESCALATORS BETWEEN EAST AND WEST MEZZANINES AND UPPER PLATFORM

- Queuing time and headway-effect levels of service are acceptable for Year 2000, but are projected to be deficient by Year 2025.

E PASSAGEWAYS

- The rate of passenger flow in Entrance and Lower Platform passageways is acceptable for Year 2000. Rate of flow in passageways between entrances and upper mezzanines is projected to remain acceptable by Year 2025, but rate of flow in passageways serving the Lower Platform is projected to be deficient by Year 2025.

F ESCALATORS AND STAIRS BETWEEN UPPER PLATFORM AND LOWER PLATFORM

- Queuing time and headway-effect levels of service are acceptable for Year 2000, but are projected to be deficient by Year 2025.

6.2.2.2 Station Enhancements

The following station enhancements are referenced to their locations as shown on Figure 22.

WIDENED PLATFORMS AND MEZZANINES

Responds to Capacity Constraint **A**

- Upper Level side platforms and portions of the North and South Mezzanines would be increased in width by approximately two feet. The increase in width would extend along the full length of both side platforms.
- The North and South Mezzanines would be widened along the vault sides for a distance of approximately 100 feet from the side platforms.

WIDENED MEZZANINE, ADD FARE GATES

Responds to Capacity Constraints **B** and **E**

- The east and west sides of the North Mezzanine would each extended approximately six feet.
- Four fare gates would be added, two on each end of the array.

FARE GATES

Responds to Capacity Constraint **B**

- Two fare gates are added on the West Mezzanine, one on each end of the array.

CONNECTOR MEZZANINE

Responds to Capacity Constraints **C**, **D** and **E**

- Continuous, same level connection would be provided between the East and West Mezzanines. The Connector would be elevated on a single row of new columns located between the Upper Platform tracks.
- Bridges from the Connector would cross over the trainways to connect to new stairs located within new Vertical Circulation Structures outside of the station vault. The stairs would be reached by passing through new portals in the existing vault.

EXTENDED MEZZANINE

Responds to Capacity Constraints **D** and **F**

- Existing East Mezzanine would be extended to both north and south directions.
- One stair and one escalator would be provided between the north extension and the North Mezzanine.
- One stair and one escalator would be provided between the south extension and the South Mezzanine.

6.2.2.3 Length of Project

- **CONNECTOR MEZZANINE:** Approximately 540 feet in length; approximately 12,960 square feet.
- **EXTENDED MEZZANINES:** Approximately 150 feet in length; approximately 5,400 square feet.
- **WIDENED PLATFORMS:** Approximately 1,060 linear feet, approximately 2 feet in width; approximately 2,120 square feet.
- **WIDENED MEZZANINES:** Approximately 340 linear feet, approximately 6 feet in width; approximately 2,040 square feet.

6.2.2.4 Estimated Cost $60 Million

6.2.2.5 Total Project Duration 76 Months

6.2.3 PROJECT NUMBER 23
L'ENFANT PLAZA STATION ENHANCEMENTS

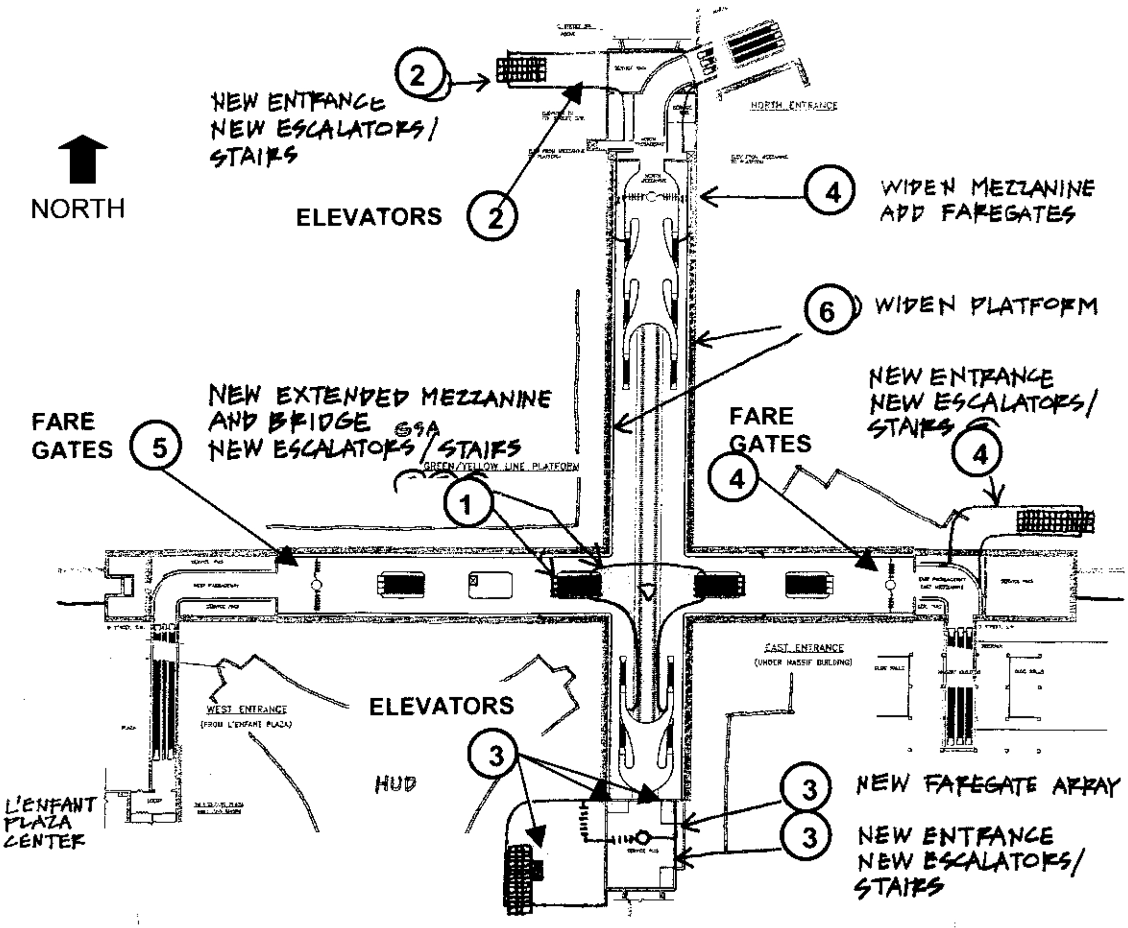


Figure 23 L'ENFANT PLAZA STATION

6.2.3.1 Station Capacity Constraints

A MEZZANINE FAREGATES

- Queuing time level of service is marginal for Year 2000, and is projected to be deficient by Year 2025.

B UPPER PLATFORM CAPACITY

- The ability of the side platforms to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is marginal for Year 2000, and is projected to be deficient by Year 2025.
- The side platforms accommodate patron flow consisting of both Upper Platform entry and exit, and access to the Lower Platform from the East and West Mezzanines.
- The side platforms also accommodate transfer flow between the Blue, Orange, Green and Yellow Lines.

C ESCALATORS BETWEEN ENTRANCES AND MEZZANINES

- Queuing time and headway-effect levels of service are acceptable for Year 2000, but are projected to be deficient by Year 2025.

D LOWER PLATFORM CAPACITY

- The ability of the center platform to accommodate passenger flow, to provide queuing space for stairs, escalators and the elevator, and to hold patrons waiting for trains is acceptable for Year 2000, but is projected to be deficient by Year 2025.
- The center platform accommodates entry and exit flow between the Lower Platform and all mezzanines.
- The center platform accommodates transfer flow between the Blue, Orange, Green and Yellow Lines.

E ESCALATORS AND STAIRS BETWEEN UPPER PLATFORM AND LOWER PLATFORM

- Queuing time and headway-effect levels of service are acceptable for Year 2000, but are projected to be in the upper range of marginal by Year 2025.

6.2.3.2 Station Enhancements:

The following station enhancements are referenced to their locations as shown in Figure 23.

EXTENDED MEZZANINE

Responds to Capacity Constraints **B**, **C**, **D** and **E**

- Extended Mezzanine would connect the East, West and South Mezzanines.
- One stair and two escalators would be provided from the center of the Connector Mezzanine to each of the East and West Mezzanines.
- Existing escalators on the East and West Mezzanines beneath the new Connector Mezzanine would be removed and replaced with a new stair and escalator pair rotated 180-degrees from the direction of the existing escalators.

NORTH ENTRANCE

Responds to Capacity Constraints **A** and **C**

- One stair, two escalators and two elevators would be provided between the surface and the mezzanine level.
- The existing passageway would be widened.
- The North Mezzanine would be widened on two sides by extending the floor toward the east and west vault faces.
- Two fare gates would be added in the existing fare gate array.

SOUTH ENTRANCE

Responds to Capacity Constraints **A** and **C**

- One stair, two escalators and two elevators would be provided between the surface and mezzanine levels.
- The existing South Mezzanine would be enlarged by providing a pedestrian portal through the south endwall and modifying the ancillary areas on the south side of that endwall.
- One elevator would be provided from the enlarged South Mezzanine to each of the upper side platforms, for a total of two elevators.
- Nine fare gates would be provided in a new fare gate arrays on the enlarged South Mezzanine.
- One emergency exit stair would be added from the South Mezzanine to the surface.

EAST ENTRANCE

Responds to Capacity Constraints **A** and **C**

- One stair, two escalators and two elevators would be provided between the surface and mezzanine levels.
- Two fare gates would be added to the existing fare gate array.

WEST MEZZANINE

Responds to Capacity Constraint **A**

- Two fare gates would be added to the existing fare gate array.

WIDENED PLATFORMS AND MEZZANINES

Responds to Capacity Constraints **A** and **B**

- Each side platform on the Upper Level would be increased in width by approximately three feet; increase in width would extend along the full length of both side platforms.
- East and West Mezzanines would be widened along the vault sides for a distance of approximately 80 feet from the side platforms.

6.2.3.3 Length of Project

- **EXTENDED MEZZANINE:** Approximately 150 feet in length from South Mezzanine, and approximately 100 ft in length crossing the Upper Platform tracks between the East Mezzanine and the West Mezzanine. Total area approximately 7,600 sq ft.
- **WIDENED PLATFORMS AND MEZZANINES:** Approximately 1,500 linear feet. Total area approximately 5,600 sq ft.
- **NORTH ENTRANCE:** Total area approximately 6,500 sq ft.
- **EAST ENTRANCE:** Total area approximately 6,200 sq ft.
- **SOUTH ENTRANCE AND ENLARGED SOUTH MEZZANINE:** Total area approximately 18,000 sq ft.

6.2.3.4 Estimated Cost $80 Million

6.2.3.5 Total Project Duration 78 Months

6.2.4 PROJECT NUMBER 24
ROSSLYN STATION ENHANCEMENTS

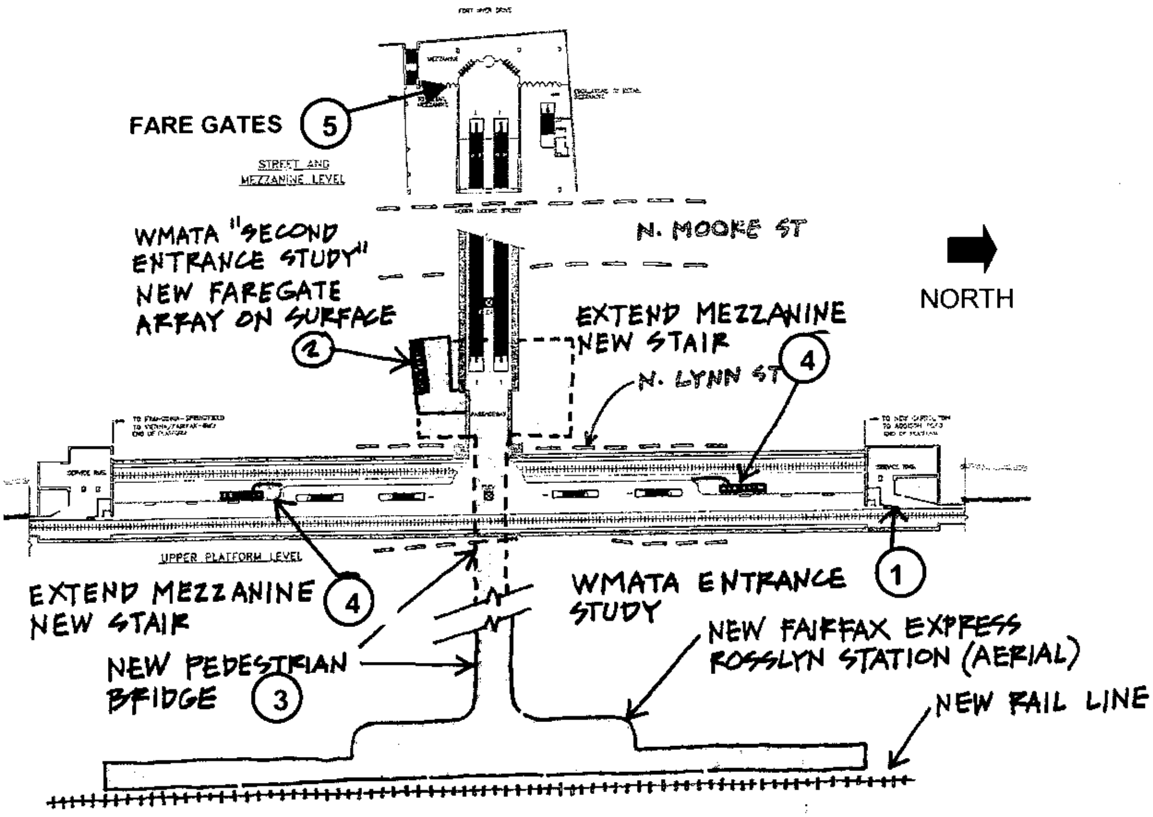


Figure 24 ROSSLYN STATION

6.2.4.1 Station Capacity Constraints

A ESCALATORS AND STAIRS BETWEEN UPPER PLATFORM AND LOWER PLATFORM

- Queuing time and headway-effect levels of service are acceptable for Year 2000, but are projected to be in upper range of marginal by Year 2025.

B MEZZANINE FAREGATES

- Queuing time level of service is acceptable for Year 2000, and is projected to be in upper range of marginal by Year 2025.

C LOWER PLATFORM CAPACITY

- The ability of the Lower Platform to accommodate passenger flow, to provide queuing space for stairs, escalators and the elevator, and to hold patrons waiting for trains is acceptable for Year 2000, and is projected to be marginal by Year 2025.

D UPPER PLATFORM CAPACITY

- The ability of the Upper Platform to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is acceptable for Year 2000, and is projected to be marginal by Year 2025.

6.2.4.2 Station Enhancements

The following station enhancements are referenced to their locations as shown in Figure 24.

NORTH ENTRANCE STUDY

Responds to Capacity Constraints **A** and **B**

- A new North Entrance is under study by WMATA, which may include a new connection to the station through the north end wall.

SECOND ENTRANCE STUDY

Three Center Entrance preliminary concepts have been developed by WMATA

Responds to Capacity Constraints **A** and **B**

- **Street Level Mezzanine**
  - Street-level, enclosed mezzanine would be located between North Moore Street and North Lynn Street.
  - Nine fare gates and six elevators, plus one existing elevator, would be provided to the Upper Platform level.
  - Paid area passageway would be provided on Upper Platform level.
- **Platform Level Mezzanine**
  - Street level elevator array would be located in open-air plaza between North Moore Street and North Lynn Street.
  - Three new elevators, plus one existing elevator, would extend to Upper Platform level.
  - Three fare gates would be provided on Lower Platform level mezzanine.
- **Inclinator**
  - One Inclined elevator would be provided from the east side of North Lynn Street to the Upper Platform level. A new portal through the station exterior wall would provide access to the bottom inclinator landing.

ROSSLYN STATION / VIRGINIA EXPRESS TRACK CONNECTOR

- Weather-protected passageway (Pedestrian Bridge) connection with new aerial station would be located east of Rosslyn Station between Arlington Ridge Road and George Washington Memorial Parkway.

EXTENDED MEZZANINE

Responds to Capacity Constraints **A, C,** and **D**

- North and south ends of the Center Mezzanine / Upper Platform would be extended to provide landings for stairs.
- Two stairs would be provided between the Upper Platform and the Lower Platform, one from each of the mezzanine extensions.

FARE GATES

Responds to Capacity Constraint **B**

- Two new fare gates would be added to the south array on the West Mezzanine.

6.2.4.3 Length of Project

- **NORTH ENTRANCE:** 100 ft elevator rise.
- **SECOND ENTRANCE, STREET LEVEL MEZZANINE:** 5,000 sq ft mezzanine; 2,500 sq ft passageway; 100 ft elevator rise; 200 ft inclinator run.

- **SECOND ENTRANCE, PLATFORM LEVEL MEZZANINE:** 3,000 sq ft mezzanine; 100 ft elevator rise.
- **INCLINATOR:** 200 ft run.
- **ROSSLYN STATION / VIRGINIA EXPRESS TRACK CONNECTOR:** 500 ft.
- **EXTENDED MEZZANINES:** 300 sq ft of added mezzanine area.

6.2.4.4 Estimated Cost $60 Million

6.2.4.5 Total Project Duration 88 Months

6.2.5 PROJECT NUMBER 25
DUPONT CIRCLE STATION ENHANCEMENTS

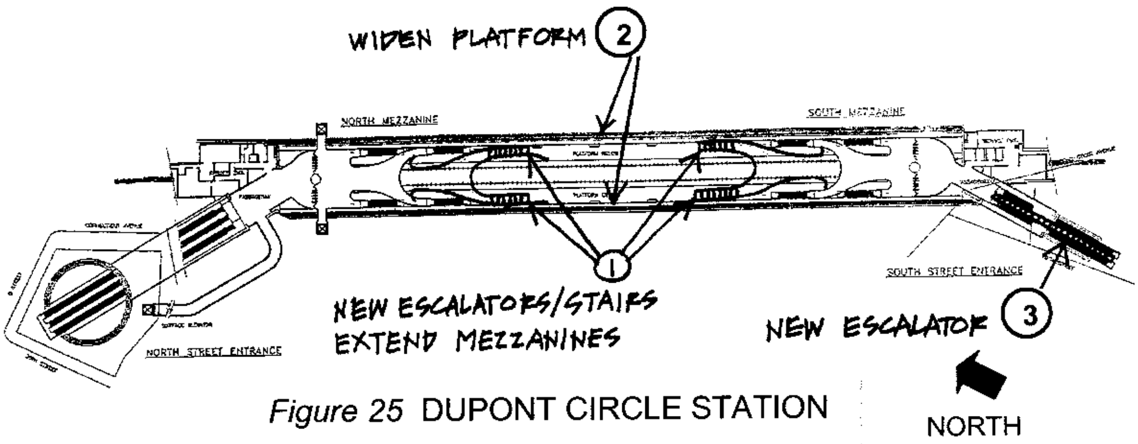


Figure 25 DUPONT CIRCLE STATION

6.2.5.1 Station Capacity Constraints

A ESCALATORS AND STAIRS BETWEEN MEZZANINES AND PLATFORM

- Queuing time and headway-effect levels of service are deficient for Year 2000, and are projected to be deficient by greater percentages by Year 2025.

B PLATFORM CAPACITY

- The ability of the platform to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is acceptable for Year 2000, but is projected to be deficient by Year 2025.

C ESCALATORS AND STAIRS BETWEEN ENTRANCES AND MEZZANINES

- Queuing time and headway-effect levels of service are acceptable for Year 2000, but are projected to be in upper range of marginal by Year 2025.

D MEZZANINE FAREGATES

- Queuing time level of service is acceptable for Year 2000, and is projected to be marginal by Year 2025.

6.2.5.2 Station Enhancements:

The following station enhancements are referenced to their locations as shown in Figure 25.

EXTENDED MEZZANINES WITH STAIRS

Responds to Capacity Constraints **A** and **B**

- Extensions from the North and South Mezzanines would terminate in new stairs to the side platforms.

WIDENED PLATFORMS

Responds to Capacity Constraint **B**

- Each side platform would be widened along the vault face for the full 600 ft length of the station.

ENTRANCE ESCALATOR

Responds to Capacity Constraint **C**

- One escalator would be added between the two existing escalators in the South Entrance.

Note: Expanded SmarTrip program could respond to Faregate Capacity Constraint.

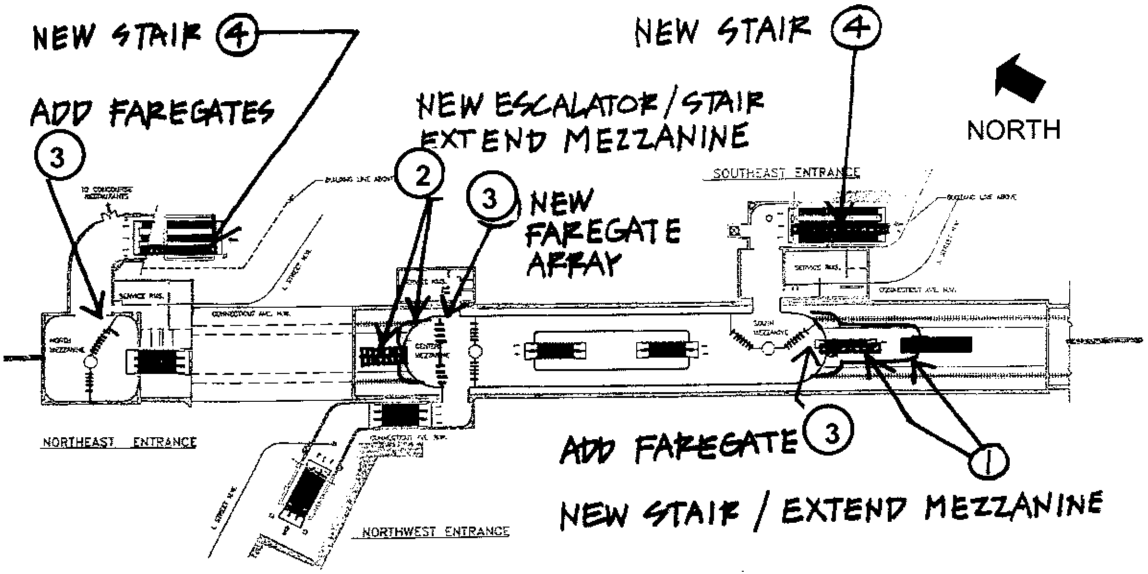
6.2.5.3 Length of Project

- **EXTENDED MEZZANINES WITH STAIRS:** Approximately 200 ft total length; total area approximately 6,000 sq ft.
- **WIDENED PLATFORMS:** Total of 1,200 linear feet; each platform widened approximately 2-1/2 feet; total area approximately 3,000 sq ft.

6.2.5.4 Estimated Cost $40 Million

6.2.5.5 Total Project Duration 40 Months

6.2.6 PROJECT NUMBER 26
FARRAGUT NORTH STATION ENHANCEMENTS



6.2.6.1 Station Capacity Constraints

A ESCALATORS AND STAIRS BETWEEN MEZZANINES AND PLATFORM

- Queuing time and headway-effect levels of service are deficient for Year 2000, and are projected to be deficient by greater percentages by Year 2025.

B MEZZANINES FAREGATES

- Queuing time level of service is marginal for Year 2000, and is projected to be deficient by Year 2025.

C PLATFORM CAPACITY

- The ability of the platform to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is marginal for Year 2000, and is projected to be deficient by Year 2025.

D ESCALATORS AND STAIRS BETWEEN ENTRANCES AND MEZZANINES

Queuing time and headway-effect levels of service are acceptable for Year 2000, but are projected to be deficient by Year 2025.

6.2.6.2 Station Enhancements

The following station enhancements are referenced to their locations as shown in Figure 26.

EXTENDED SOUTH MEZZANINE WITH STAIR ELEVATOR

Responds to Capacity Constraints **A** and **C**

- Mezzanine would be extended toward the south end of the station.
- One stair and one escalator would be added at the end of the extension.
- Existing elevator to remain next to existing escalator.

EXTENDED CENTER MEZZANINE

Responds to Capacity Constraints **A** and **C**

- Mezzanine would be extended toward the north end of the station.
- One stair and one escalator would be added at the end of the extension.

FARE GATES

Responds to Capacity Constraint **B**

- Two fare gates would be added on the North Mezzanine.
- Two fare gates would be added on the South Mezzanine.
- Two fare gates would be added on the Center Mezzanine, and existing fare gate arrays would be rearranged.

STAIRS

Responds to Capacity Constraint **D**

- One stair would be added next to the existing escalators in the North Entrance.
- One stair would be added next to the existing escalators in the South Entrance.

6.2.6.3 Length of Project

- **MEZZANINE EXTENSIONS:** Total area approximately 2,800 sq ft.

6.2.6.4 Estimated Cost $30 Million

6.2.6.5 Total Project Duration 40 Months

6.2.7 PROJECT NUMBER 27
UNION STATION ENHANCEMENTS

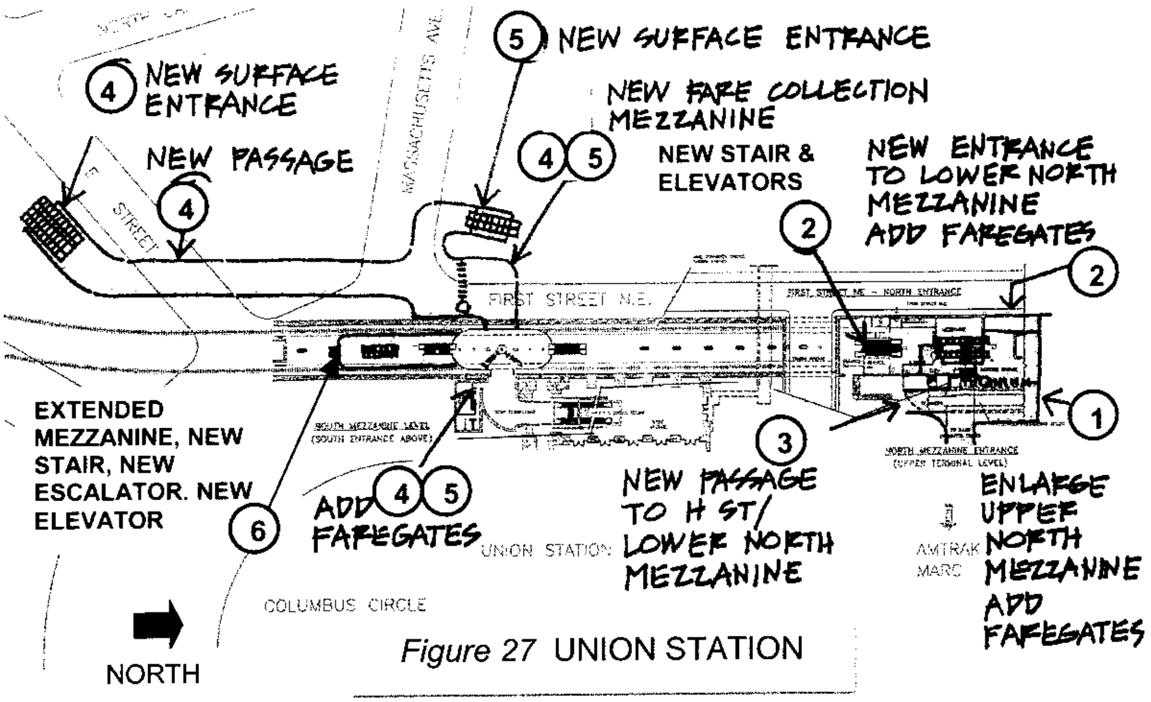


Figure 27 UNION STATION

6.2.7.1 Station Capacity Constraints

A ESCALATORS AND STAIRS BETWEEN ENTRANCES AND MEZZANINES
- Queuing time and headway-effect levels of service are deficient for Year 2000, and are projected to be extremely deficient by Year 2025.

B PASSAGEWAYS
- The rate of passenger flow in entrance passageways is acceptable for Year 2000, but is projected to be deficient by Year 2025.

C MEZZANINE FAREGATES
- Queuing time level of service is acceptable for Year 2000, and is projected to be deficient by Year 2025.

D PLATFORM CAPACITY
- The ability of the platform to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is acceptable for Year 2000, but is projected to be deficient by Year 2025.

6.2.7.2 Station Enhancements:

The following station enhancements are referenced to their locations as shown in Figure 27.

UPPER NORTH MEZZANINE

Responds to Capacity Constraints **B** and **C**

- Relocating existing north and east demising walls would increase mezzanine floor area.

- Fare vending machines, fare gates, and a kiosk would be provided to create new free and paid areas.
- Two existing escalators would be removed and two escalators would be provided between the paid side on this level and the paid side on the Lower North Mezzanine.
- One stair would be provided between the free side on this level and the free side on the Lower North Mezzanine.
- Existing single elevator would be removed and two elevators would be provided between the paid side on this level and the paid side on the Lower North Mezzanine.
- Modifications would be made to the existing corridors connecting the station to retail and Amtrak, MARC and VRE areas.

LOWER NORTH MEZZANINE ENTRANCE

Responds to Capacity Constraints **A**, **B** and **C**

- Relocating existing north demising walls would increase mezzanine floor area.
- Existing First Street Entrance would be closed. A new emergency exit would be provided in the existing masonry wall opening.
- A new First Street Entrance would be provided through the masonry wall about 100 feet north of the existing entrance. Increased door, step and ramp capacity would be provided.
- Existing fare gate array would be removed.
- Fare vending machines, fare gates and a kiosk would be arranged in new locations to provide increased queuing capacity and more direct movement paths.
- Fare gates on the Lower North Mezzanine would serve only the First Street Entrance and the H Street Passageway described below.

H STREET PASSAGEWAY

Responds to Capacity Constraint **B**

- Existing pedestrian tunnel to H Street would be opened.
- Moving walkways would be installed in the tunnel.
- Fare gates would be provided in the tunnel portal opening into the North Mezzanine lower level.

E STREET ENTRANCE AND PASSAGEWAY

Responds to Capacity Constraints **A** and **B**

- A new surface entrance would be provided on the south side of E Street NW mid-block between North Capitol Street and Columbus Circle.
- Two escalators and two stairs would be provided in the entranceway. A canopy would cover the open entranceway well.
- A passageway would be provided from the surface entrance to the south side of the enlarged South Mezzanine.

MASSACHUSETTS AVENUE ENTRANCE AND ENLARGED SOUTH MEZZANINE

Responds to Capacity Constraints **A**, **B** and **C**

- A new surface entrance would be provided in the open area on the northwest corner of the Massachusetts Avenue NW and First Street NW intersection.
- One escalator and one stair would be provided in the entranceway. A canopy would cover the open entranceway well.
- A passageway would be provided from the surface entrance to the west side of the South Mezzanine.
- A portal would be provided through the west side of the station vault onto the South Mezzanine.
- The South Mezzanine would be extended west through the new portal, and a new fare gate array would be provided.

EXTENDED SOUTH MEZZANINE

Responds to Capacity Constraint **A**

- South Mezzanine would be extended toward the north end of the station.
- One stair and one escalator would be provided between the mezzanine extension and the platform.

- One elevator would be provided at the end of the mezzanine extension to provide connection to the platform level.
- One fare gate would be added to the existing south array.

6.2.7.3 Length of Project

- **NORTH MEZZANINE UPPER AND LOWER LEVELS:** Total area is approximately 22,000 sq ft.
- **EXTENDED SOUTH MEZZANINE**: Total area is approximately 5,000 sq ft.
- **E STREET ENTRANCE, MASSACHUSETTS AVENUE ENTRANCE AND PASSAGEWAYS TO SOUTH MEZZANINE:** Distance between the proposed E Street entrance and the existing mezzanine is approximately 470 ft; total area is approximately 20,000 sq ft.

6.2.7.4 Estimated Cost $80 Million

6.2.7.5 Total Project Duration 82 Months

6.2.8 PROJECT NUMBER 28 FOGGY BOTTOM STATION ENHANCEMENTS

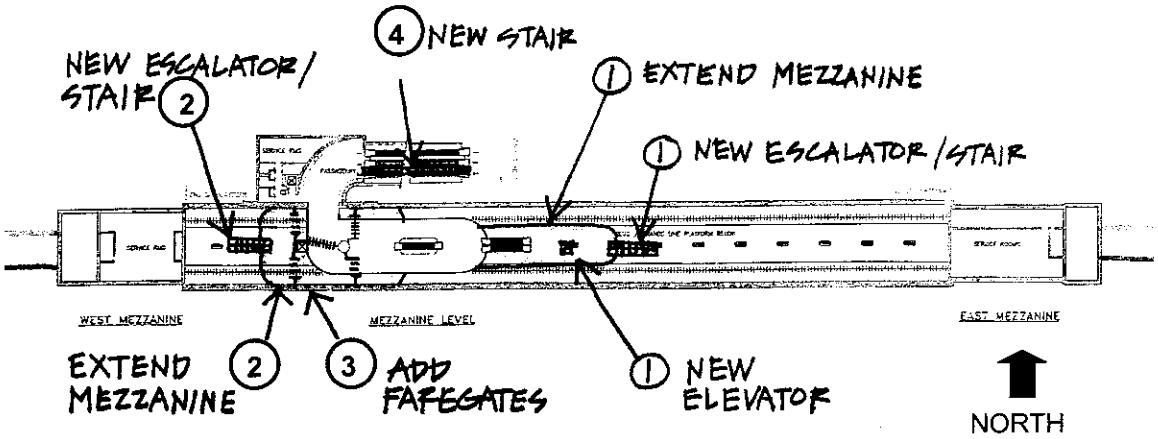


Figure 28 FOGGY BOTTOM STATION

6.2.8.1 Station Capacity Constraints

A ESCALATORS AND STAIRS BETWEEN MEZZANINES AND PLATFORM
- Queuing time and headway-effect levels of service are deficient for Year 2000, and are projected to be deficient by greater percentages by Year 2025.

B ESCALATORS AND STAIRS BETWEEN ENTRANCES AND MEZZANINES
- Queuing time and headway-effect levels of service are marginal for Year 2000, and are projected to be deficient by Year 2025.

C PLATFORM CAPACITY
- The ability of the platform to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is acceptable for Year 2000, but is projected to be deficient by Year 2025.

D MEZZANINE FAREGATES
- Queuing time level of service is acceptable for Year 2000, and is projected to be marginal by Year 2025.

E PASSAGEWAYS
- The rate of passenger flow in entrance passageways is acceptable for Year 2000, but is projected to be marginal by Year 2025.

6.2.8.2 Station Enhancements:

The following station enhancements are referenced to their locations as shown in Figure 28.

EXTENDED MEZZANINE WITH STAIR, ESCALATOR AND ELEVATOR

Responds to Capacity Constraints **A** and **E**
- Mezzanine would be extended toward the east end of the station.
- One stair and one escalator would be added at the end of the east mezzanine extension.

- One elevator would be provided within the east mezzanine extension, located at the approximate midpoint of the platform.

EXTENDED AND WIDENED MEZZANINE WITH STAIR AND ESCALATOR

Responds to Capacity Constraints **A**, **D** and **E**

- Mezzanine would be extended toward the west end of the station.
- One stair and one escalator would be added at the end of west mezzanine extension.

FARE GATES

Responds to Capacity Constraint **D**

- One fare gate would be added in the existing fare gate array on the north side of the kiosk.
- Five fare gates would be provided in a new south (east bound) fare gate array on the south side of the kiosk.
- Six fare gates would be provided in a new fare gate array on the new west mezzanine extension.
- One existing fare gate array would be removed.

STAIR

Responds to Capacity Constraint **B**

- One stair would be added in the existing escalatorway in the North Entrance.

6.2.8.3 Length of Project

- **EXTENDED AND WIDENED MEZZANINE:** Total area is approximately 7,000 sq ft.

6.2.8.4 Estimated Cost $60 Million

6.2.8.5 Total Project Duration 36 Months

6.2.9 Project Number 29
Farragut West Station Enhancements

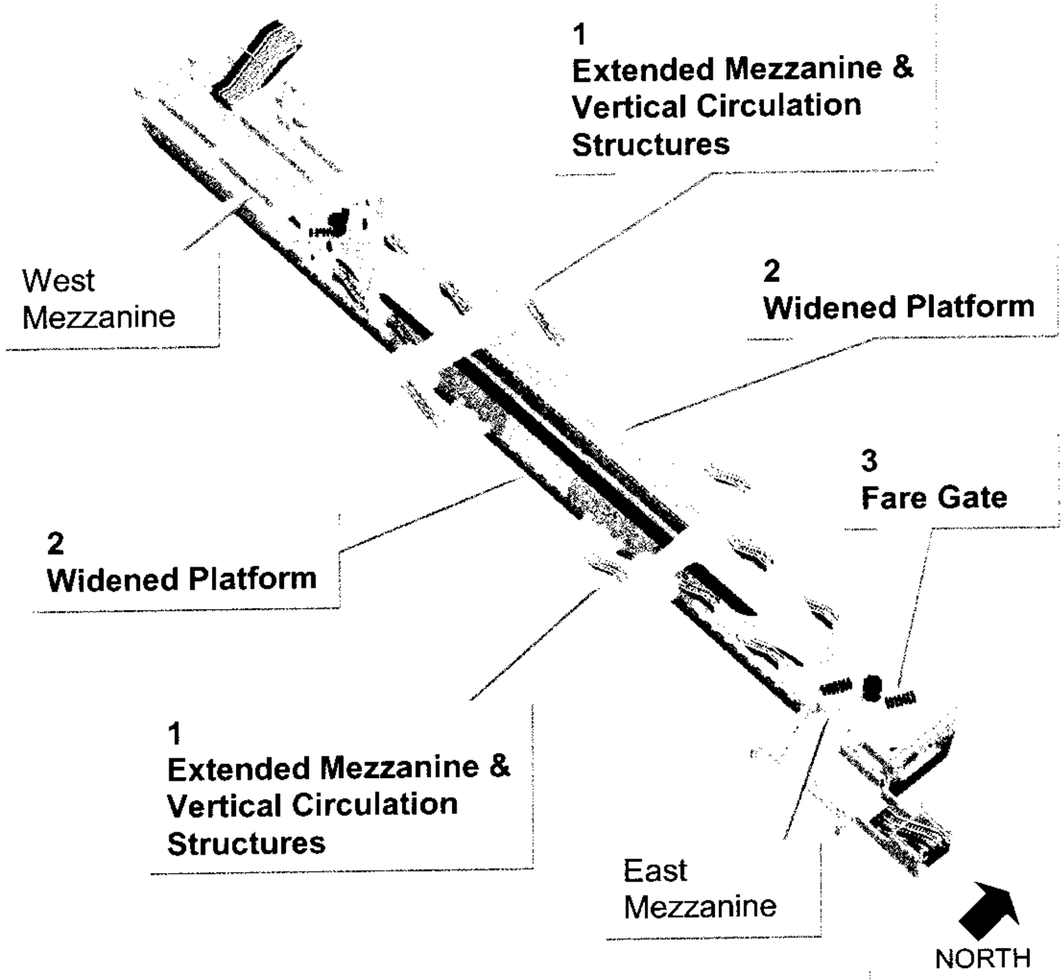


Figure 29 FARRAGUT WEST STATION

6.2.9 Station Capacity Constraints

A ESCALATORS AND STAIRS BETWEEN MEZZANINES AND PLATFORM

- Queuing time and headway-effect levels of service are extremely deficient for Year 2000, and are projected to be deficient by even greater percentages by Year 2025.

B PLATFORM CAPACITY

- The ability of the platform to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is marginal for Year 2000, but is projected to be deficient by Year 2025.

C **ESCALATORS AND STAIRS BETWEEN ENTRANCES AND MEZZANINES**

- Queuing time and headway-effect levels of service are deficient for Year 2000, and are projected to be deficient by greater percentages by Year 2025.

D **MEZZANINE FAREGATES**

- Queuing time level of service is deficient for Year 2000, and is projected to be deficient by greater percentages by Year 2025.

E **PASSAGEWAYS**

- The rate of passenger flow in entrance passageways is marginal for Year 2000, but is projected to be deficient by Year 2025.

6.2.9.2 Station Enhancements:

The following station enhancements are referenced to their locations as shown in Figure 29.

EXTENDED MEZZANINE & VERTICAL CIRCULATION STRUCTURES

Responds to Capacity Constraints **A** and **E**

- Extensions from the East and West Mezzanines would provide connections to new stairs located within new structures outside of the station vault. The stairs would be reached by passing through new portals in the existing vault.

WIDENED PLATFORMS

Responds to Capacity Constraint **B**

- Side platforms would be increased in width by approximately three feet. The increase in width would extend along the full length of both side platforms.

FARE GATE

Responds to Capacity Constraint **D**

- One new fare gate would be added to the north array on the East Mezzanine.

Note: Passenger Interconnector, Project 13, responds to Capacity Constraints **A, C, D** *and* **E.**

6.2.9.3 Length of Project

- **EXTENDED MEZZANINES:** Approximately 420 feet in length, varying in width from 8 to 90 feet; 17,000 square feet approximate total area.
- **WIDENED PLATFORMS:** Approximately 1,200 linear feet and approximately 3 feet in width; 3,600 square feet approximate total area.

6.2.9.4 Estimated Cost $40 Million

6.2.9.5 Total Project Duration 62 Months

6.2.10 Project Number 30
McPherson Square Station Enhancements

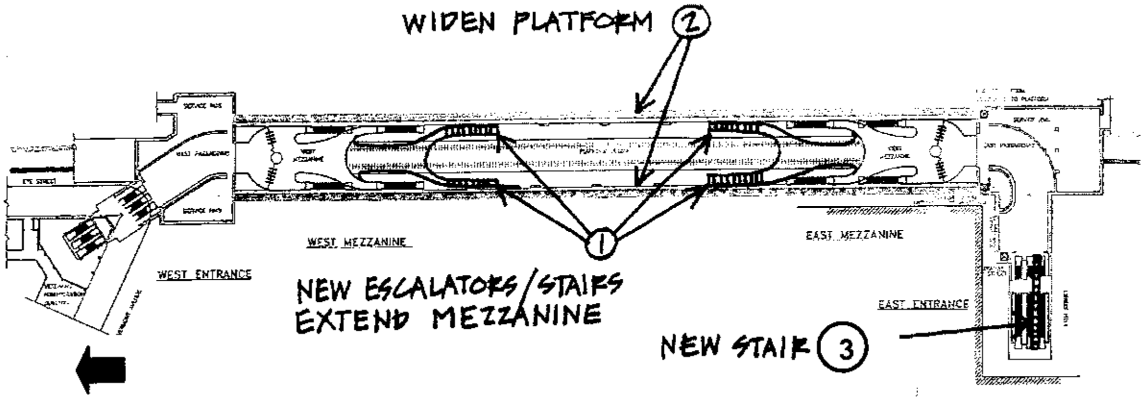


Figure 30 McPHERSON SQUARE STATION

6.2.10.1 Station Capacity Constraints

A ESCALATORS AND STAIRS BETWEEN MEZZANINES AND PLATFORM

- Queuing time and headway-effect levels of service are deficient for Year 2000, and are projected to be deficient by greater percentages by Year 2025.

B PLATFORM CAPACITY

- The ability of the platform to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is acceptable for Year 2000, but is projected to be deficient by Year 2025.

C MEZZANINE FAREGATES

- Queuing time level of service is acceptable for Year 2000, but is projected to be deficient by Year 2025.

D ESCALATORS AND STAIRS BETWEEN ENTRANCES AND MEZZANINES

- Queuing time and headway-effect levels of service are acceptable for Year 2000, but are projected to be marginal by Year 2025.

E PASSAGEWAYS

- The rate of passenger flow in entrance passageways is acceptable for Year 2000, but is projected to be marginal by Year 2025.

6.2.10.3 Station Enhancements:

The following station enhancements are referenced to their location as shown in Figure 30.

EXTENDED MEZZANINES WITH STAIRS

Responds to Capacity Constraints **A** and **E**

- Extensions from the North and South Mezzanines would terminate in new stairs to side platforms.

ENTRANCE STAIR

Responds to Capacity Constraint **D**

- One stair would be added between two existing escalators in the South Entrance.

WIDENED PLATFORMS

Responds to Capacity Constraint **B**

- Side platforms would be increased in width by approximately three feet. The increase in width would extend along the full length of both side platforms.

Note: Expanded SmarTrip program could respond to Faregate Capacity Constraint.

6.2.10.3 Length of Project

- **Extended Mezzanines with Stairs:** Approximately 200 ft total length.
- **Widened Platforms:** Total of 1,200 linear feet; each platform widened approximately 3 feet; total area approximately 3,600 sq ft.

6.2.10.4 Estimated Cost $40 Million

6.2.10.5 Total Project Duration 40 Months

6.2.11 PROJECT NUMBER 31
SMITHSONIAN STATION ENHANCEMENTS

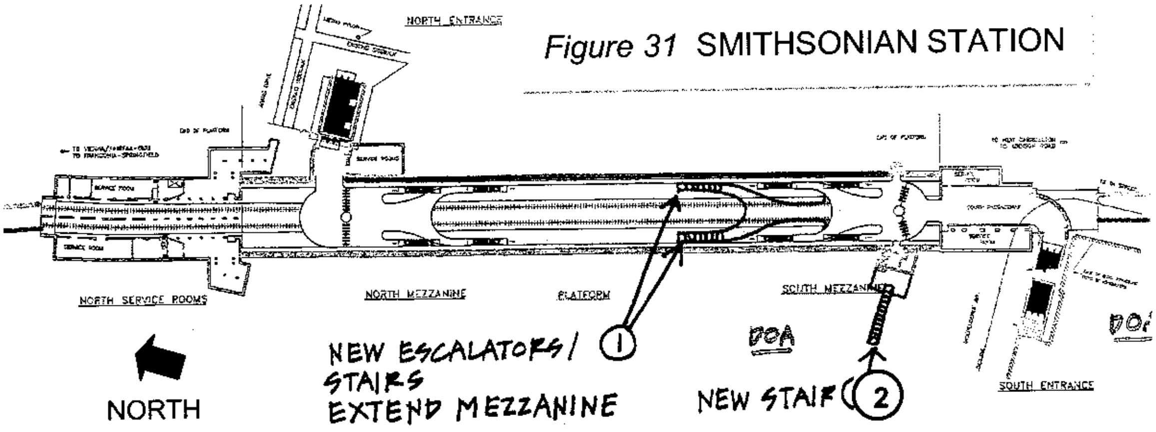


Figure 31 SMITHSONIAN STATION

6.2.11.1 Station Capacity Constraints

A **ESCALATORS AND STAIRS BETWEEN MEZZANINES AND PLATFORM**
- Queuing time and headway-effect levels of service are deficient for Year 2000, and are projected to be deficient by greater percentages by Year 2025.

B **MEZZANINE FAREGATES**
- Queuing time level of service is acceptable for Year 2000, but is projected to be deficient by Year 2025.

C **ESCALATORS AND STAIRS BETWEEN ENTRANCES AND MEZZANINES**
- Queuing time and headway-effect levels of service are acceptable for Year 2000, but are projected to be in upper range of marginal by Year 2025.

6.2.11.2 Station Enhancements:

The following station enhancements are referenced to their location as shown in Figure 31.

EXTENDED MEZZANINE WITH STAIRS

Responds to Capacity Constraint **A**
- Extension from the South Mezzanine would terminate in new stairs to side platforms.

ENTRANCE STAIR

Responds to Capacity Constraints **B** and **C**
- One stair, stairwell and landing would be added to the existing elevator lobby at South Mezzanine level.
- One Fare Gate would be added at the mezzanine level.

6.2.11.3 Length of Project

- **EXTENDED MEZZANINE:** Length is approximately 100 ft.
- **ENTRANCE STAIR AND LANDING:** Area is approximately 700 sq ft.

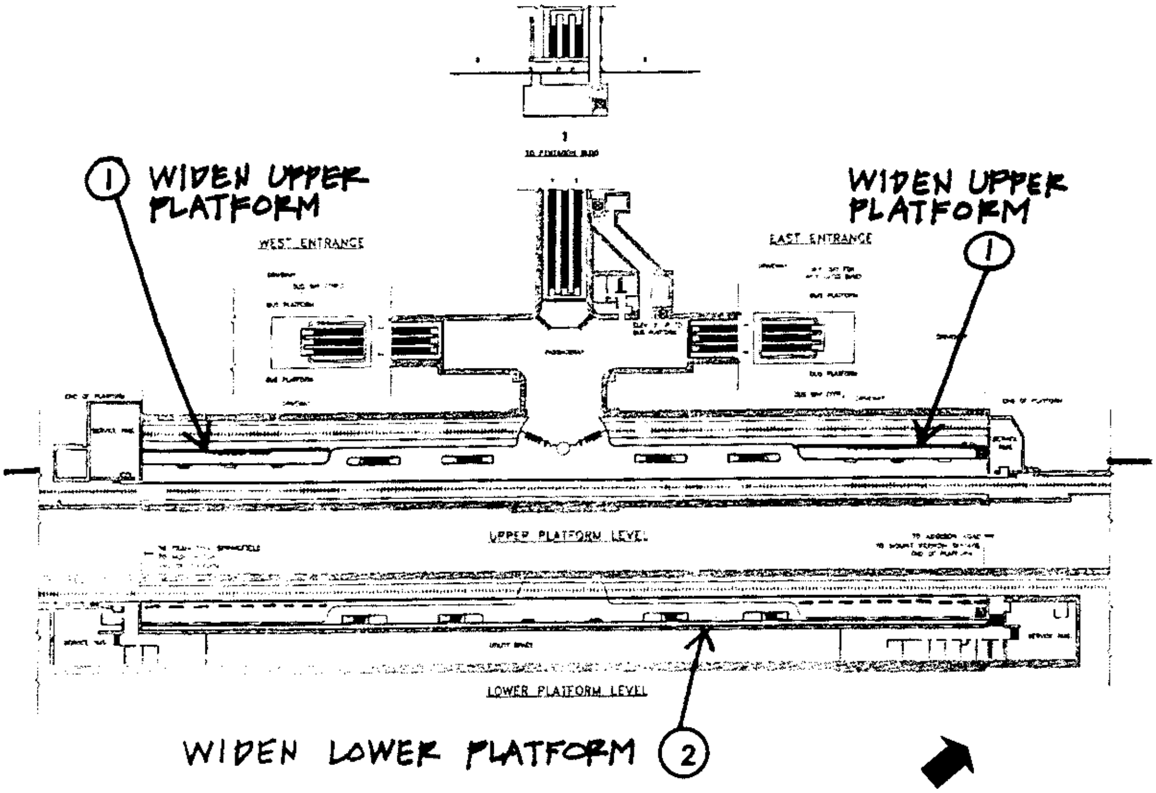
6.2.11.4 Estimated Cost

$40 Million

6.2.11.5 Total Project Duration

$40 Million

6.2.12 PROJECT NUMBER 32
PENTAGON STATION ENHANCEMENTS



6.2.12.1 Station Capacity Constraints

A PLATFORM CAPACITY

- The ability of the platform to accommodate patron flow, to provide queuing space for escalators, and to hold patrons waiting for trains is marginal for Year 2000, and is projected to be marginal by greater percentages by Year 2025.

6.2.12.2 Station Enhancements:

The following station enhancements are referenced to their locations as shown in Figure 32.

WIDENED UPPER PLATFORM

Responds to Capacity Constraint **A**

- Upper Platform would be increased in width by extending the north and south ends of the platform toward the northeast to match the existing width of the central portion of the platform.

WIDENED LOWER PLATFORM

Responds to Capacity Constraint **A**

- Side platform would be widened along the vault face for the full 600 ft length of the station.

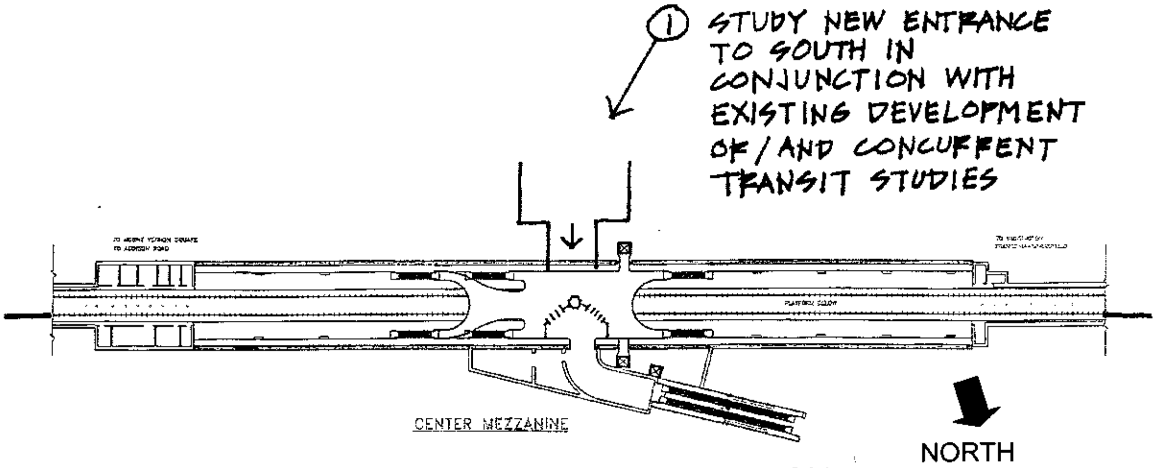
6.2.12.3 Length of Project

- **WIDENED UPPER PLATFORM:** Total area is approximately 2,800 sq ft.
- **WIDENED LOWER PLATFORM:** Total of 600 linear ft; widened approximately 3 ft; area is approximately 1,800 sq ft.

6.2.12.4 Estimated Cost $30 Million

6.2.12.5 Total Project Duration 34 Months

6.2.13 PROJECT NUMBER 33
CRYSTAL CITY STATION ENHANCEMENTS



① STUDY NEW ENTRANCE TO SOUTH IN CONJUNCTION WITH EXISTING DEVELOPMENT OF/AND CONCURRENT TRANSIT STUDIES

Figure 33 CRYSTAL CITY STATION

6.2.13.1 Description

Enhancements to the station consist of the components illustrated and numbered above. Enhancements and Capacity Constraints are discussed below.

6.2.13.2 Station Capacity Constraints

A PASSAGEWAYS

- The rate of passenger flow in entrance passageways is acceptable for Year 2000, but is projected to be marginal by Year 2025.

6.2.13.3 Station Enhancements

NEW CENTER/SOUTH ENTRANCE

Responds to Capacity Constraint **A**

- A study for a new entrance would be required to determine development requirements.
- New Entrance would include at least one stair, one escalator and one elevator between surface and mezzanine levels.
- New Entrance would include at least seven fare gates.

6.2.13.4 Length of Project

- Estimated area of new entrance could range between 7,500 sq ft and 15,000 sq ft.

6.2.13.5 Estimated Cost $50 Million

6.2.13.6 Total Project Duration 76 Months

6.2.14 PROJECT NUMBER 34
JUDICIARY SQUARE STATION ENHANCEMENTS

6.2.14.1 Description of Proposed Enhancements

RECOMMENDED:

- Add stair at North Entrance
- Add stair at South Entrance
- Widen side platforms.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

OPTIONAL:

- Extend North Mezzanine and add stairs.
- Extend South Mezzanine and add stairs.

6.2.14.2 Preliminary Estimated Cost $40 Million

6.2.14.3 Total Project Duration 30 months

6.2.15 PROJECT NUMBER 35
NEW YORK AVENUE STATION ENHANCEMENTS

6.2.15.1 Description of Proposed Enhancements

- New station in Final Design Phase; no enhancements recommended at this time.

6.2.15.2 Preliminary Estimated Cost

- Not Applicable.

6.2.16 PROJECT NUMBER 36
FEDERAL TRIANGLE STATION ENHANCEMENTS

6.2.16.1 Description of Proposed Enhancements

- Extend mezzanine and add stair / escalator pair.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

6.2.16.2 Preliminary Estimated Cost $30 Million

6.2.16.3 Total Project Duration 30 Months

6.2.17 PROJECT NUMBER 37
FEDERAL CENTER SW STATION ENHANCEMENTS

6.2.17.1 Description of Proposed Enhancements

RECOMMENDED:
- Add stair at entrance
- Extend mezzanine and add stair / escalator pair.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

OPTIONAL:
- Add second entrance.

6.2.17.2 Preliminary Estimated Cost $30 Million

6.2.17.3 Total Project Duration

- 30 Months for Recommended Enhancements.
- 70 Months for New Entrance.

6.2.18 PROJECT NUMBER 38
CAPITOL SOUTH STATION ENHANCEMENTS

6.2.18.1 Description of Proposed Enhancements

RECOMMENDED:
- Add stair at entrance
- Extend mezzanine and add stair / escalator pair.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

OPTIONAL:
- Add second entrance.

6.2.18.2 Preliminary Estimated Cost $30 Million

6.2.18.3 Proposed Project Duration

- 30 Months for Recommended Enhancements.
- 70 Months for New Entrance.

6.2.19 PROJECT NUMBER 39 EASTERN MARKET STATION ENHANCEMENTS

6.2.19.1 Description of Proposed Enhancements

RECOMMENDED:
- Add stair at entrance
- Extend mezzanine and add stair / escalator pair.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

OPTIONAL:
- Add second entrance.

6.2.19.2 Preliminary Estimated Cost $30 Million

6.2.19.3 Proposed Project Duration

- 30 Months for Recommended Enhancements.
- 70 Months for New Entrance.

6.2.20 PROJECT NUMBER 40
POTOMAC AVENUE STATION ENHANCEMENTS

6.2.20.1 Description of Proposed Enhancements

- Add stair at Entrance.
- Extend Center Mezzanine in one direction and add stair / escalator pair.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

6.2.20.2 Preliminary Estimated Cost $30 Million

6.2.20.3 Proposed Project Duration 30 Months

6.2.21 PROJECT NUMBER 41
STADIUM ARMORY STATION ENHANCEMENTS

6.2.21.1 Description of Proposed Enhancements

- Add stair at Entrance.
- Extend North Mezzanine and add stair / escalator pair.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

6.2.21.2 Preliminary Estimated Cost $30 Million

6.2.21.3 Proposed Project Duration 30 Months

6.2.22 PROJECT NUMBER 42
ARLINGTON CEMETERY STATION ENHANCEMENTS

6.2.22.1 Description of Proposed Enhancements

- Add one stair at each side platform.
- Enhanced Signage and Graphics.

6.2.22.2 Preliminary Estimated Cost $10 Million.

6.2.22.3 Proposed Project Duration 18 Months

6.2.23 PROJECT NUMBER 43
NATIONAL AIRPORT STATION ENHANCEMENTS

6.2.23.1 Description of Proposed Enhancements

- Station improvements currently in Final Design Phase.
- Enhanced Signage and Graphics.

6.2.23.2 Preliminary Estimated Cost $1 Million.

6.2.23.3 Proposed Project Duration 12 Months

6.2.24 PROJECT NUMBER 44
PENTAGON CITY STATION ENHANCEMENTS

6.2.24.1 Description of Proposed Enhancements

- Construct new mezzanine and associated entrance.
- Widen side platforms.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

6.2.24.2 Preliminary Estimated Cost $70 Million

6.2.24.3 Proposed Project Duration 70 Months.

6.2.25 PROJECT NUMBER 45
ARCHIVES-NAVY MEMORIAL STATION ENHANCEMENTS

6.2.25.1 Description of Proposed Enhancements

- Add stair at North Entrance.
- Construct South Entrance.
- Construct South Mezzanine.
- Construct connection to proposed Pedestrian Inter-Connector, Project 12e.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

6.2.25.2 Preliminary Estimated Cost $50 Million

6.2.25.3 Proposed Project Duration 70 Months

6.2.26 PROJECT NUMBER 46
MOUNT VERNON SQUARE - UDC STATION ENHANCEMENTS

6.2.26.1 Description of Proposed Enhancements

- Station improvements are under construction.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

6.2.26.2 Preliminary Estimated Cost $2 Million

6.2.26.3 Proposed Project Duration 18 Months.

6.2.27 PROJECT NUMBER 47
WATERFRONT – SEU STATION ENHANCEMENTS

6.2.27.1 Description of Proposed Enhancements

- Add stair at entrance.
- Extend mezzanine at each end, and add stair / escalator pair at each end.
- Add Fare Gates.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

6.2.27.2 Preliminary Estimated Cost $30 Million.

6.2.27.3 Proposed Project Duration 48 Months

6.2.28 PROJECT NUMBER 48
NAVY YARD STATION ENHANCEMENTS

6.2.28.1 Description of Proposed Enhancements

- Add stair at East Entrance.
- Add stair at West Entrance.
- Extend East Mezzanine and add stair / escalator pair.
- Extend West Mezzanine and add stair / escalator pair.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

6.2.28.2 Preliminary Estimated Cost $30 Million

6.2.28.3 Proposed Project Duration 30 Months.

6.2.29 PROJECT NUMBER 49
ANACOSTIA STATION ENHANCEMENTS

6.2.29.1 Description of Proposed Enhancements

- Provide additional emergency exit stairs.
- Enhanced Lighting.
- Enhanced Signage and Graphics.

6.2.29.2 Preliminary Estimated Cost $20 Million

6.2.29.3 Proposed Project Duration 18 Months

6.2.30 PROJECT NUMBER 12D METRO CENTER / GALLERY PLACE PASSENGER INTERCONNECTION

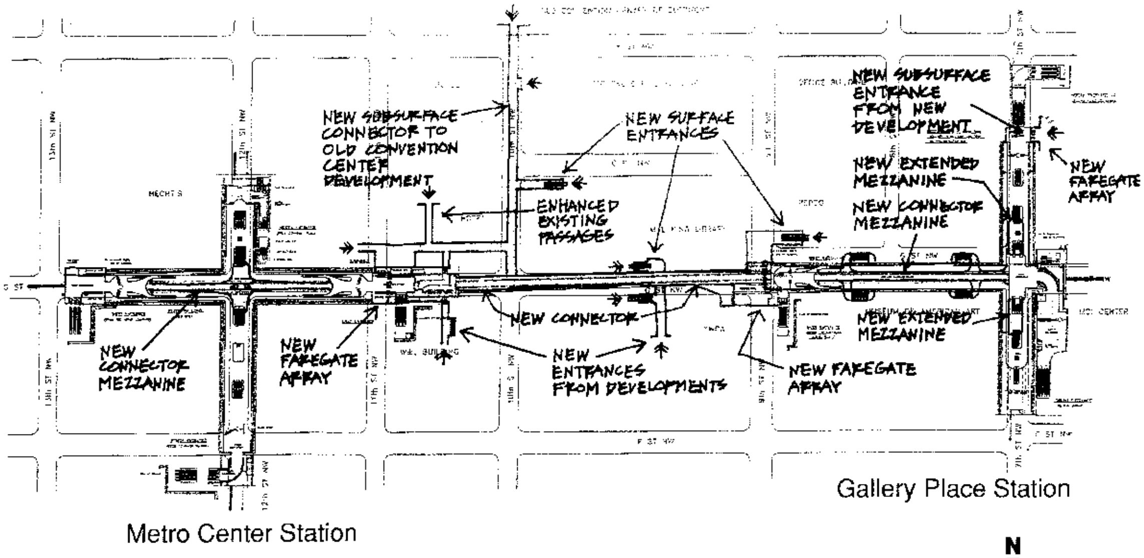


Figure 12d METRO CENTER / GALLERY PLACE PASSENGER INTERCONNECTION

6.2.30.1 Description

Enhancements to the individual stations are described under separate Projects: see Project 21, Metro Center Station Enhancements; and Project 22, Gallery Place Station Enhancements. The Passenger Interconnection is illustrated above, and the components of the Interconnector are discussed below.

6.2.30.2 Passenger Interconnector

- Continuous, same level connection would be provided between the Metro Center East Mezzanine and the Gallery Place West Mezzanine. The Interconnector would be supported on top of the existing track vaults. In addition to new entrances from the surface, other new or enhanced entrances would serve existing adjacent development via underground connections. Small scale retail would be provided at nodal points, including a point at which the interconnector shifts to pass around an existing ventilation structure at the west end of Gallery Place Station. A new underground passageway to the Old Convention Center Site would extend northward under 10th Street. New fare gate arrays would be provided on the enlarged Metro Center East Mezzanine and the enlarged Gallery Place West Mezzanine. Ventilation and emergency exit stairs would be provided at intervals along the passageway. Single-fare passenger transfers could be facilitated by timed / validated SmarTrip program.

6.2.30.3 Length of Project

PASSENGER INTERCONNECTOR:

- Length of passageway from Metro Center Station East Mezzanine to Gallery Place Station West Mezzanine would be approximately 750 feet.
- Area of passageways would be about 18,000 square feet, including connections to existing underground entrances and new emergency exit stairs.
- Area of new entrance with stair and escalator in open plaza area near gallery Place Station West Mezzanine would be about 2,000 square feet.
- Area of retail along passageway would be about 7,500 square feet.

Interconnector with Proposed Old Convention Center Site or Station is not included.
Interconnector with Proposed New Convention Center Station is not included.

6.2.30.4 Estimated Cost $70 Million

6.2.30.5 Total Project Duration 86 Months

6.2.31 PROJECT NUMBER 12E NATIONAL MALL ENTRANCE & SMITHSONIAN / ARCHIVES-NAVY MEMORIAL PASSENGER INTERCONNECTIONS

6.2.31.1 Description

Enhancements to the Smithsonian Station are described in Project No. 31, Smithsonian Station Enhancements. The Passenger Interconnectors are illustrated above, and the components of the Interconnectors are discussed as follows.

6.2.31.2 Passenger Interconnectors

MALL ENTRANCE TO SMITHSONIAN STATION:

- From the new Mall Entrance at the intersection of 9th Street NW and Madison Drive, a passageway would take an approximate southwest direction under the National Mall to reach the north end of Smithsonian Station. A new portal through the station vault would connect the enlarged North Mezzanine with the passageway. Ventilation and emergency exit stairs would be provided at intervals along the passageway.

MALL ENTRANCE TO ARCHIVES-NAVY MEMORIAL STATION:

- From the new Mall Entrance at the intersection of 9th Street NW and Madison Drive, a passageway would take an approximate northeast direction under the National Mall to cross over the southbound train tunnel at the south end of Archives-Navy Memorial Station. The mezzanine-level knock-out panel at the south end of the station would be removed to connect the passageway and the new South Mezzanine. Ventilation and emergency exit stairs would be provided at intervals along the passageway.

SINGLE-FARE PASSENGER TRANSFERS:

- Transfers between the two stations could be facilitated by timed / validated SmarTrip program.

6.2.31.3 Length of Project

- Length of new entrance and passageway to Smithsonian Station would be approximately 1,200 feet.
- Length of new entrance and passageway to Archives-Navy Memorial Station would be approximately 1,700 feet.

6.2.31.4 Estimated Cost $80 Million

6.2.31.5 Total Project Duration 86 Months

6.2.32 PROJECT NUMBER 13
FARRAGUT NORTH / FARRAGUT WEST PASSENGER INTERCONNECTION

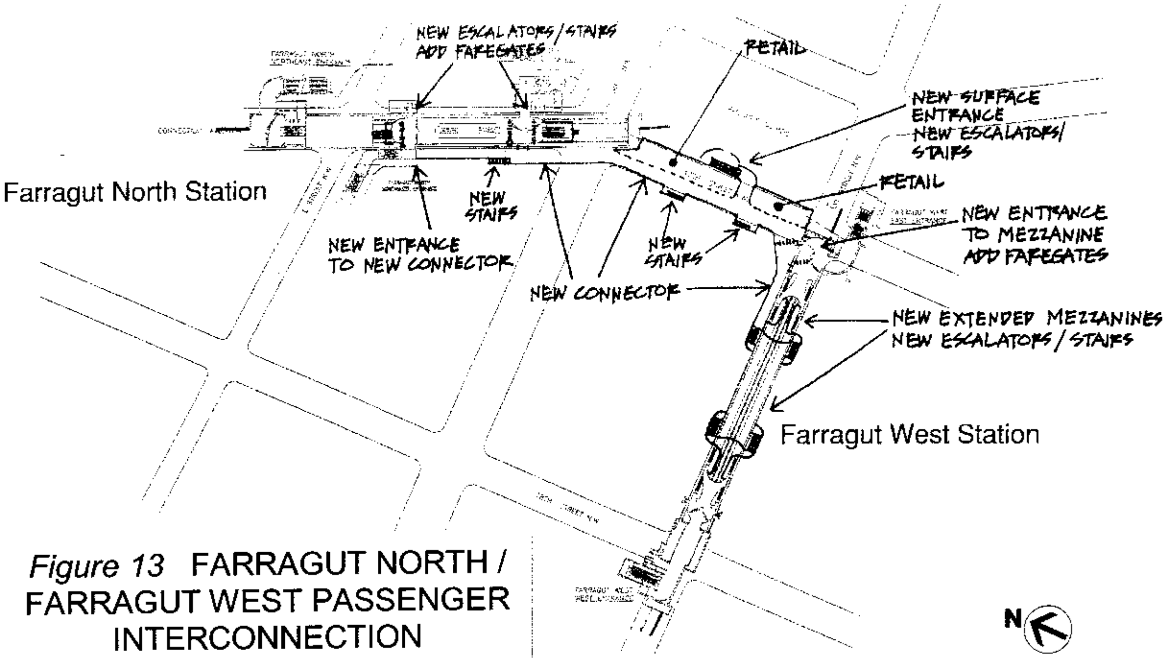


Figure 13 FARRAGUT NORTH / FARRAGUT WEST PASSENGER INTERCONNECTION

6.2.32.1 Description

Enhancements to the individual stations are described under separate Projects: see Project No. 26, Farragut North Station Enhancements; and Project No. 29 Farragut West Station Enhancements. The Passenger Interconnector is illustrated above, and the components of the Interconnector are discussed below.

6.2.32.2 Passenger Interconnector

- Interconnector would consist of a continuous, single level or moderately ramped underground pedestrian passageway extending from the south sides of the Center Mezzanine and South Mezzanine at Farragut North Station to the west sides of the East Mezzanine and proposed East Mezzanine Extension at Farragut West Station.
    - Single-fare passenger transfers could be facilitated by timed / validated SmarTrip program.
- Farragut North Station South Mezzanine fare gate array would be altered to accommodate the new entrance from the Interconnector.
- Farragut West Station East Mezzanine fare gate array would be modified to accommodate two new entrances from the Interconnector.
- A new fare gate array would be provided in the Interconnector connection at Farragut West Station East Mezzanine
- Three entrance stairs would be provided between the Interconnector and public sidewalks on the west sides of Connecticut Avenue and 17th Street NW.
- A new entrance would be provided between the Interconnector and the public sidewalk on 17th Street NW along Farragut Square.

- Elevators (not illustrated) from adjacent private developments could be provided to the Interconnector level.
- Small-scale retail could be located at nodal points in the Interconnector. Non-Metro customers could access such retail from the new sidewalk entrances without being obligated to purchase a fare because the Interconnector could function as a free area between the fare collection mezzanines at the Interconnector terminations.
- Ventilation and emergency exit stairs would be provided at intervals along the Interconnector.

6.2.32.3 Length of Project

UNDERGROUND PEDESTRIAN INTERCONNECTOR

- Length would be approximately 730 feet from Farragut North Station Center Mezzanine to Farragut West Station East Mezzanine Extension.
- Area would be about 42,000 square feet, including, passageways, emergency exit stairs and retail spaces.

FARRAGUT SQUARE ENTRANCE

- Area would be about 3,000 square feet.
  Refer to Project 26 and Project 29 for costs associated with the respective stations.

6.2.32.4 Estimated Cost $80 Million

6.2.32.5 Total Project Duration 82 Months

6.2.33 Safety Criteria

The National Fire Protection Agency "Standard for Fixed Guideway Transit and Passenger Rail Systems" (NFPA 130) was developed to define emergency exiting requirements for transit systems. It requires that there should be sufficient exit lanes to evacuate the transit patrons from station platforms in four (4) minutes or less. Similarly the stations must be designed to permit evacuation from the most remote point on the platform to a point of safety in six (6) minutes or less. However, the WMATA Metrorail stations were designed and constructed before the NFPA 130 standards were approved. As a result, many of the stations do not meet the criteria set by NFPA 130 for emergency exiting. The proposed station enhancements helped to improve the exit times considerably but several stations still fell short of the minimum.

To help aid visualization of the constraints, a computer-based simulation model was used to analyze the emergency exiting of the passengers from the Farragut West, Metro Center, and Union Stations. The simulation depicted the patron loads on the platforms and the time it took to exit all the patrons from the platforms to the nearest safe location. The simulations confirmed that the fare-gate arrays (considered open during emergency exiting) and escalators / stairs (downward escalators assumed stopped) are the critical elements in the exit lane for a patron leaving the station. A manual calculation of exiting times was completed for the remaining Core stations. The results of these NFPA 130 analyses for the 29 enhanced Core stations are tabulated in Exhibit 6.5

Exhibit 6.5: NFPA 130 Results for 29 Enhanced Core Stations

No.	Station Location	Criteria 1 ≤ 4 minutes		Criteria 2 ≤ 6 minutes	
		Time to Clear Platform (minutes)		Total Exit Time (minutes)	
21	Metro Center Station Enhancements	[redacted]	A	[redacted]	C
22	Gallery Place Station Enhancements	4.083	B	[redacted]	C
23	L'Enfant Station Enhancements	[redacted]	A	[redacted]	A
24	Rosslyn Station Enhancements	4.605	B	[redacted]	C
25	Dupont Circle Station Enhancements	4.869	B	[redacted]	C
26	Farragut North Station Enhancements	[redacted]	A	6.343	B
27	Union Station Enhancements	4.228	B	6.571	B
28	Foggy Bottom Station Enhancements	[redacted]	A	[redacted]	C
29	Farragut West Station Enhancements	[redacted]	A	[redacted]	A
30	McPherson Square Station Enhancements	[redacted]	C	8.208	B
31	Smithsonian Station Enhancements	[redacted]	A	[redacted]	A
32	Pentagon Station Enhancements	[redacted]	C	[redacted]	C
33	Crystal City Station Enhancements	4.431	B	6.458	B
34	Judiciary Square Station Enhancements	[redacted]	C	7.873	B
35	New York Avenue Station Enhancements	[redacted]	A	[redacted]	A
36	Federal Triangle Station Enhancements	4.645	B	[redacted]	A
37	Federal Center Station Enhancements	[redacted]	C	7.745	B
38	Capitol South Station Enhancements	[redacted]	C	7.586	B
39	Eastern Market Station Enhancements	[redacted]	C	[redacted]	C
40	Potomac Avenue Station Enhancements	[redacted]	C	7.142	B
41	Stadium- Armory Station Enhancements	[redacted]	C	7.419	B
42	Arlington Cemetery Station Enhancements	[redacted]	C	7.275	B
43	National Airport Station Enhancements	[redacted]	C	7.948	B
44	Pentagon City Station Enhancements	[redacted]	C	[redacted]	C
45	Archives-Navy Memorial Station Enhancements	4.474	B	6.209	B
46	Mount Vernon Square Station Enhancements	[redacted]	A	6.247	B
47	Waterfront Station Enhancements	4.676	B	[redacted]	C
48	Navy Yard Station Enhancements	[redacted]	A	6.086	B
49	Anacostia Station Enhancements	[redacted]	C	6.087	B

A = Passed Criteria
B = Marginally Passed Criteria
C = Failed Criteria

Four of the 29 enhanced Core stations satisfy both parts of the NFPA 130 criteria. Nine stations meet the four-minute criteria for exiting the platform and an additional eight stations can be exited in less than five minutes. Five of the stations meet the more demanding criteria of being able to exit from the most remote point on the platform in six minutes or less and an additional fourteen stations can be exited in less than eight minutes. Thus, the proposed station enhancements greatly improve the ability of the Core stations to meet the subjective criteria set forth in NFPA 130.

6.3 Other Vital Systems

Minimum Sustainable Headway

The current Metrorail system can run an 8-car train with minimum sustainable headway of 135 seconds. If the headway were reduced from 135 seconds to 120-second headway, it would result in 4 additional peak, one-way trains, and generating capacity from 3,800 additional customers per line.

To reduce the headway to 120-second would necessitate undertaking analysis/feasibility study to determine effects of advanced technologies to reduce headways. Such analyses would require long lead-time and may also require substantial investments. The reduction in headways using advanced technologies has the potential to absorb the ridership growth up to three years.

Operating Margin

CTC recommends that the Operating Margin should be in the range of 20-30 percent of the service headway; a 25 percent margin was used in CTC's calculations of Train Throughput Capacity. If WMATA is able to significantly and consistently reduce the frequency and impact of delay events, as well as enforce more consistent dwell times, it might be appropriate to consider lowering the Operating Margin below this level. Please refer the Operations Control Center section for its effect on reducing the Operating Margin.

8-Car Trains

Providing 8-car trains from current 6-car trains would essentially increase the capacity of the trains from 18,700 passengers per hour to 25,000 passengers per hour. That in effect could sustain the ridership increase of upto 3 years.

The effect of providing 8-car trains is shown in the following Exhibit 6.1.

Exhibit 6.1: Redeployment of 5000 Series Rail Cars

FY 2001 BASE	Red Line	Orange Line	Blue Line	Yellow Line	Green Line
2000					■
2001					■
2002					■
2003			■		■
2004	■		■		■
2005	■		■		■
2006	■	■	■	■	■
2007	■	■	■	■	■
2008	■	■	■	■	■
2009	■	■	■	■	■
2010	■	■	■	■	■
2011	■	■	■	■	■
2012	■	■	■	■	■
2013	■	■	■	■	■
2014	■	■	■	■	■
2015	■	■	■	■	■
2016	■	■	■	■	■
2017	■	■	■	■	■
2018	■	■	■	■	■
2019	■	■	■	■	■
2020	■	■	■	■	■
2021	■	■	■	■	■
2022	■	■	■	■	■
2023	■	■	■	■	■
2024	■	■	■	■	■
2025	■	■	■	■	■

By 2014	Red Line	Orange Line	Blue Line (Largo)	Yellow Line	Green Line
2000					■
2001					■
2002					■
2003					
2004					
2005					
2006					
2007					
2008					
2009					
2010					
2011					
2012					
2013					
2014					
2015					
2016					
2017					
2018					
2019					
2020		■			
2021		■			
2022		■			
2023		■			
2024		■			
2025	■	■		■	

LEGEND:
Red – TSCU is greater than 1.6
Orange – TSCU is between 1.0 and 1.6
Green – TSCU is 1.0 or less

Note: Train Service Capacity Utilization (TSCU) = Train Throughput Demand (Maximum Link Load Volume) / Train Throughput Capacity.

6.3.1 ROLLING STOCK

INCREASING THE CAPACITY

Stanchion, Horizontal Handhold, and Windscreen Configuration

The single longitudinal horizontal handholds should be reconfigured. These handholds can be reconfigured by installing two rows of ceiling mounted horizontal handholds along the edges of the aisles and adding vertical stanchions to various seatbacks. Horizontal handholds should be installed directly above the outside edge of the back-to-back seats. This combination of stanchions and handholds above and at the seatbacks will tend to move standing passengers into the aisles leaving room for passengers to pass and enter the train, thereby contributing to reduce the dwell time.

Vestibule Seating Configuration

The seats at the ends of the cars should be removed. One row of transverse seats and the flip seat at the car-end should be removed thereby adding more standing space. Similarly the longitudinal seats at each corner of the center vestibule should increase the amount of space for standing and moving passengers in this area resulting in improved passenger flow in the car center.

Interior Seating Configuration

One of the primary ways to create better distribution inside the vehicle during peak loading is to widen the aisle between seats by altering the current seating configuration. This will have the effect of moving passengers from crowded areas to less crowded areas of the train. Also, a wider aisle will allow more standees to be accommodated in the aisles during the peak loading times.

REDUCING THE DWELL TIME

Addition of the One Door Set per Side of the Vehicle

A modification that should have the greatest impact on improving passenger flow inside the vehicle is the addition of an extra door set on each side of the vehicle. This modification would provide 33% more door opening over the existing design. The seating capacity reduces by nearly 28% (with the revised seating configuration) and the standing capacity increases from maximum 188 to maximum 238.

Widening of the Door Openings

The doors in the current car design are 50 inches wide. Observations show that the current doorways are not quite wide enough to allow two passengers to comfortably exit or enter the train at the same time. An increase in the width by 4 inches, with only minor necessary structural modifications, would allow sufficient space to fit two passengers in the doorway at the same time without any serious interference.

STATION STOPPING ACCURACY

Passenger management on the platforms can be greatly improved by improving the station stopping accuracy of the trains. If the trains can stop within one foot of a predetermined point with relation to the platform, then platform-marking signs can be employed to direct passengers to a cue-up area prior to the arrival of the trains. This platform management strategy has been employed at BART with success.

EIGHT-CAR TRAIN OPERATION

Increasing the train size from the current six to eight cars would improve passenger flow by increasing available passenger space on the train. This will in effect reduce the crowding on the train and the platforms and further improve the passenger flow.

Based on the minimum time needed to recycle a train door, each door recycle following a door obstruction extends the station dwell time by four seconds. If enough passenger capacity per train is available and a better train frequency, to allow passengers on the platform to board the train, then fewer passengers will attempt to board an already full train and fewer door obstruction will occur.

It should be noted though that eight-car train operation could only be achieved with improved station stopping accuracy.

6.3.2 TRACTION POWER

The Power Master Plan (PMP) identified which substations will require upgrading and similarly passenger stations that would require upgrade were identified from Core study. PMP also recommended that the enhancements be made in units of 3 MW.

A summary of the enhancements needed is as tabulated below.

Exhibit 6.3: Traction Power Enhancements within the Core

Substation Name	Address	Existing Capacity	Upgrade Capacity
		MW	MW
National Airport	C10	4	7
18th & Fern Street	C09	4	7
Shirley Highway	C08	4	7
Washington Boulevard	C06	4	7
Watergate	C04	4	7
Metro Center	C01	6	9
Smithsonian	D02	4	7
Federal Center	D04	4	7
Seward Square	D06	4	7
Potomac Avenue	D07	6	9
Stadium Armory	D08	4	7
Subtotal 2005 - 2010			
Belmont	A03	4	7
Gallery Place	B01	6	9
Union Station	B03	4	7
Rhode Island	B04	6	9
Subtotal 2010 - 2015			
U Street	E03	4	7
Mt. Vernon Square	E01	4	7
Pennsylvania Avenue	F02	4	7

Maine Avenue	F04	4	7
Navy Yard	F05	4	7
Anacostia	F06	4	7
Subtotal 2015 - 2020			

The original (GEC) 1995 report provided only for expansion via installation of supplemental units with ratings of 2 MW, as this was the standard rating (at that time) for WMATA rectifier/transformer units. Since then, WMATA has revised their standard to call for 3 MW units for all new construction. The PMP has followed this newer standard. Units with 3 MW ratings are only slightly more expensive than 2 MW units, and there are maintenance benefits to standardization of sizes. In addition, the PMP has called for additional system upgrades that were not part of the recommendations of the 1995 study (including upgrade of additional rectifier/transformers, and shielded cable). The operational and maintenance considerations that obviously dictated these additional requirements (in the PMP) were not considered at the time of the 1995 study. The 1995 PMP study was based on consideration of vehicles with cam controllers (or equivalent). A more definitive study should be conducted, based on the current chopper/AC controllers.

With lead times for design, ordering of equipment, manufacture, and installation, it would take about 1.5 to 2.5 years for completion of upgrades.

There is no simple way to determine whether the existing system will support 8 car trains at any specific headway, other than to conduct a new simulation. We strongly recommend that WMATA undertake a new system-wide evaluation of the traction power system, considering anticipated service levels to 2025.

6.3.3 TRAIN CONTROL

Improved schedule resolution with new ATS computer hardware and / or software may produce a significant improvement in performance in the CORE of the WMATA system. However, extent of improvement will also be constrained by other factors that necessarily affect train separation. Specifically, dwell time and coordination of trains at operational merge points in the system.

Computer simulations, including sensitivity analysis and modeling are recommended to enable WMATA to understand the degree to which improved schedule resolution in the ATS system can reduce train separation. This type of analysis will also serve to highlight the impact of undisciplined dwell times and operational merge point delays may be affecting train separation.

Once the relative affect of each "train separation" driver is understood, WMATA would then have a basis to undertake a more detailed cost/benefit analysis to support the decision to improve the schedule resolution of their traffic regulation system and / or their rail performance schedules.

Based upon actual revenue service experience in North America and Europe, WMATA should expect significant performance and operational improvement if it upgrades its existing fixed-block train control system to one based upon Communications Based Train Control (CBTC).

The two transit agencies in US that have studies underway to study CBTC are NYCT and SF BART. The primary purpose of CBTC for NYC Transit is to increase safety. NYCT also presumes very high braking rates that are much higher than used by most heavy rail systems. With fully automated operation and CBTC, SF Muni has doubled its previous capacity and can operate 40-48 trains/hr/direction in the subway.

While CBTC technology was primarily responsible for permitting Muni to effectively double the number of trains/hour compared with its older fixed block system, this level of improvement should not be expected to be achieved at a heavy rail system such as WMATA. Here are some of the key reasons why:

- Braking System Differences: Unlike WMATA and most US heavy rail systems, Muni trains have electromagnetic track brakes permitting braking rates typically in excess of 3 miles/hr/sec above 30 MPH, and 6 miles/hr/second below 30 MPH. These very high braking rates at Muni are unavailable at most typical US heavy rail systems because of the adhesion limits between steel wheels and steel rails. Were WMATA to entertain improved braking (for example, by adding electromagnet or eddy-current brakes) it would be possible to significantly improve braking rates and therefore significantly reduce headways and improve performance.

- Double Berthing of Trains: Muni's long 700-foot platforms and short 150 foot (two car) and 75 foot (one car) trains permit "double berthing" at several critical downtown stations. This provides a very significant ability for more trains/hour to pass through the network. The WMATA system does not have this capability.

- One Second Schedule Resolution: Like most modern transit properties, Muni and BART are able to schedule merges and thus mitigate conflicts. As discussed in question 1 (above) WMATA may benefit from implementing this capability.

While CBTC can offer considerable improvement in performance, it is unlikely to meet all of needed increase by itself to meet the 2025 demand. Similarly CBTC or even ATC may provide little benefit unless effective measures are taken to reduce the station dwell time.

6.3.4 OPERATIONS CONTROL CENTER

An improvement in the way Operations Control Center (OCC) operates could yield a significant improvement in the operation of the entire system. An example is the Lille (France) VAL System CC, used in Chicago O'Hare Airport Transit System and similar to WMATA metrorail, is able to obtain a minimum monthly availability quota of 99.35%. This figure is calculated by dividing the total amount of time when the system was operating normally by the total time in a calendar month. WMATA's metrorail can sustain 8-car train operation with a minimum sustainable headway of 135 seconds with 98% on-time performance.

OCC Equipment

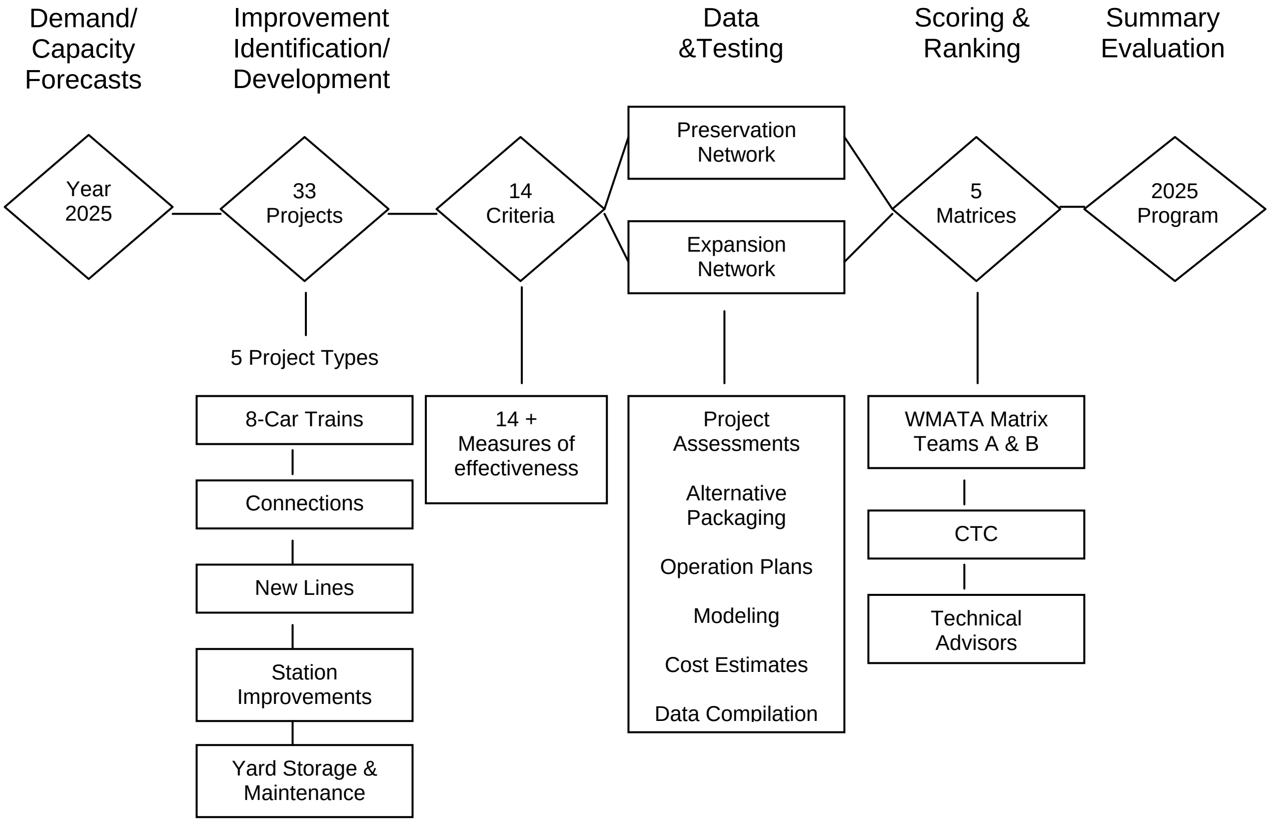
- The current system that dispatches trains into service when the Train Operator presses the "ATO Start" button. It should be replaced by a system that automatically dispatches trains at the appropriate time.
- OCC controllers should be provided with hardware and software tools to run the system as efficiently as possible. This includes complete information on train performance, and the ability to adjust this performance based on predicted event times for the trains.
- As much as possible, all new equipment that can affect Metrorail operation should be equipped with self-diagnostic and redundant systems that lessen or negate the impact of a failure, and that accelerate the recovery process when service is affected.

OCC Personnel

- The competency of the OCC controllers is critical. Careful attention must be paid to their selection, sufficient number, training, and continual re-certification.
- WMATA should generate detailed procedures for delivering timely, accurate, and consistent audible and visual messages.

7. EVALUATION FRAMEWORK

WMATA initially proposed a comprehensive list of 14 evaluation criteria for use in an initial screening evaluation of 49 proposed improvements. The evaluation process was as outlined in the flow chart below.



The 14 criteria were refined into five core criteria which related to study goals and priorities. These core criteria provided data and information that clearly differentiated among alternatives and directly supported decisions that were made at the early stage of the planning, project, and program development. The five core criteria were:

1. Increased capacity (to meet 2025 demand requirements)
2. Enhanced operations and operating flexibility
3. Improved quality of service
4. Improved maintainability
5. Improved operating capability

Recognizing that WMATA desired a comprehensive evaluation, several evaluation criteria (see criteria 6-14) were added that are beyond the specific scope and goals of the Core Capacity Study. Most of these issues will be more appropriately and thoroughly addressed in a subsequent stage of project development. The method for addressing these issues was at a “second tier” level, and on a more qualitative and narrative basis. The five core criteria and other supporting criteria are shown below:

Evaluation Criteria (measure)	Assessment
1. Increase Capacity (ridership)	Ridership per se is not a measure of capacity. Passenger throughput based on service and operating standards or assumptions is an indicator of capacity. Since some proposed improvements (e.g. new lines) are likely to tap new transit markets, ridership could alter the current identified need for capacity. These improvements should be identified and tested. Also, consideration should be given to special events, as well as the peak period, in developing and applying this measure.
2. Enhances operating flexibility (line connections, interlockings, pocket tracks)	Two criteria are involved here; flexibility for normal revenue service, and failure management for non-revenue service. Since non-revenue service improvements are not reflected in the system-operating plan, two separate measures will be needed. Measures for these criteria should be based on existing policies or standards for operating flexibility where they exist, or new standards when appropriate.
3. Improve quality of service (passengers / car, headway)	Improvements may result in both increase and decrease in service to riders and lines. Assessing the net service impact of such trade-offs will accurately reflect quality of service changes.
4. Improves maintainability (available maintenance time)	All the improvements will have some maintenance implications. However, the need for new shops to accommodate fleet expansion for 8-car trains is the largest and most direct impact. Depending on when additional cars are deployed and with what package of capacity improvements, the timing, size, and location of shop expansion might vary. This is especially true for alternatives with new lines.
5. Improves operating capability (dwell, operating margin, headway)	Combined with #3 above in order to focus on failure management, and the relationship between revenue and non-revenue operation in evaluating improvements.

Evaluation Criteria (measure)	Assessment
6. Improves rider access and mobility (passenger flow rate)	Improved rider access applies to existing stations only within the context of this study, since the location and design of new stations has not been established. ADA compliance and design considerations should be addressed at the policy level, rather than as a screening criteria, at this stage of planning and project development.
7. Improves connectivity with activity/employment centers	May indicate a good project, but not be directly relevant to meeting capacity needs.
8. Cost estimate ($)	The basis for cost estimates of individual improvements and alternatives should be documented and applied uniformly with respect to base year (and future year if escalated), contingencies, assumptions, cost factors, etc.

9. Cost Effectiveness (relative cost/capacity increase)	How alternatives perform with respect to dollars invested per increase in capacity is an important piece of information to decision makers. How individual projects in the same category perform with respect to this measure is less important. This is because the best individually rated projects rarely combine to create a coherent highly performing alternative. As screening criteria, cost effectiveness is rarely applied. As a bottom-line indicator of the differences among competing network alternatives, it is likely to be the decisive factor.
10. Community impacts	Community impact covers a number of physical and socio-economic implications for local areas and residents. These can be both positive and negative. Community impacts are usually associated with a fairly well defined project and are identified and investigated during the environmental assessment stage. Community impact assessment also requires community engagement in order to properly define the issues and validate the results with those communities and residents potentially affected. At this stage, improvements and alternatives are very preliminary and conceptual, and no community involvement is anticipated. There is a risk of premature characterization of improvements based on sketch plans rather than proposed design. This can precipitate false public expectations and unnecessary controversy. Some physical impacts, such as construction feasibility, type, location, disruption, and mitigation will be reflected in the study cost estimates. These indicate one type of community impact that has a quantitative basis and is comparable across all improvements.
11. Safety and security	Maintaining a safe and secure transit system and facilities is WMATA policy. It is also subject to a number of well-defined standards, such as the NFPA. These policies and standards apply to projects and facilities regardless of their capacity, service and cost implications. Therefore, safety and security is an important, but secondary criterion for the purposes of this study.
12. Environmental considerations	At this stage, environmental considerations are those that directly translate into significant constructability and cost issues, and should be considered under those criteria discussed above. Once a preferred capacity improvement program(s) has been identified, a wide range of environmental assessment considerations come into play, pursuant to NEPA and other state and local environmental requirements.
13. Consistency with other concurrent transportation studies	This criterion refers to the Regional Bus Study and Washington Regional Mobility Initiative. Efforts by WMATA senior management to ensure coordination of these studies with the Core Capacity Study are underway.
14. Consistent with other existing plans	This criterion refers to other local and regional transportation studies. The assessment is the same as #13 above.

8. IMPLEMENTATION STRATEGY

Through a series of three Board Workshops in late 2001, senior WMATA management presented the staff findings and recommendations from the Core Capacity Study. After careful evaluation, the Board provided direction, regarding the proposed projects and system improvements that should be advanced. The recommended projects and improvements were prioritized into five phases and summarized into a plan of action through 2025. The resulting Summary of Recommendations is shown in Exhibit 8.1.

Exhibit 8.1: Summary of Recommended Enhancements

Step 1: 6-Car Trains (Complete By 2003)	**Step 2: Optimize Portals (Complete By 2006)**	**Step 3: Ramping Up To 8 Car Trains (Complete By 2010)**	**Step 4: All 8 Car Trains (Complete By 2014)**	**Complete 2015-2025**
ACTIONS: ▪ Accomplish implementation of 6-car peak period trains on all lines through redeployment plan for 5000 Series Cars ▪ Modify peak period headway from 6 to 7 minutes on all lines except the Red line (Red remains at 5 minutes during peak period). ▪ Set stage for 8 car train operation by initiating the necessary planning, design and engineering for traction power, train control and system upgrades ▪ Initiate expansion of 3 rail maintenance yards/shops ▪ Take delivery of 50 buses for system access and growth ▪ Enhance bicycle and pedestrian station access ▪ Initiate procurement process for 174 rail cars and 225 buses ▪ Initiate preliminary activities for two line connection projects	**ACTIONS:** ▪ Reconfigure Blue and Orange Line service patterns to maximize utilization of Rosslyn and L'Enfant Plaza portals ▪ Accomplish 25% implementation of 8-car train operations ▪ Take delivery of 174 rail cars (24 unfunded) by end of 2004 ▪ Initiate installation of upgraded traction power, train control and system upgrades ▪ Complete expansion of 3 rail maintenance yards/shops ▪ Initiate design of 1 new rail maintenance yard/shop (Dulles-Loudoun) ▪ Take delivery of 225 buses for system access, growth and bus TSM services ▪ Add one bus garage and replace another ▪ Enhance bicycle and pedestrian station access ▪ Add 5,400 parking spaces ▪ Enhance 2 core stations (Metro Center, Gallery Place/Chinatown) ▪ Construct 1 station connector (Metro Center to Gallery Place/Chinatown) ▪ Initiate procurement process for 190 rail cars and 275 buses ▪ Complete construction of Orange-Blue and Blue-Yellow Line Connection projects	**ACTIONS:** ▪ Take delivery of 190 rail cars ▪ Continue installation of upgraded traction power, train control and system upgrades ▪ Open 1 new rail maintenance yard/shop (Dulles-Loudoun) ▪ Initiate design of new Benning Road rail maintenance yard/shop ▪ Complete 50% implementation of 8-car train operations ▪ Operate all Red Line service to Shady Grove ▪ Take delivery of 275 buses for system access, growth and bus TSM ▪ Add 2 bus garages ▪ Enhance bicycle and pedestrian station access ▪ Add 8,100 parking spaces ▪ Enhance 1 core station (Union Station) ▪ Initiate procurement process for 206 rail cars and 200 buses ▪ Complete construction of Potomac Avenue Pocket Track	**ACTIONS:** ▪ Complete 100% implementation of 8-car train operations ▪ Take delivery of 206 rail cars ▪ Complete installation of upgraded traction power, train control and system upgrades ▪ Complete new Benning Road rail maintenance yard/shop ▪ Take delivery of 200 buses for system access and expansion ▪ Add 2 bus garages ▪ Enhance bicycle and pedestrian station access ▪ Add 9,100 parking spaces ▪ Enhance 2 core stations (Farragut West, Farragut North) ▪ Construct 1 station connector (Farragut North to Farragut West) ▪ Implement Demand Management Strategies ▪ Initiate procurement process for 550 buses	**ACTIONS:** ▪ Take delivery of 550 buses for system access and growth ▪ Add 2 bus garages ▪ Enhance bicycle and pedestrian station access ▪ Add 10, 400 parking spaces ▪ Enhance 1 core station (L'Enfant Plaza)
RESULTS: ▪ 25% increase in systemwide peak period service ▪ Meets passenger demand to 2006	**RESULTS:** ▪ Accommodates Largo extension, NY Avenue station and provides long term capacity for Tysons Corner service ▪ Maximizes portal utilization ▪ Meets passenger demand to 2010	**RESULTS:** ▪ Provides long term capacity for Dulles / Loudoun Co. service ▪ Meets passenger demand to 2014	**RESULTS:** ▪ Utilizes full design capacity of the Metrorail system ▪ Meets passenger demand to 2020	**RESULTS:** ▪ Meets passenger demand on all lines to 2025 or beyond, except the Orange Line which tops out in 2020

Expanding the capacity of the existing Metro system to accommodate a doubling of ridership, which will maintain its vital market share in the region during the next 25 years, is a prudent and cogent investment. The existing system cost $9.4 billion to construct over a period of thirty years. The $4.5 billion investment in core capacity improvements represents half of that original cost and 20% of the price–more than $22 billion–that would be required to build the system today. This investment is in the context of the $246 billion annual economy of the Washington Metropolitan area. The return on investment is compelling: an enhanced and expanded Metro system fully capable of meeting market demand, fostering economic vitality and an enhanced quality of life, meeting the mobility needs of this vibrant region as it continues to grow and providing requisite transit services during times of emergency.

The scope of projects and associated capital funding needs to implement the core capacity recommendations are set forth in Exhibits 8.2 and 8.3.

Exhibit 8.2: Capital Requirements Summary

Capital Investment	Base 2002	Step 1: Redeploy 5000 series rail cars (2003)	Step 2: Optimize Rosslyn & L'Enfant portals (2006)	Step 3: Ramp up to 8 car trains (2010)	Step 4: All 8-car trains (2014)	2015 to 2025	Change From Base
Rail Cars	758	950	1,124 [1]	1,314 [3]	1,520	1,520	762
Rail Yard Capacity	1,262	1,262	1,404 [2]	1,524 [4]	1,644	1,644	382
Rail Shop Capacity	126	126	174	200 [4]	224	224	98
Buses	1,471	1,521	1,746	2,021	2,121	2,771	1,300
Station Access		20	80	160	240	480	480
Ridrship Growth		30	120	240	260	670	670
Bus TSM		0	75	150	150	150	150
Bus Garages	10	10	11	13	15	17	8 [5]
Bicycle and Pedestrian Station Access		1	4	4	8	11	28
Parking Spaces	52,279	52,279	57,679	65,779	74,879	85,279	33,000
TPSS Upgrades							
4 MW to 7 MW			15	15	21		
6 MW to 9 MW			3	3			
Station Enhancements			2	1	2	1	6
Station Connections			1		1		2
Line Inter-connectivity			2	1			3

Notes:

1 - 100 rail cars funded by Largo and Dulles

2 - 42 storage spaces funded throgh Largo

3 - 42 rail cars funded by Dulles

4 - Yard and shop capacity funded by Dulles

5 - 7 new garages and a replacement garage for Royal St in Alexandria

Exhibit 8.3: Major Program Capital Costs by Phase (Based on Obligation Schedule Requirements)

	Phase 1				Phase 2			
	Step 1 FY03	Step 2 FY04-06	Step 3 FY07-10	Phase 1 Subtotal	Step 4 FY11-14	FY 15-25	Phase 2 Subtotal	Total
1) 8-Car Train Operations								
Rail Cars	0.0	430.0	515.0	945.0	0.0	0.0	0.0	945
Associated Systems Support	3.0	132.0	127.0	262.0	82.0	51.0	133.0	395
Maintenance Yards / Shops	104.0	219.0	315.0	638.0	47.0	0.0	47.0	685
SUBTOTAL - 8-Car Train Operations	*107.0*	*781.0*	*957.0*	*1,845.0*	*129.0*	*51.0*	*180.0*	*2,025*
2) Access to Metrorail								
Buses	52.8	85.2	90.0	228.0	60.0	220.0	280.0	508
Bus Garages	8.0	72.0	80.0	160.0	80.0	80.0	160.0	320
Parking	16.0	145.0	180.0	341.0	140.0	156.0	296.0	637
Pedestrian & Bicycle Station Access	3.0	12.0	28.5	43.5	40.5	66.0	106.5	150
SUBTOTAL - Access to Metrorail	*79.8*	*314.2*	*378.5*	*772.5*	*320.5*	*522.0*	*842.5*	*1,615*
3) Station Enhancements								
Station Enhancements	1.0	119.0	150.0	270.0	0.0	80.0	80.0	350
Station Connections	1.0	69.0	80.0	150.0	0.0	0.0	0.0	150
SUBTOTAL - Station Enhancements	*2.0*	*188.0*	*230.0*	*420.0*	*0.0*	*80.0*	*80.0*	*500*
4) Line Connections								
Orange/Blue Line Connection at Rosslyn	0.0	125.0	0.0	125.0	0.0	0.0	0.0	125
Blue/Yellow Line Connection at Pentagon	0.0	150.0	0.0	150.0	0.0	0.0	0.0	150
Potomac Avenue Pocket Track	0.0	0.0	80.0	80.0	0.0	0.0	0.0	80
SUBTOTAL - Line Connections	*0.0*	*275.0*	*80.0*	*355.0*	*0.0*	*0.0*	*0.0*	*355*
Core Capacity / SAP Total Program ($FY 02)	**188.8**	**1,558.2**	**1,645.5**	**3,392.5**	**449.5**	**653.0**	**1,102.5**	**4,495**
Inflated Dollars	*197.7*	*1,696.9*	*2,122.6*	*4,017.2*	*609.0*	*1,075.2*	*1,684.3*	*5,701*

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Core Capacity Study Participants

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