A. INTRODUCTION

The project alternatives are examined in this chapter in accordance with the evaluation criteria established by the Metropolitan Transportation Authority (MTA) and the Federal Transit Administration (FTA). Section B evaluates the three project alternatives—Transportation Systems Management (TSM) Alternative, Build Alternative 1, and Build Alternative 2—and compares them with the No Build and TSM Alternatives. This section begins with a qualitative assessment of the overall project benefits and concludes with a quantitative comparison using predefined evaluation measures. Section C describes the cost effectiveness analysis, where the monetary value of each alternative's customer and social benefits are compared with the alternative's total cost. Section D summarizes and compares various MTA and federal business measures. Section E summarizes the findings and conclusions of the comparative evaluation of the project alternatives.

The MESA study selected and applied evaluation criteria and measures from the illustrative list suggested for studies being conducted under the umbrella of the MTA Long Range Planning Framework (LRPF).* This common approach enables the MTA to provide comparable information about LRPF projects for consideration by regional decision-makers.

B. EVALUATION OF PROJECT ALTERNATIVES

This section evaluates the three project alternatives—TSM Alternative, Build Alternative 1 and Build Alternative 2—in comparison with the No Build and TSM Alternatives. The evaluation is presented in two parts. The first part discusses qualitatively how, based largely on the travel demand forecasts, the project alternatives would each address the study area's problems and needs, which are identified in Chapter 1, "Project Purpose and Need." The second part quantitatively compares the project alternatives based on predefined MTA and FTA evaluation criteria and measures. Additional information on the project alternatives' transportation effects is provided in Chapter 9 ("Transportation"), Section D ("Rail Transit").

OVERALL BENEFITS OF PROJECT ALTERNATIVES

The relative ability of each project alternative to address the study area's problems and needs are compared in this section and contrasted with the No Build and TSM Alternatives.

* The suggested evaluation approach is described in the paper, MTA Long Range Planning Framework, *Project Evaluation Measures*, February 1998 (draft 02/11/98).

TRANSIT PASSENGERS BENEFITTING

The project alternatives would benefit transit passengers in different ways, as described below and summarized in Table 20-1.

Table 20-1
Comparison of Project Alternatives: Passengers Benefitting (trips per year)

Passenger Benefits	Alternative vs. No Build			Alternative vs. TSM	
	TSM	Build 1	Build 2	Build 1	Build 2
Reduced Subway Crowding, Faster and More Reliable Service					
Second Ave./Broadway Subway Service: All Users (125th St. to Union Square)	0	115,272,000	114,564,000	115,272,000	114,564,000
Reduced Peak Period Crowding with Less Delay					
Lexington Ave. Express Subway Service, Nos. 4-5: Weekday Users (125th St. to Bowling Green)	0	54,942,000	55,254,000	54,942,000	55,254,000
Seventh Ave. Express Subway Service, Nos. 2-3: Weekday Users at West 72nd St.	0	17,593,000	17,075,000	17,593,000	17,075,000
Reduced Off-Peak Standing					
Lexington Ave. Local Subway Service, No. 6: All Off-Peak Users at West 68th St.	0	17,380,000	17,468,000	17,380,000	17,468,000
Faster and More Reliable Surface Transit Service					
Second Ave. Bus Service, M15: Average All Users Leaving 72nd/42nd Sts.	2,759,000	0	0	-2,759,000	-2,759,000
Lower East Side Light Rail Service: All Users Between Union Square and Whitehall St.	0	0	32,938,000	0	32,938,000
Total Passengers Benefitting	2,759,000	205,187,000	237,299,000	202,428,000	234,540,000

- *Reduced Subway Crowding, Faster and More Reliable Service*—Passengers using the new subway service proposed in Build Alternatives 1 and 2 would benefit from reduced crowding and faster, more reliable service. It is estimated that 115.3 million passengers per year in Build Alternative 1 and 114.6 million passengers per year in Build Alternative 2 would benefit from this new subway service.

- *Reduced Peak Period Crowding and Less Delay*—Transit riders continuing to use existing express services on the Lexington Avenue and Seventh Avenue subway lines under Build Alternatives 1 and 2 would benefit from reduced peak period crowding and less delay. It is estimated that a total of 72.5 million passengers per year under Build Alternative 1 and 72.3 million passengers per year under Build Alternative 2 would experience reduced crowding on the Lexington Avenue and Seventh Avenue express subway services.

- *Reduced Off-Peak Standing*—Passengers continuing to use the Lexington Avenue local line (No. 6) during off-peak hours under Build Alternatives 1 and 2 would benefit from more passengers being able to get a seat. It is estimated that 17.4 million and 17.5 million passengers per year would experience a more comfortable ride, under Build Alternative 1 and 2, respectively.

- *Faster and More Reliable Surface Transit Service*—Bus riders traveling the Second Avenue corridor (M15 route), under the TSM Alternative, and transit riders using the proposed light rail transit (LRT) line under Build Alternative 2 would both benefit from faster, more reliable transit services. It is estimated that 2.8 million bus passengers per year under the TSM Alternative, and 32.9 million light rail riders per year under Build Alternative 2, would experience this improved transit service.

In summary, the TSM Alternative, as compared with the No Build Alternative, would benefit nearly 2.8 million bus passengers per year, but Build Alternatives 1 and 2 would benefit substantially more subway and light rail passengers—205.2 million and 237.3 million passengers per year, respectively.

RELIEVE SUBWAY OVERCROWDING

The new East Side subway extension—proposed under both Build Alternatives 1 and 2—would substantially reduce overcrowding on the Lexington Avenue express service during the AM and PM peak periods. In the 2020 forecast year, the No Build Alternative would have passenger volumes on the Lexington Avenue express that exceed guideline capacity leaving each station between 125th Street and the Brooklyn Bridge. The proposed new north subway segment would eliminate this subway car overcrowding by diverting riders from the crowded Lexington Avenue line to the new subway service. By comparison, enhanced Lexington Avenue local service and New York busways on First and Second Avenues—proposed in the TSM Alternative—would not relieve overcrowding on the Lexington Avenue express subway services.

Build Alternatives 1 and 2 would also reduce transfer volumes and thereby relieve overcrowding at several subway stations on the Lexington Avenue line, including 125th Street, 86th Street, 59th Street, and Grand Central. By comparison, the TSM Alternative would not significantly reduce these transfer volumes.

ABILITY TO MEET DEMAND ON NORTH–SOUTH BUS LINES

The new subway service proposed under both Build Alternatives 1 and 2 would reduce ridership demand by about 18 percent on north-south bus lines within the study area and by about 5 percent on the First/Second Avenue (M15) bus route. These two build alternatives would reduce crowding and shorten "dwell times," thereby improving schedule reliability. The TSM Alternative on the other hand—with its proposed dedicated busways on First and Second Avenues—would increase ridership by about 48 percent on the heavily used M15 bus route. Additional buses would be added on this route to serve the increased passenger demand, but bus crowding and dwell times in East Midtown and the Upper East Side would not be significantly improved from No Build conditions.

IMPROVED TRANSIT ACCESSIBILITY

Transit accessibility in the Upper East Side neighborhood would be improved with the proposed subway line under Build Alternatives 1 and 2. A 5- to 10-minute walk eastward from the new subway under Second Avenue would bring a pedestrian to approximately York Avenue. For locations on streets between subway stops, where the pedestrian must also spend time walking north or south, the 5- to 10-minute walk would bring the pedestrian to First Avenue. Similarly, in the East Harlem neighborhood, the 5- to 10-minute walk would extend to First Avenue and FDR Drive, respectively. Compared with the No Build Alternative, the two Build alternatives would extend the 5- to 10-minute walk zone two avenues eastward.

The LRT proposed under Build Alternative 2 would extend the 5- to 10-minute walk zone into the heart of the Lower East Side neighborhoods. It would also improve rail transit accessibility to the Civic Center and the Financial District in Lower Manhattan.

REDUCED TRANSIT TRAVEL TIME

The new subway service proposed under both Build Alternatives 1 and 2 would reduce transit travel time for residents of the Upper East Side and East Harlem. For example, from a residential building on East 110th Street between First and Second Avenues, this new subway service would save one minute to Grand Central Terminal, 15 minutes to Times Square, and 11 minutes to the World Trade Center. The TSM Alternative would save little, if any, time to these destinations as compared with the No Build condition.

This new subway service would also reduce excessive dwell times on the Lexington Avenue express service by attracting passengers to the new subway service. This would reduce overcrowding, the primary cause of excessive dwell times, on the Lexington Avenue express service during the AM and PM peak periods. It is estimated that the reduced station dwell times would reduce the total AM peak hour running times on the Lexington Avenue express between 125th Street and Bowling Green from 26 minutes under the No Build to 23 minutes under either Build alternative—a savings of 3 minutes. The TSM Alternative would not significantly improve the running time compared to the No Build Alternative.

The New York busways on First and Second Avenues proposed under the TSM Alternative would improve bus speeds on the M15 route by separating traffic (with the exception of right turn movements) from the busway. Bus speeds would increase by about 20 percent on the dual bus lane segments, between East 96th Street and East 14th Street, and by about 15 percent in the single bus lane segments, between East 14th Street and East Houston Street.

ABILITY TO ACCOMMODATE FUTURE GROWTH

Between 1990 and 2020, the MESA primary study area is predicted to have a growth of 17,000 dwelling units, with a population increase of more than 33,000. The primary study area's labor force is predicted to grow by 39,000 people. During this period, employment in the MESA primary study area is also predicted to increase by more than 165,200 trip-based workers plus 12,400 people working-at-home for a total employment increase of 177,600. See Chapter 4, "Social Conditions" and Chapter 5, "Economic Conditions" for more information.

The new subway service proposed under both Build Alternatives 1 and 2 would provide additional subway capacity to handle this future growth within NYCT service guidelines. The No Build and TSM Alternatives would not be able to accommodate this future growth without overcrowded subway trains.

EMISSIONS REDUCTIONS AND ENERGY SAVINGS

In the primary study area and the citywide network, all of the project alternatives would reduce vehicle miles of travel (VMT) from a high of 2.7 million vehicle miles annually under Build Alternative 1 to a low of 860,000 vehicle miles annually under Build Alternative 2. These savings in VMT would contribute to lower pollutant emissions and reduced energy consumption due to the project alternatives. See Table 10-6 in Chapter 10, "Air Quality."

COMPARATIVE EVALUATION MEASURES

This section quantitatively compares the project alternatives with the No Build Alternative for the following categories:

- Mobility Improvements
- Person Trips by Mode
- System Capacity Improvements
- Transit Accessibility Improvements

MOBILITY IMPROVEMENTS

The project alternatives are compared with the No Build and TSM Alternatives based on their ability to improve mobility, including changes related to transit ridership; auto and taxi vehicle trips; vehicle travel time and distance; person travel by mode; and person travel time and distance. These mobility improvements are summarized in Table 20-2.

Transit Ridership

The number of new riders attracted to the transit system and the number of existing and new transit riders attracted to the new project facilities and services would differ among the project alternatives.

Project Ridership. As shown in Table 20-2, Build Alternative 2 would carry the largest number of passengers (147.5 million) on new project services during the 2020 forecast year, about 28 percent more annual passengers than Build Alternative 1 (115.3 million). The project ridership for Build Alternative 2 includes riders on both the proposed new subway service and the proposed new LRT system, serving the Lower East Side and Lower Manhattan. The project ridership for Build Alternative 1 includes only the new subway service. The TSM Alternative, with its relatively modest improvements to local bus and local subway services, would attract only 15.3 million annual riders to the new project services—87 percent fewer riders than Build Alternative 1 and 90 percent fewer riders than Build Alternative 2.

Table 20-2
Comparison of Project Alternatives: Mobility Improvements

Evaluation Measures	Alternative vs. No Build			Alternative vs. TSM	
	TSM	Build 1	Build 2	Build 1	Build 2
Transit Ridership					
Project Ridership					
All Origins*	15,268,500	115,272,000	147,501,600	100,003,500	132,233,100
Origins Within East Harlem and Upper East Side*	13,785,600	40,207,200	39,357,600	26,421,600	25,572,000
New Transit Riders*	285,000	1,092,000	1,596,000	807,000	1,311,000
Net Change in Transit Travel Time and Distance					
Person Hours Traveled Per Year	-1260,000	-11,340,000	-12,300,000	-10,080,000	-11,040,000
Person Miles Traveled Per Year	2,430,000	20,700,000	26,580,000	18,270,000	24,150,000
Net Change in Auto and Taxi Vehicle Trips					
Automobile Trips	-230,800	-623,100	-883,800	-392,300	-652,000
Taxi Trips	-13,800	-175,400	-281,500	-161,600	-267,700
Net Change in Vehicle Travel Time and Distance					
Vehicle Hours Traveled Per Year					
City-Wide	4,800	-127,200	5,037,600	-132,000	5,032,800
Primary Study Area	43,200	-33,600	2,239,200	-76,800	2,196,000
Vehicle Miles Traveled Per Year					
City-Wide	-2,190,000	-2,730,000	-840,000	-540,000	1,350,000
Primary Study Area	-900,000	-1,530,000	-1,470,000	-630,000	-570,000

Note: * Trips/year.

New Transit Riders. The mobility improvements provided by the project alternatives would generally result in a few thousand people a day changing mode from auto, taxi, or walk to transit. As shown in Table 20-2, Build Alternative 2 would attract the largest number of new subway, bus, and light rail riders, totaling approximately 1.6 million transit trips per year in 2020. This is followed by Build Alternative 1 and the TSM Alternative, which would attract approximately 1.1 million and 0.6 million new subway and bus trips, respectively. These estimates of new transit riders would also approximate the net change in annual transit ridership that New York City Transit could expect due to these proposed transit improvements.

Auto and Taxi Vehicle Trips

All three project alternatives would reduce auto and taxi trips citywide. The TSM Alternative would reduce auto and taxi trips the least—by only 245,000 vehicle trips per year. Build Alternatives 1 and 2 would reduce auto and taxi trips substantially more—by 799,000 and 1,165,000 vehicle trips per year, respectively. See Table 20-2 for details.

Vehicle Hours Traveled. Only Build Alternative 1 would reduce vehicle hours of travel (VHT) both citywide and within the primary study area—a reduction of 127,200 and 33,600 vehicle-hours, respectively, as shown in Table 20-2. The TSM Alternative and Build Alternative 2 would result in a net increases in VHT both citywide and within the primary study area. These VHT increases indicate a worsening of traffic congestion and slower travel speeds due to the reduced street capacity caused by the priority bus lanes in the TSM Alternative and the LRT in Build Alternative 2. See Chapter 9, "Transportation," for more information.

Vehicle Miles Traveled. All project alternatives would reduce vehicle miles traveled (VMT), due to fewer auto and taxi trips, but some alternatives would reduce VMT more efficiently than others. Citywide, Build Alternative 2 would reduce VMT the least of the three project alternatives, as shown in Table 20-2. This is because on the Lower East Side, increased traffic congestion due to the LRT would result in some trips shifting between East River crossings at Manhattan entry portals. Within the primary study area, the TSM Alternative would reduce VMT by about 40 percent less than Build Alternatives 1 and 2. This increased travel distance would be caused by some auto and taxi trips avoiding traffic congestion on First and Second Avenues by taking a longer route. Build Alternative 1 would reduce VMT the most, both citywide and within the primary study area.

Transit Travel Time and Distance

Travel Time. Build Alternative 1 would reduce transit travel time annually by 11.3 million person hours in the year 2020. Build Alternative 2 would reduce it slightly more, by 12.3 million person hours, as shown in Table 20-2. The TSM Alternative would reduce transit travel the least, by about 1.3 million person hours.

Travel Distance. As expected, all three project alternatives would increase total person miles of travel (pmt) by transit, simply because each alternative would attract more transit trips. Build Alternative 2 would increase it the most (26.6 million pmt) and the TSM Alternative the least (2.4 million pmt), as shown in Table 20-2.

PERSON TRIPS BY MODE

The project alternatives would change travel behavior to varying degrees. In general, people would shift from auto, taxi, local bus, and walk modes to the improved rail transit mode(s). This section compares changes in person trips by mode in the year 2020 for the following categories (see Tables 20-3 and 20-4):

Table 20-3
Comparison of Project Alternatives: Person Trips by Mode—Citywide (Trips per Year)

Evaluation Measures	Alternative vs. No Build			Alternative vs. TSM	
	TSM	Build 1	Build 2	Build 1	Build 2
Net Change in Person Trips by Mode					
Total Person Trips					
Automobile	-300,000	-810,000	-1,149,000	-510,000	-849,000
Taxi	-18,000	-228,000	-366,000	-210,000	-348,000
Transit					
Subway/LRT	405,000	2,349,000	2,955,000	1,944,000	2,500,000
Bus	-120,000	-1,257,000	-1,359,000	-1,137,000	-1,239,000
Walk	33,000	-54,000	-81,000	-87,000	-114,000
CBD-Bound Person Trips					
Automobile	-234,000	-645,000	-951,000	-411,000	-717,000
Taxi	-12,000	-222,000	-360,000	-210,000	-348,000
Transit					
Subway/LRT	357,000	2,046,000	2,634,000	1,689,000	2,277,000
Bus	-147,000	-1,134,000	-1,254,000	-987,000	-1,107,000
Walk	36,000	-45,000	-69,000	-81,000	-105,000
Non-CBD-Bound Person Trips					
Automobile	-66,000	-165,000	-198,000	-99,000	-132,000
Taxi	-6,000	-3,000	-6,000	3,000	0
Transit					
Subway/LRT	48,000	303,000	321,000	255,000	273,000
Bus	27,000	-123,000	-105,000	-150,000	-132,000
Walk	-3,000	-12,000	-12,000	-9,000	-9,000

Table 20-4
Comparison of Project Alternatives—Year 2020: Person Trips by Mode—Primary Study Area (Trips per Year)

	Alternative vs. No Build			Alternative vs. TSM	
Evaluation Measures	**TSM**	**Build 1**	**Build 2**	**Build 1**	**Build 2**
Net Change in Person Trips by Mode					
Origins in the Primary Study Area					
Automobile	-48,300	-300,000	-420,000	-251,700	-371,700
Taxi	-20,700	-210,600	-324,900	-189,900	-304,200
Transit					
Subway/LRT	169,500	1,376,400	1,863,300	1,206,900	1,693,800
Bus	-137,700	-833,700	-1,056,900	-696,000	-919,200
Walk	37,200	-32,100	-61,200	-69,300	-98,400
Upper East Side Origins					
Automobile	-35,199	-253,800	-269,400	-218,700	-234,300
Taxi	-15,900	-199,500	-226,200	-183,600	-210,300
Transit					
Subway/LRT	106,500	1,164,000	1,281,600	1,057,500	1,175,100
Bus	-98,100	-693,900	-769,200	-595,800	-671,100
Walk	42,600	-16,800	-16,200	-59,400	-58,800
Lower East Side Origins					
Automobile	-6,600	-10,500	-38,700	-3,900	-32,100
Taxi	-300	-3,000	-10,200	-2,700	-9,900
Transit					
Subway/LRT	-5,700	13,800	106,800	19,500	112,500
Bus	14,400	2,700	-41,400	-11,700	-58,800
Walk	-1,500	-2,700	-16,200	-1,200	-14,700
Origins Elsewhere in the Primary Study Area*					
Automobile	-6,300	-35,400	-111,300	-29,100	-105,000
Taxi	-5,100	-8,400	-88,800	-3,300	-83,700
Transit					
Subway/LRT	69,000	198,900	474,900	129,900	405,900
Bus	-53,700	-142,800	-246,000	-89,100	-192,300
Walk	-4,200	-12,600	-28,800	-8,400	-24,600

Note: * Other origins in the primary study area include: East Harlem, East Midtown, Midtown South/Medical Center, and Lower Manhattan zones. See Chapter 2 for more information.

- Total Person Trips
- Central Business District (CBD)-Bound
- Non-CBD Bound
- Origins on the Primary Study Area
- Origins on the Upper East Side
- Origins on the Lower East Side
- Origins Elsewhere in the Primary Study Area

Citywide Person Trips

Total Person Trips. Build Alternative 2 would reduce auto, taxi, bus, and walk person trips the most—shifting nearly 2.96 million person trips per year to subway or light rail services, as shown in Table 20-3. Build Alternative 1 would also reduce travel by these four modes—shifting nearly 2.35 million person trips per year to the subway system. The more modest bus and subway system improvements in the TSM Alternative would also reduce travel by auto, taxi, and bus—shifting more than 400,000 person trips per year to the subway system and more than 30,000 trips per year to the walk mode.

CBD-Bound Person Trips. The mode shift changes for trips destined to the CBD south of 60th Street would parallel those described above for total trips. Build Alternative 2 would reduce auto, taxi, bus, and walk person trips the most—shifting about 2.63 million person trips per year to the subway or light rail services, as shown in Table 20-3. Build Alternative 1 would also reduce travel by these four modes—shifting nearly 2.05 million person trips per year to the subway system. The TSM alternative would reduce auto, taxi, and bus trips the least—only 357,000 person trips per year would shift to the subway system and 36,000 person trips would be shifted to walking.

Non-CBD Bound Person Trips. For trips not destined to the CBD, the TSM Alternative would reduce automobile, taxi, and walk trips—shifting 48,000 trips per year to the subway system and 27,000 trips per year to the bus system, as shown in Table 20-3. The two Build alternatives would reduce auto, taxi, bus, and walk trips substantially more than the TSM Alternative. Build Alterative 1 would shift 303,000 trips to the subway system and Build Alternative 2 would shift 321,000 trips to subway and light rail systems.

Primary Study Area Person Trips

Total Person Trips with Origins in the Primary Study Area. For trips with origins in the primary study area, Build Alternative 2 would reduce auto, taxi, bus, and walk person trips the most—shifting about 1.86 million person trips per year to subway or light rail services, as shown in Table 20-4. Build Alternative 1 would also reduce travel by these four modes—shifting nearly 1.38 million person trips per year to the subway system. The more modest bus and subway system improvements in the TSM Alternative would also reduce travel by auto, taxi and bus—shifting nearly 170,000 person trips per year to the subway system and more than 37,000 trips per year to the walk mode.

Origins on the Upper East Side. For trips with origins on the Upper East Side, the TSM Alternative would result in nearly 138,000 fewer bus trips, 48,000 fewer auto trips, and nearly 21,000 fewer taxi trips per year. Nearly 107,000 trips per year would shift to the subway, but nearly 43,000 would also shift to the walk mode (see Table 20-4). Build Alternative 1 would reduce auto, taxi, bus, and walk trips by shifting 1.16 million person trips per year to the subway.

Similarly, Build Alternative 2 would shift more than 1.28 million auto, taxi, bus, and walk trips per year to the subway and light rail transit systems.

Origins on the Lower East Side. The LRT proposed as part of Build Alternative 2 is designed to serve the Lower East Side and Lower Manhattan. This alternative would shift nearly 107,000 person trips per year from the auto, taxi, bus, and walk modes to the subway and light rail systems, as shown in Table 20-4. Build Alternative 1 would shift 16,500 auto, taxi, and walk trips to transit with 83 percent shifting to the subway and 17 percent shifting to the bus. The TSM Alternative would shift more than 14,000 auto, taxi, subway, and walk trips to the enhanced bus service, which would include a busway on First and Second Avenues for the M15 route.

Origins Elsewhere in the Primary Study Area. In the remainder of the primary study area, all three project alternatives would shift trips from auto, taxi, bus, and walk modes to the subway system.* Build Alternative 2 would shift nearly 475,000 trips per year to the subway system, as shown in Table 20-4. This would be more than twice the number of trips shifted under Build Alternative 1 (199,000 trips) and nearly seven times more than would be shifted under the TSM Alternative (69,000 trips). The remainder of the primary study area includes three neighborhoods —Financial District, Civic Center, and Midtown South/Medical Center—that would be served by the proposed LRT in Build Alternative 2.

SYSTEM CAPACITY IMPROVEMENTS

The project alternatives are compared with the No Build and TSM Alternatives based on their system capacity improvements, including changes related to peak period passenger crowding, off-peak passenger standees, and impacts at key transit facilities.

Reduced Peak Period Crowding

Level of Service Concept. This study uses the Level of Service (LOS) concept pioneered for highways (*Highway Capacity Manual*) and adapted for pedestrian use by John Fruin** to differentiate degrees of crowding relief in subway cars. Generally, six levels of service—A through F—are defined, where LOS A is free flow or completely uncrowded conditions and LOS F is completely congested or extremely crowded conditions. The concept of level of service is that a change of one level of service to another is a very noticeable change—both to the user and operator of the transportation facility—while marginal changes within a single level of service are not very significant.

The LOS concept has been used by NYCT for designing subway station pedestrian circulation elements. In this application and others, NYCT prefers to define the lower boundary of LOS C as the design guideline capacity of a facility, where the ratio of volume-to-capacity, or v/c, is 1.00. For subway car crowding, this would be 3 square feet per standing passenger, or approximately 110 passengers in an A Division subway car.

* Other origins in the primary study area include East Harlem, East Midtown, and Lower Manhattan. See Chapters 2, “Alternatives Considered,” and 3, “Land Use, Zoning, and Public Policy,” for more information on neighborhoods in Manhattan.

** Fruin, John J., “Pedestrian Planning and Design,” Metropolitan Association of Urban Designers and Environmental Planners, Inc., New York, 1971.

Table 20-5 shows the relative distribution of subway car capacities to define the six levels of service. The upper boundary between LOS E and LOS F is that defined earlier by Fruin. When subway cars are combined into trains, this concept is easily extended to the line haul capacity of a subway or commuter railroad line.

Table 20-5
Volume-to-Capacity Ratio and Level of Service For Subway Cars

NYCT A Division Subway Car*		
Subway Car Passenger Volume	V/C Ratio	LOS
66 or less	0.60 or less	A
67-83	0.61-0.85	B
84-110	0.86-1.00	C
111-137	1.01-1.15	D
138-165	1.16-1.30	E
166 or more	1.31 or more	F

Note:
* The same v/c ratio ranges LOS categories would apply to other NYCT subway car series, but the subway car passenger volume ranges would change depending on the size of the subway car.

Generally, LOS F conditions are not common, and occur on subway lines only during the peak 15-minutes or on individual trains or on individual cars within a train consist. No MESA transit model runs have reported a line segment with LOS F conditions for the entire peak hour. This analysis, therefore, focuses mostly on LOS E and LOS D conditions. Using a v/c ratio of 1.15 as the boundary between LOS D and E is supported by NYCT's assignment model calibration, where it was found that when crowding reaches this level, subway passengers begin significantly to shift to other, less crowded route alternatives. In other words, crowding where the v/c ratio is between 1.00 and 1.15 is generally uncomfortable and inefficient, but tolerable. Crowding where the v/c ratio is above 1.15 is no longer tolerable to a significant proportion of subway riders.

Subway Crowding Comparisons. The TSM Alternative, which would add three local trains during the AM peak period through dwell time reduction measures, would not eliminate any crowded subway segments, but it would noticeably reduce the number of subway passengers experiencing very crowded (LOS E) conditions. This is because riders would be expected to transfer from the overcrowded Lexington Avenue express service (Nos. 4 and 5 trains) to the comparatively frequent, but less crowded Lexington Avenue local service (No. 6 train). As shown in Table 20-6, the TSM Alternative in 2020 would reduce passenger exposure to LOS E conditions by 2.3 million passenger hours per year, but it would increase passenger exposure to LOS D conditions by nearly 342 thousand passengers hours per year.

Build Alternatives 1 and 2 would reduce the number of crowded subway line segments system-wide by more than 40 percent, including all crowded segments in Manhattan. These two Build

Table 20-6
Comparison of Project Alternatives: System Capacity Improvements

Evaluation Measures	Alternative vs. No Build			Alternative vs. TSM	
	TSM	Build 1	Build 2	Build 1	Build 2
Net Change in Peak Period Crowding					
Passenger Hours of Crowding per Year					
LOS E (v/c ratio = 1.16-1.30)*	-2,300,100	-1,093,000	-1,147,000	1,215,100	1,161,100
LOS D (v/c ratio = 1.01-1.15)*	342,600	-9,217,800	-10,239,700	-9,560,400	-10,582,400
Net Change in Off-Peak Passenger Standing					
Passenger Hours of Standing per Year	-2,042,100	-10,712,500	-11,830,400	-8,670,400	-9,788,300

alternatives would reduce passenger exposure to LOS E conditions, but only about half as much as the TSM Alternative. The reason is that these two Build alternatives, with the new subway service and its connection to the 63rd Street line, would attract 15 percent more riders to the already heavily used Q subway service from Queens. Build Alternatives 1 and 2 would, however, dramatically reduce passenger exposure to LOS D conditions by approximately 9.2 million and 10.2 million passenger hours per year, respectively.

Off-Peak Standing Passengers

During off-peak hours, people make many discretionary trips where time of day and mode choice are more flexible. New York City Transit has a goal of attracting more of these discretionary trips to the subway system. One way they are doing so is by making the ride more comfortable by providing passengers with the ability to find a seat, if passengers would distribute themselves throughout the length of the train. While this objective has only been achieved to a limited extent to date, Build Alternatives 1 and 2 would be expected reduce off-peak passenger standing by 10.7 million and 11.8 million passenger hours per year, respectively, as shown in Table 20-6. Most of this improvement would occur on the Lexington Avenue local subway service. The TSM Alternative, however, would only modestly reduce off-peak passenger standing by 2.0 million passengers per year, again mostly on the Lexington Avenue local.

Key Subway Station Impacts

The project alternatives would also change transfer movement patterns and/or volumes at major subway stations on the Lexington Avenue and N and R lines (see Table 9D-29 in Chapter 9, "Transportation").

TRANSIT ACCESSIBILITY IMPROVEMENTS

Each project alternative would improve accessibility to the transit system. As shown in Table 20-7 below, Build Alternative 2 would serve the largest population, followed by the TSM alternative and Build Alternative 1.

The project alternatives are compared with the No Build Alternative and the TSM Alternative based on their transit travel time savings for trips with both origins and destinations within Manhattan. Selected neighborhood origins are paired with several destinations in other neighborhoods, and the travel times are compared between alternatives, based on output from the MESA

Table 20-7
Population within ¼-Mile and ½-Mile of the Project Alternatives

Alternative	¼-Mile		½-Mile	
	Total Population	Population below Poverty Level	Total Population	Population below Poverty Level
TSM	468,874	35,406	554,687	61,130
Build Alternative 1	188,693	46,362	316,982	55,374
Build Alternative 2	369,838	96,927	628,654	115,963

Source: 1990 Census of Population and Housing.

Project's transit assignment model. The changes in travel time are compared and summarized in Table 20-8 by origin neighborhood.

The travel time savings for trips originating in East Harlem (East 110th Street between First and Second Avenues) are summarized at the top of Table 20-8 for six destinations in neighborhoods throughout Manhattan. With the exception of Grand Central and the NYU Medical Center, the two Build alternatives would provide very significant travel time savings for trips to Times Square, Chelsea (23rd Street), West Lower Manhattan, and the East Financial District, ranging between 10 and 18 minutes. Trips to the NYU Medical Center would be best served by the improved M-15 bus service proposed in the TSM Alternative, where an 8-minute time savings is estimated. No significant travel time change is predicted for trips to the Grand Central area.

Upper East Side

For trips originating in the Upper East Side (East 86th Street between First and Second Avenues), the two Build Alternatives would provide very significant travel time savings to Times Square and Chelsea (23rd Street), ranging between 9 and 15 minutes. More modest travel time savings would be provided to West Lower Manhattan and the East Financial District, ranging between 2 and 6 minutes. Here, the LRT in Build Alternative 2 would provide 4 additional minutes of travel time savings to the East Financial District, compared with Build Alternative 1. Trips to the NYU Medical Center would again be better served by the improved M-15 bus service on the First and Second Avenue busways, proposed in the TSM Alternative, where a 6-minute time savings is estimated. No significant travel time change is predicted for trips to the Grand Central area.

For trips originating near the Lexington Avenue subway line (East 86th Street and Lexington Avenue), trips to the East Financial District (Wall Street at Water Street) would also be shortened by 6 minutes with the LRT in Build Alternative 2.

Lower East Side

For trips originating at East 8th Street and Avenue C in the Lower East Side, the light rail service in Build Alternative 2 provides very significant travel time savings to Union Square,

Table 20-8
Comparison of Project Alternatives: Accessibility Improvements Average Travel Time Savings per Trip 2020 AM Peak Hour (minutes)

		Alternative vs. No Build			Alternative vs. TSM	
Trip Origin	Trip Destination	TSM	Build 1	Build 2	Build 1	Build 2
East Harlem						
E. 110th St. btwn First and Second Aves.	Grand Central Terminal	0	-1	-1	-1	-1
	Times Square	0	14	15	14	15
	Chelsea (23rd Street)	0	17	18	17	18
	NYU Medical Center	8	0	0	-8	-8
	West Lower Manhattan	0	11	11	11	11
	East Financial District	0	10	10	10	10
Upper East Side						
E. 86th St. btwn Second and Third Aves.	Grand Central Station	0	1	1	1	1
	Times Square	0	9	9	9	9
	Chelsea (23rd Street)	1	15	15	14	14
	NYU Medical Center	6	0	0	-6	-6
	West Lower Manhattan	1	6	6	5	5
	East Financial District	1	2	6	1	5
Upper East Side						
East 86th St. and Lexington Ave.	Times Square	-2	0	0	2	2
	NYU Medical Center	2	0	0	-2	-2
	East Financial District	0	2	6	2	6
Lower East Side						
East 8th St. and Avenue C	Union Square	0	0	12	0	12
	Times Square	0	2	10	2	10
	NYU Medical Center	21	21	21	0	0
	Civic Center	6	6	16	0	10
	West Lower Manhattan	0	0	3	0	3
	East Financial District	2	2	12	0	10
Midtown South/Chelsea						
West 23rd St. btwn Sixth and Seventh Aves.	Grand Central Terminal	0	0	0	0	0
	Civic Center	0	0	0	0	0
	Upp. E. Side / NY Hosp.	4	11	11	7	7
Midtown South/Union Square						
West 14th St. btwn Sixth and Seventh Aves.	Times Square	0	1	1	1	1
	NYU Medical Center	0	0	0	0	0
	East Financial District	1	1	4	0	3
Lower Manhattan/Civic Center						
Reade St. btwn B'way & Church St.	Grand Central Terminal	0	0	0	0	0
	Upp. E. Side / NY Hosp.	2	12	12	10	10
	Union Square	0	3	3	3	3
Lower Manhattan/Financial District						
Water St. at Whitehall St.	Times Square	0	3	3	3	3
	East Village	0	0	0	0	0
	Upp. E. Side / NY Hosp.	2	6	6	4	4

Times Square, NYU Medical Center, the Civic Center area and East Financial District, ranging between 12 and 21 minutes. The other alternatives provide only modest, if any, travel time savings.

Midtown South/Chelsea

For trips originating on West 23rd Street between Sixth and Seventh avenues in the Midtown south neighborhood, both Build alternatives would save 11 minutes on trips to the Upper East Side.

Lower Manhattan / Financial District

Trips originating on Water Street near Whitehall Street in Lower Manhattan would save a modest amount of travel time to the Upper East Side (6 minutes) and Times Square (3 minutes) with either of the two Build alternatives.

C. COST EFFECTIVENESS ANALYSIS

OVERALL APPROACH

The cost effectiveness of the project alternatives were determined by identifying the customer and social benefits for each alternative and comparing these benefits in various ways with the project costs. These measures include the net present value of the public investment and the benefit-cost ratio. The net present value measures the project's cumulative financial effect over the project's life cycle. The benefit-cost ratio compares the overall customer and social benefits of each project alternative, as compared with the No Build Alternative, to total investment in the project. Selected MTA and FTA business measures are also computed and compared.

CUSTOMER AND SOCIAL BENEFITS

Several of the comparative evaluation measures, discussed earlier in this chapter, were selected as representative of the project alternatives' customer and social benefits:

- Travel time savings
- Peak period crowding reductions
- Off-peak standing passenger reductions
- Non-recurring subway passenger delay reductions
- Auto and taxi travel reductions

Table 20-9 summarizes and compares the monetary value of customer and social benefits by category for the project alternatives.

TRAVEL TIME SAVINGS

Analytical Approach

Travel time savings is usually the single most important benefit in comparing one transportation alternative with another. Travel time savings are computed as the net person travel time savings for transit modes and auto and taxi modes combined. There is general consensus in the transportation planning literature that travel time has a monetary value, and this value is

Table 20-9

Customer & Social Benefits

Benefit Category	1997 Benefit Value per Unit	Units	Comparison of Project Alternatives: 2020 Trip or Travel Characteristic (AM peak hour -- see units): Alternative vs. No Build: TSM	Build 1	Build 2	2020 Annual Customer & Social Benefits (1997 dollars in millions): Alternative vs. No Build: TSM	Build 1	Build 2	Alternative vs. TSM: Build 1	Build 2
Travel Time Savings										
Change in Transit Person Travel Time										
In-Vehicle Time Savings	$10.15	pht	495	2,426	1,831	12.05	59.10	44.60	47.05	32.55
Out-of-Vehicle Time Savings	$20.30	pht	147	2,650	3,880	7.14	129.11	189.03	121.97	181.89
Change in Auto / Taxi Person Travel Time										
In-Vehicle Time Savings	$10.15	pht	(25)	20	(1,306)	(0.61)	0.48	(31.81)	1.09	(31.20)
Total Travel Time Savings Benefit						*18.58*	*188.69*	*201.82*	*170.11*	*183.24*
Reduced Peak Period Subway Crowding										
Change in PHT Spent in Crowded Conditions										
Reduced Crowding at LOS E	$7.11	pht	3,119	1,477	1,550	16.40	7.77	8.15	(8.63)	(8.25)
Reduced Crowding at LOS D	$2.54	pht	(463)	12,456	13,837	(0.87)	23.39	25.98	24.26	26.85
Total Reduced Peak Period Crowding Benefit						*15.53*	*31.16*	*34.13*	*15.63*	*18.60*
Reduced Off-Peak Standing Passengers										
Change in Passenger Hours Spent Standing										
Reduced Standing	$2.54	pht	2,327	12,208	13,482	5.18	27.18	30.02	22.00	24.84
Total Reduced Off-Peak Standing Benefit						*5.18*	*27.18*	*30.02*	*22.00*	*24.84*
Reduced Non-Recurring Subway Delays										
Change in Travel Time due to Service Problem										
Incident on Lexington Avenue Express	$1.02	pht	643	4,508	5,146	1.57	10.98	12.54	9.41	10.97
Total Reduced Non-Recurring Delay Benefit						*1.57*	*10.98*	*12.54*	*9.41*	*10.97*
Reduced Auto & Taxi Travel										
Vehicle Operating Cost Savings	$0.09	vmt	916	1,143	351	0.19	0.24	0.07	0.05	(0.12)
Parking Costs Avoided										
Capitalization Costs	$6.67	space	30	81	115	0.48	1.30	1.84	0.82	1.36
User Parking Fee Costs	$12.11	round-trip	48	130	184	1.40	3.78	5.35	2.38	3.95
Taxi Costs Avoided										
Net User Fares (taxi to transit)	$2.27	trip	7	95	152	0.04	0.52	0.83	0.48	0.79
Emissions Reductions										
Carbon Monoxide (CO)	$3,889	ton	0.01852	0.02466	0.00844	0.18	0.24	0.10	0.07	(0.08)
Nitrogen Oxide (NO)	$3,731	ton	0.00086	0.00189	0.00104	0.01	0.02	0.01	0.01	0.00
Volitile Organic Compounds (VOC)	$7,500	ton	0.00104	0.00129	0.00042	0.02	0.02	0.01	0.00	(0.01)
Hydrocarbons (HC)	$1,774	ton	0.00084	0.00132	0.00055	0.00	0.01	0.00	0.00	0.00
Respriable Particulates (PM10)	$11,066	ton	0.00003	0.00007	0.00004	0.00	0.00	0.00	0.00	0.00
Greenhouse Gases (CO2)	$3.56	ton	0.35528	0.44332	0.13614	0.00	0.00	0.00	0.00	0.00
Noise Cost Avoided	$0.003	vmt	916	1,143	351	0.01	0.01	0.00	0.00	0.00
Accident Cost Avoided										
Internal (User) Accident Costs										
Fatal Accidents	$2,317,398	accident	0.000012	0.000016	0.000005	0.07	0.09	0.03	0.02	(0.04)
Injury Accidents	$50,760	accident	0.001523	0.001900	0.000584	0.19	0.23	0.07	0.05	(0.11)
Property Damage Only Accidents	$2,824	accident	0.002785	0.003475	0.001067	0.02	0.02	0.01	0.00	(0.01)
External (Societal) Accident Costs										
Fatal Accidents	$408,952	accident	0.000012	0.000016	0.000005	0.01	0.02	0.00	0.00	(0.01)
Injury Accidents	$8,958	accident	0.001523	0.001900	0.000584	0.03	0.04	0.01	0.01	(0.02)
Property Damage Only Accidents	$498	accident	0.002785	0.003475	0.001067	0.00	0.00	0.00	0.00	0.00
Total Reduced Auto & Taxi Travel Benefits						*2.64*	*6.53*	*8.34*	*3.89*	*5.70*
Total Annual Customer & Social Benefits						**43.50**	**264.54**	**286.85**	**221.04**	**243.35**

equivalent to a percentage of the prevailing wage rate. FTA Section 5309 guidance states that riders value "out-of-vehicle" time more than "in-vehicle" time, typically by a factor of two. (See "value of travel time" definition below.) This is supported by empirical research and general transportation planning theory, and is endorsed by the MTA for use in Long Range Planning Framework studies. However, because of the nature of travel in the New York region, in-vehicle travel is defined as the time spent in the primary transit mode, while out-of-vehicle travel time is that time spent in accessing the primary transit mode, as well as waiting and transfer times. Thus, a local bus used to access the primary modes—subway or commuter railroad—would be considered out-of-vehicle, or access time. Similarly, a subway line used to access a commuter railroad would be considered out-of-vehicle time from the point of view of the commuter railroad. Both market research and common sense support this relationship, because access mode is viewed as being more onerous by riders of the primary mode.

For the MESA study, the subway and bus networks have been combined into one network to address the recent change in MTA fare policy, whereby riders can transfer between buses and subways for free. Therefore, it is not possible to directly accumulate passenger hours of travel by feeder and line-haul bus services. In an effort to be consistent with the MTA criteria, the MESA study assumes that half the bus passenger hours are associated with access to a primary mode, i.e., subway or commuter railroad. These trips are assigned the higher monetary value of out-of-vehicle travel time. The other half are assumed to be bus passenger hours associated with travel on the primary mode, and these trips are assigned the lower monetary value of in-vehicle travel time.

The MESA study also does not have the capability to compile separate wait times from its transit model. The change in the average wait times between Build and No Build alternatives, however, is minimal (less than 15 seconds), where there is any change at all.

Value of Travel Time

FTA guidance specifies a range of the hourly value of in-vehicle travel time ($6.40 to $10.70) and out-of-vehicle travel time ($12.80 to $21.40) for a composite of personal and business related travel to be used in the analysis for Section 5309 "New Start" funding.*

The New York metropolitan area had an average wage rate in 1997 of $20.30 per hour. The MESA project used half of this average wage rate as hourly value for in-vehicle travel time ($10.15) and the full average wage rate ($20.30) as the value of out-of-vehicle travel time. These values fall within FTA guidelines.

2020 Travel Time Savings Benefits

As shown in Table 20-9, the travel time savings benefits for the TSM Alternative ($18.58 million) represent only one-tenth and one-eleventh of the benefits for Build Alternative 1 ($188.69 million) and Build Alternative 2 ($201.82 million), respectively. Most of the additional travel time savings benefits are due to the proposed East Side subway extension with connections to the Broadway line, which is common to both Build alternatives. Build Alternative 2 gains $45.6 million in benefits over Build Alternative 1, due to the proposed light rail transit service on the

* Source: Appendix C, Tables 4 and 5, "*Technical Guidance on Section 5309 New Start Criteria*," FTA, 1997.

Lower East Side, but it loses $32.3 million in benefits due to increased traffic congestion. Therefore, the net gain in travel time savings benefits for Build Alternative 2 is only $13.3 million.

PEAK PERIOD CROWDING

Analytical Approach

One of the most common customer complaints is "overcrowding" during the AM and PM peak periods. Hence, reduced peak period crowding is another important benefit in comparing one transportation alternative with another. The value of reduced peak period crowding benefit is based on the LOS concept explained above (see Table 20-5, above).

Value of Crowding Reduction

Previous MTA market research has indicated that the elimination of severe overcrowding is valued at approximately 70 percent of the value of travel time.* The MESA study, therefore, set the value of eliminating one passenger hour of peak period crowding (i.e., a change from LOS E to LOS C) at 70 percent of the value of an equivalent reduction of in-vehicle travel time. As previously defined (see above), in-vehicle travel time is valued at $10.15 per hour. Therefore, eliminating overcrowding entirely (LOS E to LOS C) is valued at $7.11 per hour. These 70 percentage points are further split into two components to acknowledge the greater benefit of reducing severe crowding from LOS E to LOS D than reducing moderate crowding from LOS D to LOS C. The MESA study allocated 45 percent to reductions in severe crowding from LOS E to LOS D and allocated 25 percent to reductions in moderate crowding from LOS D to LOS C.

The crowding reduction benefits in dollars are calculated by assigning a "cost per crowded passenger hour" by LOS, e.g., the cost of severe crowding—LOS E conditions—is set at 70 percent of the value of in-vehicle travel time, or $7.11 per crowded passenger hour. Similarly, the cost of moderate crowding—LOS D conditions—is set at 25 percent of the value of in-vehicle travel time, or $2.54 per crowded passenger hour. If crowding is improved from LOS E to LOS D, the value would be the difference between the cost of crowding at LOS E and the cost of crowding at LOS D, i.e., 70 percent minus 25 percent equals 45 percent of in-vehicle travel time, or $4.57 per crowded passenger hour. Under this approach, it is not necessary to know the change in LOS link-by-link between the No Build and Build alternatives. Instead, for each alternative, the crowding cost is computed for each level of service and totaled. The benefits are calculated as the total cost of the crowding for the No Build Alternative minus the total cost of crowding for the TSM or Build alternatives. (A negative value would indicate costs rather than benefits.)

2020 Reduced Peak Period Crowding Benefits

Both Build Alternatives 1 and 2 provide about twice the reduced peak period crowding benefits as the TSM Alternative ($15.53 million), as shown above in Table 20-9. Build Alternative 2

* Vollmer Associates determined this percentage by stripping the MTA's earlier Consumer Decision Criteria (CDC) market research of its monetary values and looking only at the proportional relationships between values.

($34.13 million) has about 10 percent more in reduced peak period crowding benefits than Build Alternative 1 ($31.16 million). This difference is attributed to the proposed LRT serving the Lower East Side and Lower Manhattan.

OFF-PEAK STANDING SUBWAY PASSENGERS

Analytical Approach

The two Build alternatives would provide additional off-peak transit service on the Second Avenue line that would attract riders from the heavily used Lexington Avenue line. This reduced travel demand would enable more passengers on the Lexington Avenue to have seated rides during off-peak hours, especially on the Lexington Avenue local service. The number of passengers benefitting was estimated based on 24-hour cordon counts at the Lexington Avenue lines peak load point—north of the 59th Street station. It was assumed that 75 percent of riders diverted from the Lexington Avenue line during the AM peak hour would also be diverted during the off-peak hours.

Value of Reduced Off-Peak Standing

During off-peak hours, standing passengers would generally be able to find seats on uncrowded Lexington Avenue local trains, which typically operate at LOS A or B conditions. Therefore, compared with reduced peak period crowding, the benefits of reduced off-peak standing should not be high in value. For this reason, the MESA study set the reduced off-peak standing benefit equal to 25 percent of the in-vehicle travel time benefit, or $2.54 per hour, which is the same monetary benefit as eliminating moderate peak period crowding from LOS D to LOS C.

2020 Reduced Off-Peak Standing Benefits

The TSM Alternative is estimated to decrease off-peak standing moderately on the Lexington Avenue service. Hence, the TSM Alternative would have $5.18 million in benefits per year, as shown in Table 20-9. Both Build alternatives would significantly reduce off-peak standing. Build Alternative 2 ($30.02 million) would earn 10 percent more reduced off-peak standing benefits than Build Alternative 1 ($27.18 million).

NON-RECURRING SUBWAY DELAYS

Analytical Approach

Transit service reliability is affected by two very different types of service delays, which NYCT refers to as “recurring” and “non-recurring” delays.

Recurring Delays. Recurring delays are those delays that occur consistently on a daily basis. These delays are largely related to operating a service at or above design capacity—both of the vehicle (subway car or bus) and the guideway (track or roadway). For example, subway cars that are over capacity have delays due to longer dwell times at stations, as passengers squeeze out of and into the car. Tracks that are operated over the design capacity of the signal system have delays due to merging, etc., regardless of the passenger loading condition of the trains’ cars.

Regular transit passengers currently factor in the daily recurring delays into their estimated total travel time. The MESA study has used available data and observations to quantify recurring delay within the primary study area. Estimates have been developed of the likely increases in recurring delays for the future No Build Alternative, as well as the likely decreases in recurring delay that would resulting from the TSM or Build alternatives. These increases and decreases in recurring delay have been incorporated in the track segment running times coded into the transit assignment models for the No Build and Build alternatives. Hence, reductions in these delays would be measured in the travel time savings benefit.

Non-Recurring Delays. Non-recurring delays are those delays resulting from incidents, such as sick passengers, signal or switch malfunctions, etc., which are significant in duration but occur only occasionally.

The MESA study proposes a different approach for non-recurring delays. The Build alternatives do not have any way of preventing non-recurring delays. This type of delay will occur from time to time. The Build alternatives, however, do provide an "escape valve." For example, customers on the Lexington Avenue line, who would not normally use the proposed Second Avenue line, could use this new route to travel around an obstruction on their line.

Using 1995 data, NYCT determined that the Lexington Avenue express service operating between 125th Street and 59th Street had an incident occurring on average once every four AM peak hours. These incidents on average resulted in a 12-minute delay, which affected 10 to 12 trains. Because these delays typically do not affect the entire peak hour, it can be shown that the typical rider would encounter such a delay approximately once every 20 trips, or 5 percent of the time.

To determine the Build alternatives' potential benefit to passengers when non-recurring delays occur, the transit assignment models for No Build and Build alternatives were rerun with an additional 12 minutes of running time on the Lexington Avenue express service to simulate a typical incident. Not surprisingly, total passenger hours would be higher for both the No Build and Build alternatives, compared with the previous model runs without the incident, but the increase is less for the Build alternative. This is a quantifiable benefit.

Value of Reduced Non-Recurring Delay Benefit

The MESA study set the value of the time saved due to reduced non-recurring delays as equal to the out-of-vehicle travel time rate ($20.30 per hour). This higher rate is used because transit customers value "uncertain" travel time saved significantly higher than everyday travel time, by which they plan their day. Because transit riders only experience non-recurring delays on average once every 20 trips or 5 percent, the actual value of travel time saved due to these delays is $1.02 per hour (5 percent of $20.30 per hour).

2020 Reduced Non-Recurring Delay Benefit

The TSM Alternative with a modest increase in local service on the Lexington Avenue line has limited capacity to relieve non-recurring delays on the express service. The resulting benefits ($1.57 million) are small, one-seventh and one-eighth the benefits of Build Alternative 1 ($10.98 million) and Build Alternative 2 ($12.54 million), respectively. Both Build alternatives would provide an alternative subway route on Second Avenue.

AUTO AND TAXI TRIPS

Analytical Approach

The project alternatives would reduce both auto and taxi travel and trips to varying degrees. These reductions would in turn reduce pollutant emissions, conserve energy, reduce noise, avoid accidents, and reduce out-of-pocket expenses, which are quantifiable benefits to society and/or the user. The MESA study used a spreadsheet-based procedure, derived from the Surface Transportation Efficiency Analysis Model (STEAM) to both quantify and establish monetary values for these reduced auto and taxi travel benefits. STEAM was developed by Cambridge Systematics, Inc. for the Federal Highway Administration (FHWA).The full application of STEAM would enable the analyst to compute pollutant emissions, energy consumption, etc., based on link-specific data from the highway assignment model. However, STEAM could not be applied directly on the MESA study, because the underlying computer-based model is currently limited to 2,000 analysis zones, which is exceeded by the MESA model.

For the spreadsheet-based procedure, the MESA study used the following simplifying assumptions in lieu of accumulated link-specific data: (1) the total change in VMT (stratified by mode); (2) the total change in auto and taxi person trips, and (3) the citywide average travel speed (computed by dividing total VMT by total VHT).

The MESA study also used various analysis parameters from STEAM for fuel consumption rates, emission rates (HC, CO, NO, and PM_{10}), cold start emissions, greenhouse gas emissions, cost per ton of emissions, accident costs and accident rates (fatality, injury and property damage only), and noise costs.* For the cost effectiveness analyses, the MESA study applied the pollutant emissions rates from STEAM, which are based on the MOBILE5A air quality model, to calculate the very modest emissions benefits.** New York region-specific percentages were used to stratify VMT into “autos and other light vehicles” (95 percent) and “heavy trucks” (5 percent) and for the proportion of vehicles beginning a trip from a cold start (8 percent).

Value of Reduced Auto and Taxi Travel Benefits

Table 20-9 above summarizes the monetary values of the elements that comprise the reduced auto and taxi travel benefits.

2020 Reduced Auto and Taxi Travel Benefits

The two Build alternatives would produce the most benefits due to reduced auto and taxi travel. Build Alternative 2 ($8.34 million) would produce nearly 28 percent more benefits than Build Alternative 1 ($6.53 million) and 215 percent more benefits than the TSM Alternative ($2.64 million).

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* Analysis parameters are included in the *STEAM Users Manual*, FHWA and Cambridge Systematics, Inc., 1997, as part of Exhibit 4.24, STEAM Scenario File.

** The air quality analyses presented in Chapter 10 of this MIS/DEIS are based on a New York adaptation of MOBILE5B, approved by NYSDEC/NYCDEP.

PROJECT COSTS

The project costs of the alternatives comprise the capital cost of the system improvements and the incremental net operating cost of the project services. All project costs are expressed in 1997 dollars.

CAPITAL COSTS

The total capital cost of an alternative comprises two components, the initial capital cost and re-investment capital cost. Table 20-10 compares the cost of the project alternatives by these two categories at the mid-point of the capital cost range. More detailed cost estimates can be found in Appendix C. The low end of the capital cost range excludes a design contingency and the high end of the range includes a 25 percent design contingency, which is typical for a project at the conceptual engineering stage of design. Hence, the mid-point capital costs presented in this document effectively include a 12.5 percent design contingency.

Initial Capital Cost

The initial capital cost is the full cost of the capital improvement, which includes engineering design, right-of-way acquisition, construction, rolling stock, and other equipment. For a multi-year project like MESA, the initial capital costs include all expenditures from start to completion of the project.

TSM Alternative. The TSM Alternative is estimated to cost $119.0 million at the mid-point of the capital cost range. As shown in Table 20-10, the most costly element in this estimate would be the purchase of 35 new A Division subway cars, which are needed to enhance local service on the Lexington Avenue line. Another significant item would be the construction of a New York busway on First and Second Avenues, which would reduce travel time on the M15 bus route. The faster running times on the M15 route would attract 48 percent more riders, which would normally require 38 more articulated buses to keep the average bus load at the peak load point within service guidelines. The busway's faster running times, however, would enable each bus to travel farther in the same amount of time. Thus, the scheduled service could be provided with only 28 additional articulated buses plus 3 spares for a total 31 additional articulated buses, as shown below in Table 20-11.

Table 20-10
Comparison of Project Alternatives: Capital Costs—Initial and Reinvestment (Millions of 1997 Dollars)

Cost Component	Alternative vs. No Build			Alternative vs. TSM	
	TSM	Build 1	Build 2	Build 1	Build 2
Initial Capital Costs: Mid-Point of Range					
Construction					
Excavation, structures, track, stations, etc.[1]	38.5	2,705.1	3,577.5	2,666.6	3,539.1
Signals, power, line equipment, etc.[2]	1.2	371.3	422.3	370.1	421.1
Rolling Stock					
Subway Cars	66.3	389.9	389.9	323.6	323.6
LRT Cars	0.0	0.0	107.3	0.0	107.3
Articulated Buses	13.0	-0.4	-2.5	-13.4	-15.5
Property Acquisition	0.0	84.4	84.4	84.4	84.4
Total Initial Capital Costs[3]	119.0	3,550.3	4,579.0	3,431.4	4,460.0
Reinvestment Capital Costs: Mid-Point of Range					
Construction					
Excavation, structures, track, stations, etc.[1]	56.7	78.2	346.0	21.5	289.3
Signals, power, line equipment, etc.[2]	0.0	84.0	94.1	84.0	94.1
Rolling Stock					
Subway Cars	28.5	167.7	167.7	139.2	139.2
LRT Cars	0.0	0.0	107.3	0.0	107.3
Articulated Buses	41.2	-1.3	-7.9	-42.5	-49.1
Property Acquisition	0.0	0.0	0.0	0.0	133.9
Total Reinvestment Capital Costs[3]	126.4	328.6	707.2	202.2	580.8

Notes:
[1]Includes excavation, structures, track, stations, yards, and shops.
[2]Includes line equipment, signal equipment, communications equipment, power equipment, and traffic signals, signs, and pavement markings.
[3]Detailed capital cost estimates can be found in Appendix C.

Build Alternative 1. At the mid-point of the capital cost range, Build Alternative 1 is estimated to cost $3.55 billion (see Table 20-10). The highest cost component would be the construction of the new East Side subway extension on Second Avenue between 63rd and 125th Streets. Another major item included in this cost estimate is the purchase of 252 new B Division subway cars, including spares, needed to operate the proposed new subway service. This cost would be partially offset by the need for 46 fewer A Division subway cars, including spares, due to a service adjustment on the Lexington Avenue subway line (see Table 20-11).

Build Alternative 2. Build Alternative 2 is estimated to cost $4.58 billion at the mid-point of the capital cost range (see Table 20-10). Compared to Build Alternative 1, an additional $1.03 billion would be needed to build and equip the proposed LRT. The equipment includes 38 new light rail cars, which are estimated to cost $107.3 million. This LRT would reduce the number of buses needed to serve the Lower East Side, which would reduce the project's net initial capital by $2.5 million. See Table 20-11 for more detail on rolling stock.

Table 20-11
Comparison of Project Alternatives: Rolling Stock Summary

Rolling Stock Category	Alternative vs. No Build			Alternative vs. TSM	
	TSM	Build 1	Build 2	Build 1	Build 2
Subway Cars					
Second Ave./Broadway Service (B Division) Cars					
Peak Hour Service (86th St. station): 27 eight-car trains		216	216	216	216
Spares at 15.8%		36	36	36	36
Total		252	252	252	252
Lexington Ave. Service (A Division) Cars					
Peak Hour Service (86th St. station): 3 or 4 ten-car trains	30	-40	-40	-70	-70
Spares at 15%	5	-6	-6	-11	-11
Total	35	-46	-46	-81	-81
Non-Revenue Cars	0	0	0	0	0
Light Rail Cars					
Lower East Side/Financial District Service					
Peak Hour Service (Chambers St. station): 12 two-car trains plus 10 one-car trains			34	0	34
Spares at 12%			4	0	4
Total			38	0	38
Non-Revenue Motor Vehicles (LRT)			5	0	5
Articulated Buses					
Peak Hour Service (Buses)					
Due to increased demand on M15 bus route	38			-38	-38
Due to faster running times on busway	-10			10	10
Due to service adjustments		-1	-5	-1	-5
Spares at 10%	3	0	-1	-3	-4
Total	31	-1	-6	-32	-37

Reinvestment Capital Cost

Over the 50-year standard service life of the project, various capital investments would have to made to keep the initial system improvements in service. From the prospective of the public, the most obvious capital reinvestment would be the replacement of buses and subway cars after their useful lives of 12 and 35 years, respectively. Other system components would also have to be replaced all or in part. For example, subway line equipment—which includes ventilation and emergency exhaust systems, fan plants, fire controls, tunnel lighting, pump stations, etc.—typically has a 35-year useful life and then requires full replacement of the equipment. Subway station facilities also have a 35-year useful life, but only about 50 percent of the initial capital investment would have to be replaced or rehabilitated. Table 20-12 summarizes for each major capital investment component the standard useful life and the percentage of the initial capital cost that would have to be reinvested over the 50-year service life. These values are used to compute the present value of the reinvestment capital expenditures as part of the cost effectiveness analysis.

Table 20-12
Useful Life of Capital Investment Components: Replacement and Reinvestment Cycles

Capital Investment Components	Replacement Cycle (years)	Reinvestment Cycle (years)	Reinvestment Cost as Percent of Initial Capital cost
Project Planning Costs	100	100	
Property Acquisition (includes 27% soft costs)	100	100	
ROW Grading, Tunneling, and Preparation	100	100	
Structures			
Subway/LRT: Grade Separated	100	50	30%
LRT: Street Railway	50	30	30%
Line Equipment	35	35	100%
Track			
Subway/LRT: Grade Separated	30	30	50%
LRT: Street Railway	30	30	50%
Signals			
Subway/LRT: Grade Separated	50	50	100%
LRT: Street Railway (modified DOT signals)	30	30	100%
Communications	20	20	100%
Power			
Subway/LRT: Grade Separated	40	40	65%
LRT: Street Railway	30	30	65%
Station Facilities			
Subway/LRT: Grade Separated	100	35	50%
LRT: Street Railway	50	30	50%
Shop Facilities	100	17	40%
Storage Yards	40	40	50%
Subway Cars	35	35	100%
LRT Cars	25	25	100%
Buses	12	12	100%

TSM Alternative. As shown above in Table 20-10, the TSM Alternative would require reinvestment capital expenditure of $126.4 million at the mid-point of the capital cost range. A reinvestment capital expenditure of $28.5 million would be needed to replace subway cars after their 35-year useful life. This alternative would also need $41.2 million to replace buses periodically every 12 years over the 50-year standard service life. Construction would require a replacement capital expenditure of $56.7 million.

Build Alternative 1. At the mid-point of the capital cost range, Build Alternative 1 would have a reinvestment capital cost of $328.6 million. Most of this expenditure would be needed to replace rolling stock and other equipment.

Build Alternative 2. Build Alternative 2 would have a reinvestment capital cost of $707.2 million at the mid-point of the capital cost range. Compared with Build Alternative 1, the additional $378.3 million expenditure would be needed to reconstruct and reequip the proposed LRT. Portions of the light rail line built at-grade on city streets would on average have to be replaced sooner than the portions built in a tunnel. These reinvestment expenditures would be partially offset by accumulated savings of $7.9 million, due to the LRT reducing the number of buses needed to serve the Lower East Side.

OPERATING COSTS AND REVENUES

Operating Cost

The implementation of the TSM Alternative or either of the two Build alternatives would affect NYCT's operating and maintenance budgets for its subway and bus systems. The incremental operating costs above those for the future No Build condition were derived component-by-component from 1996 data provided by NYCT. For each operating and maintenance cost component three variables were defined, where applicable:

- Unit of Service (e.g., subway car miles, track miles, bus hours, etc.)
- Productivity Ratio (e.g., crew persons per train, track workers per track mile, etc.)
- Unit Cost (e.g., dollars per crew person hour, track worker salary per year, dollars per station)

Table 20-13 summarizes the net annual operating costs (savings) for the bus, subway, and light rail system improvements in 1997 dollars for the three project alternatives. The operating costs for the TSM Alternative and Build Alternative 2 include traffic enforcement costs needed to maintain the reliability of the proposed busway and light rail system, respectively. The TSM Alternative would have the lowest annual operating cost at $6.5 million, followed by Build Alternative 1 at $25.8 million, and Build Alternative 2 at $36.7 million.

Table 20-13

Comparison of Project Alternatives: Operating Cost and Fare Revenue (Millions of 1997 Dollars)

Cost Component	Alternative vs. No Build			Alternative vs. TSM	
	TSM	Build 1	Build 2	Build 1	Build 2
Operating and Maintenance Costs for Project Services: Net Annual Operating Costs (Savings)					
Subway System	2.15	26.03	26.08	23.88	23.93
Light Rail System	0.00	0.00	10.64	0.00	10.64
Bus System	3.18	-0.19	-0.67	-3.37	-3.85
Traffic Enforcement Agents	1.18	0.00	0.63	-1.18	-0.56
Total Operating and Maintenance Cost	6.51	25.84	36.68	19.33	30.16
New Transit Riders: Net Change in Transit Ridership					
Subway LRT*	405,000	2,349,000	2,955,000	1,944,000	2,550,000
Bus*	-120,000	-1,257,000	-1,359,000	-1,137,000	-1,239,000
Total New Transit Riders					
Fare Revenue: Net Change in Fare Revenue					
Subway/LRT	0.55	3.17	3.99	2.62	3.44
Bus	-0.16	-1.70	-1.83	-1.54	-1.67
Total Fare Revenue	0.39	1.47	2.16	1.08	1.77

Note: * Trips/year.

Fare Revenue

The bus, subway, and light rail system improvements proposed in the TSM and Build alternatives would divert large numbers of existing bus and subway riders to the new project transit services, but these improvements would also attract new transit riders. These new bus and subway/LRT riders would produce additional fare revenue for NYCT, as shown in Table 20-13, approximately $0.4 million, $1.5 million, and $2.2 million for the TSM Alternative, Build Alternative 1, and Build Alternative 2, respectively. The average fare with MetroCard discounts is assumed to be $1.35 in 1997 dollars.

COST EFFECTIVENESS MEASURES

There are three cost effectiveness measures upon which the project alternatives are compared:

- Net Present Value—Public Investment
- Incremental Cost per Incremental Passenger
- Benefit-Cost Ratio

These cost effectiveness measures are defined below and summarized in Table 20-13 for the TSM and the two Build alternatives. The analytical assumptions used in computing these cost effectiveness measures are also summarized in Table 20-13.

NET PRESENT VALUE—PUBLIC INVESTMENT

Methodology

The Net Present Value (NPV) of the public investment is a measure of the project's cumulative financial effect over the project's life cycle. It is computed by subtracting present value costs from present value benefits. The relative magnitude of the positive net present value indicates the amount by which benefits are greater than costs in base year dollars. The definitions of financial benefits and capital costs are the same as those used in the Benefit-Cost Ratio (see below). Present value is the total amount that a series of future payments is worth in the base year and at a prescribed discount rate. The results of the present value function are summarized in Table 20-13 for:

- Customer and Social Benefits
- Net Operating Costs (Savings)
- Construction Cost

The MESA study and other Long Range Planning Framework projects use 1997 as their base year in computing benefits and costs. The discount rate reflects the value of time waiting for benefits to accrue, or put another way, how the current generation feels about investing today's funds for the benefit of a future generation. Use of discounting is warranted when the ratio of costs and benefits is not constant through the analysis period, which is the case for MESA project alternatives. The discount rates do not include interest rates, inflation rates, or estimates of project risk. It is not necessary to include inflation, because all costs and revenues are expressed in constant 1997 dollars. Risk are reflected in the capital cost contingencies.

The MTA Capital Program uses as a matter of policy a discount rate of 2.65 percent per year, while FTA Section 5309 guidance requires a discount rate of 7 percent per year. The MESA study uses MTA's discount rate as the default value, but it also applies FTA's discount rate to a few selected measures required by FTA.

Comparing Net Present Values

All three project alternatives at the MTA's discount rate have positive net present values for public investment, as shown in Table 20-14. Build Alternative 1 has the highest net present value of $1.68 billion. Compared to the other two project alternatives, it would have the greatest positive financial effect over the life of the project, because the present value of its benefits exceeds the present value of its costs by the greatest amount. It would be followed by Build Alternative 2 with a net present value of $ 1.06 billion, and distantly followed by the TSM Alternative with a net present value of $673 million.

INCREMENTAL COST PER PASSENGER

The incremental cost per *incremental* passenger is a cost effectiveness measure preferred by the FTA. This measure, expressed in the base year dollars, is based on the annualized total capital investment (federal and local funds) and the annual operating costs divided by the forecast change in annual transit system ridership. This measure is calculated using the higher FTA discount rate of 7.0 percent. The project alternatives are compared with the No Build and TSM Alternatives in Tables 20-14.

In the case of the MESA project, however, a measure based on "benefitting" passengers rather than "new" riders is more appropriate. Unlike a traditional new start project, whose primary purpose is to create a new transit customer base where none exists today, the MESA build alternatives benefit a large base of existing customers as well as attracting new transit riders. This is important because the build alternatives preserve a high market share that is critical to the region's mobility. Transit passengers benefitting from the build alternatives are described above in Section B and quantified above in Table 20-1.

Table 20-14
Comparison of Project Alternatives:
Cost Effectiveness Summary (1997 Dollars)

Cost Component	Alternative vs. No Build: TSM	Alternative vs. No Build: Build 1	Alternative vs. No Build: Build 2	Alternative vs. TSM: Build 1	Alternative vs. TSM: Build 2
MTA Analysis Method: Discount Rate: 2.65% Base Year: 1997 Federal/MTA Funding Shares: 50%/50% Standard Service Period: 50 years Construction Start: TSM Alternative: 2003 Build Alternative: 2004 Service Start: TSM Alternative: 2007 Build Alternative: 2014					
Present Value (millions of 1997 dollars)					
Customer and Social Benefits	946.2	4,668.2	5,061.7	3,721.9	4,115.5
Net Operating Costs (Savings)	141.6	456.0	647.7	314.4	506.1
Capital Costs					
Initial	94.9	2,416.4	3,138.6	2,321.5	3,043.7
Reinvestment	37.3	120.4	215.8	83.1	178.6
Cost Effectiveness Measures					
Net Present Value – Public Investment (millions of 1997 dollars)	672.5	1,675.4	1,058.6	1,002.9	387.2
Benefit Cost Ratio	3.46	1.56	1.26	1.37	1.10
Federal Analysis Method: Discount Rate: 7.00% Base Year: 1997 Federal/MTA Funding Shares: 50%/50% Standard Service Period: 50 years Construction Start: TSM Alternative: 2003 Build Alternative: 2004 Service Start: TSM Alternative: 2006 Build Alternative: 2014					
Cost Effectiveness Measures					
Incremental Cost per Incremental Passenger (1997 dollars/trip)	42.00	128.00	115.00	158.00	131.00
Incremental Cost per Benefitting Passenger (1997 dollars/trip)	4.38	1.21	1.61	1.13	1.54

The incremental cost per benefitting passenger is based on the annualized total capital investment (federal and local funds) and the annual operating costs, divided by the total annual passengers benefitting in the forecast year from Table 20-1. This measure is expressed in base year dollars and is calculated using the higher FTA discount rate of 7.0 percent. The project alternatives are compared with the No Build and TSM Alternatives in Table 20-14.

Comparing Cost per Passenger

Incremental Cost per Incremental Passenger. The TSM Alternative has the lowest incremental cost per incremental passenger, $42 per trip. Both Build alternatives have much higher incremental costs per incremental passenger. Build Alternative 2 has the second lowest value ($115 per trip), and Build Alternative 1 has the highest value ($128 per trip). The difference between the two Build alternatives is relatively small.

Incremental Cost per Benefitting Passenger. The TSM Alternative has the highest incremental cost per benefitting passenger, $4.38 per trip. Both Build alternatives have much lower incremental costs per benefitting passenger. Build Alternative 2 has the second highest value of $1.61 per trip and Build Alternative 1 has the lowest value of $1.21 per trip. The difference between the two Build alternatives, while small, is significant.

New York Context

The incremental cost per incremental passenger is relatively high for the two Build alternatives. The reason is that New York City is already highly transit-oriented. Citywide, 47 percent of passengers travel by subway or bus during the AM peak period; within the primary study area, 50 percent do so. For CBD-bound trips, the AM peak period transit share increases to 75 percent citywide, and is likely to be higher for origins within the primary study area. Hence, it is difficult for the MESA Project to attain large increases in transit ridership within a corridor already served by transit, even though the existing transit services are operated at near capacity, and trains and buses are overcrowded.

On the other hand, the incremental cost per *benefitting* passenger is relatively low for the two Build alternatives. Considering New York City's transit-orientation, this is a better measure to compare the project's alternatives.

BENEFIT-COST RATIO

The Benefit-Cost Ratio (B/C) measures the overall social benefit of the total investment in the project. The central question of this analysis is whether the regional or citywide "well-being" would be increased with the proposed investment. The numerator includes the discounted present value of project customer and social benefits, where the definition of benefits is as expansive as possible. The customer and social benefits used for the MESA study are defined above. The denominator includes the discounted present value of the project's total capital costs and any social costs of the project.[*] Ratios over 1.0 are associated with projects where the customer and social benefit values exceed the value of the total capital investment.

Comparing Benefit Cost Ratios

All three project alternatives have benefit cost ratios greater than 1.00 under the MTA discount rate, which means the value of customer and social benefits exceeds the value of the capital investment (see Table 20-14). The TSM Alternative, with its relatively low capital cost and modest benefits, has the highest benefit cost ratio of 3.46. Of the two Build alternatives, Build Alternative 1 has the higher benefit cost ratio of 1.56. Build Alternative 2 has the lower, but still very respectable, benefit cost ratio of 1.26.

MTA BUSINESS MEASURES

In addition to the cost effectiveness measures described above, the MTA uses two selected "business measures" to evaluate proposed capital investments:

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* Revenues and subsidies to the MTA are excluded from this benefit-cost analysis, since they reflect a transfer of wealth from one sector to another rather than an increase in regional productivity, quality of life, or competitiveness. This exclusion includes fare revenue from new transit riders.

- Net Annualized Capital Cost
- Operating Cost per Passenger Mile

These business measures are defined below and summarized in Table 20-15 in two categories, capital cost related and operating cost related. Within these two categories, the project's alternatives are compared with the No Build and TSM Alternatives.

NET ANNUALIZED CAPITAL COST

Definition. The Net Annualized Capital Cost is equivalent to the annual payment that would be paid if the cost of the project were "financed" over the 50-year standard service life. It is calculated based on the discounted present value of the initial capital cost plus the discounted present value of the reinvestment capital cost over a 50-year term at interest rates equal to the discount rate. The MTA's discount rate of 2.65 percent is used.

Comparing Annualized Capital Costs. The TSM Alternative has the lowest net annualized capital cost of $4.8 million. Both Build alternatives have much higher annualized capital costs, as shown in Table 20-15. Build Alternative 1 has an annualized cost of $92.1 million, and Build Alternative 2 has an annualized cost of $121.8 million.

OPERATING COST PER PASSENGER MILE

Definition. The operating cost per passenger mile is reported for the entire transit system for the project alternatives as compared with the No Build and TSM Alternatives. At the request of FTA, this measure is also computed by the incremental operating cost per incremental passenger mile due to the new project facilities and services.

Comparing Project Alternatives. Systemwide, the operating cost per passenger mile would not change very much due to the project alternatives, as shown in Table 20-15. It is estimated this cost would increase 0.04, 0.16, and 0.22 cents per passenger mile, due to the TSM Alternative, Build Alternative 1, and Build Alternative 2, respectively. The incremental operating cost per incremental passenger mile would be substantially higher: $2.68, $1.25, and $1.38 per passenger mile for these three alternatives, respectively. Under this FTA measure, the two Build alternatives have the lowest incremental operating cost per incremental passenger mile.

Table 20-15
Comparison of Project Alternatives: MTA Business Measures (1997 Dollars)

Business Measure	Alternative vs. No Build			Alternative vs. TSM	
	TSM	Build 1	Build 2	Build 1	Build 2
Capital Cost Related: MTA Analysis Method*					
Annualized Capital Cost (millions of 1997 dollars)	4.8	92.1	121.8	87.3	117.0
Operating and Maintenance (O&M) Cost Related					
O&M Cost per Passenger Mile (1997 dollars /passenger mile)					
System-wide	0.00042	0.00156	0.00223	0.00114	0.00181
Project Increment	2.68	1.25	1.38	1.06	1.25

Note:
* MTA Analysis Method:
Discount Rate: 2.65%
Base Year: 1997
Federal/MTA Funding Shares: 50%/50%
Standard Service Period: 50 years
Construction Start:
TSM Alternative: 2003
Build Alternatives: 2004
Service Start:
TSM Alternative: 2007
Build Alternatives: 2014

D. FINDINGS AND CONCLUSIONS

FINDINGS

TSM ALTERNATIVE

The TSM Alternative has some favorable cost effectiveness measures, including the lowest incremental cost per incremental passenger and highest benefit cost ratio. However, this alternative does not address the project's purpose and needs, as demonstrated by its having the highest incremental cost per benefitting passenger, and the lowest reduction in subway overcrowding and smallest travel time savings. This paradox is explained by the TSM Alternative's limited scope—enhanced local subway service on the Lexington Avenue line and dedicated bus lanes on First and Second Avenues—which results in the lowest initial and reinvestment capital costs.

BUILD ALTERNATIVE 1

Build Alternative 1 would provide solid transit mobility improvements and the best reduction in auto and taxi travel. It addresses the project's purpose and needs, as demonstrated by its second-place rankings in both reduced subway crowding and travel time savings. Moreover, these transit benefits would be achieved without increasing traffic congestion in Manhattan. Build Alternative 1 has solid cost effectiveness measures, including the highest net present value and the second highest benefit cost ratio.

BUILD ALTERNATIVE 2

Build Alternative 2 would provide the best transit mobility and accessibility improvements and the most favorable reduction in non-transit trips. This alternative, however, would have a large increase in vehicle hours of travel in the primary study area, which indicates a very significant increase in traffic congestion, due to the on-street operation of the proposed light rail transit component. Build Alternative 2 would produce the most customer and social benefits, but its cost effectiveness measures are comparatively weak. Its benefit cost ratio would be the lowest of the three alternatives and its net present value would be second lowest. This is because the addition of the light rail service would not generate sufficient benefits to offset the $1.03 billion increase in initial capital costs and $280 million increase in reinvestment capital costs.

CONCLUSIONS

TSM ALTERNATIVE

The TSM Alternative does not provide a satisfactory response to the project's purpose and needs. Therefore, it is not a viable stand-alone alternative. This alternative's limited customer and social benefits are nevertheless provided in a very cost effective manner—resulting a benefit cost ratio of 3.46. Hence, elements of the TSM Alternative should be considered as complementary additions to one of the Build alternatives.

BUILD ALTERNATIVE 1

Overall, Build Alternative 1 provides the best combination of improved transit mobility and accessibility, reduced auto and taxi trip making, and cost effectiveness. It has a very acceptable benefit cost ratio of 1.56.

BUILD ALTERNATIVE 2

The difference between Build Alternative 1 and 2 is that Build Alternative 2 includes the LRT serving the Lower East Side and Lower Manhattan. The addition of the LRT would provide significant improvements, especially in the Lower East Side, related to transit mobility, transit accessibility, and auto and taxi trip reductions. On the other hand, Build Alternative 2 would increase vehicular traffic congestion. The resulting net customer and social benefits of the LRT, however, do not justify the $1.03 billion increase in initial capital cost, which results in this alternative having the lowest—but still acceptable—benefit cost ratio of 1.26. ❖