3

A CONTEXT FOR OUR PLANNING—SYSTEM PERFORMANCE AND FUTURE NEEDS

The performance targets which appear in the following section are regularly updated. The most current targets are available at the Regional Transportation Plan web area

3.1 OVERVIEW

Moving Forward *defines NYMTC's Shared Vision for Regional Mobility and describes the recommended approaches, actions, and investment of resources in projects, programs, and studies to pursue this shared vision during the planning period. These recommended actions and investments—both speculative and defined—use the shared vision as a strategic framework. However, before advancing the vision, it is important to assess the current performance of the transportation system and forecast future conditions in the NYMTC planning area and the larger multi-state metropolitan region. Chapter 3 describes performance and anticipated future conditions to provide an important context for the* ***Moving Forward's*** *recommended actions and investments.*

3.2 MEASURING SYSTEM PERFORMANCE

Under federal metropolitan planning regulations, NYMTC must apply a transportation performance management approach in carrying out its federally required transportation planning and programming activities. The process requires the establishment and use of a coordinated, performance-based approach to transportation planning and programming in support of national goals for federal-aid highway and public transportation programs.

As mandated, the System Performance Report is an element of *Moving Forward* that evaluates the condition and performance of the transportation system, sets performance targets, and reports on current progress in meeting the targets. In addition, as required, the Systems Performance Report included in this chapter addresses: highway safety, bridge and pavement, system performance, transit asset management, and transit safety performance assessments and targets.

3.2.1 HIGHWAY SAFETY PERFORMANCE

FHWA's final Safety Performance Management rule requires that performance targets be set for the following measures:

- Number of fatalities
- Fatality rate (per 100 million vehicle miles traveled [VMT])
- Number of serious injuries
- Serious injury rate (per 100 million VMT)
- Number of non-motorized fatalities and serious injuries

The following steps were used in setting the current statewide safety targets for calendar year 2021.

1. **Estimation of existing trend** as recommended by FHWA, a linear trendline was estimated using a five-year moving average (current year plus four preceding years).
2. **Adjustment for reasonability** having considered the percentage change between 2017 and 2021 and between 2014 and 2018, a cap allows for a target that forecasts a significant reduction but recognizes that large decreases are difficult to sustain year after year.
3. **Consideration of external and other factors** external and other factors such as VMT, population, and safety programs were considered in the development of the targets.

Once the statewide performance targets were established, NYMTC chose to support the statewide targets for Highway Safety Performance. These targets are shown in ***Table 3-1.***

Table 3-1

2023 Highway Safety Performance Targets

Statewide (Source)	NYSDOT Target 5-Year Moving Average 2023
Traffic Fatalities (Fatality Analysis Reporting System [FARS])	988.2
Fatalities per 100 Million VMT (FARS/FHWA)	0.836
Serious Injuries (NYS Accident Information System [AIS])	11,086.2
Serious Injuries per 100 Million VMT (AIS/FHWA)	9.337
Number of Non-Motorized Fatalities and Non-Motorized Serious Injuries (FARS/AIS)	2633.4

ASSESSMENT OF PROGRESS IN ACHIEVING TARGETS

New York State's 2017–2022 Strategic Highway Safety Plan (SHSP) contains an overall goal of reducing "the number of fatalities and serious injuries resulting from motor vehicle crashes on public roads in New York State." The SHSP guides statewide efforts to address safety and defines a framework for implementation activities. NYSDOT's Highway Safety Improvement Program focuses on the planning, implementation, and evaluation of the SHSP. It emphasizes data-driven approaches to improving highway safety, focuses attention on relevant emphasis areas, and implements a range of SHSP strategies and countermeasures. As part of this process, NYSDOT produces an annual report that documents the statewide performance targets.

In supporting the statewide Safety Performance Management targets, NYMTC continues to program federal funding for projects and activities that address fatalities and serious injuries within its planning area through this Plan and through the TIP. NYMTC supports a host of safety programs designed to reduce fatal and serious injury crashes including the Highway Safety Improvement Program, New York City's Vision Zero, and the NYSDOT Pedestrian Safety Action Plan.

At this writing, the current federal fiscal years (FFYs) 2020–2024 TIP includes a description of the anticipated effects of its program of projects in achieving the above-mentioned targets, effectively linking investment priorities to safety targets. Additionally, *Moving Forward's* Shared Vision for Regional Mobility includes a Vision Goal to address transportation system safety and security with objectives and medium-term actions that integrate performance measures and targets into NYMTC's transportation planning process.

3.2.2 PAVEMENT AND BRIDGE CONDITION PERFORMANCE

FHWA's final Pavement and Bridge Condition Performance Management (PM2) rule requires that performance targets be set for six performance measures for pavement and bridge condition on Interstate and non-Interstate National Highway System (NHS) roads:

- Percent of Interstate pavements in good condition
- Percent of Interstate pavements in poor condition
- Percent of non-Interstate NHS pavements in good condition
- Percent of non-Interstate NHS pavements in poor condition
- Percent of NHS bridges (by deck area) classified as in good condition
- Percent of NHS bridges (by deck area) classified as in poor condition

The four pavement condition measures represent the percentage of lane miles on the Interstate and non-Interstate NHS that are in good or poor condition. The PM2 rule defines NHS pavement types as either asphalt, jointed concrete, or continuously reinforced concrete pavement and defines five pavement condition metrics for states to use to assess pavement condition:

- **International Roughness Index (IRI)**—an indicator of roughness; applicable to all three pavement types.
- **Cracking percent**—percentage of the pavement surface exhibiting cracking; applicable to all three pavement types.
- **Rutting**—extent of surface depressions; applicable to asphalt pavements only
- **Faulting**—vertical misalignment of pavement joints; applicable to jointed concrete pavements only.
- **Present Serviceability Rating**—a quality rating that is applicable only to NHS roads with posted speed limits of less than 40 miles per hour (mph) (e.g., toll plazas and border crossings). A state may choose to collect and report Present Serviceability Ratings for applicable segments as an alternative to the other four metrics.

For each pavement metric, a threshold is used to establish good, fair, or poor condition. Using these metrics and thresholds, pavement condition is assessed for each one-tenth of a mile section of the through travel lanes of mainline highways on the Interstate or the non-Interstate NHS, as follows:

- Asphalt segments are assessed using the IRI, cracking, and rutting metrics; jointed concrete segments are assessed using IRI, cracking, and faulting. For these two pavement types, each segment is rated good if the ratings for all three metrics are good, and poor if the ratings for two or more metrics are poor.
- Continuous concrete segments are assessed using the IRI and cracking metrics. A segment is rated good if both metrics are rated good; it is rated poor if both metrics are rated poor.
- If a state collects and reports Present Serviceability Ratings for any applicable pavement segments, those segments are rated according to the Present Serviceability Rating scale.

For all three pavement types, sections that are not good or poor are rated fair. The good/poor pavement condition measures are expressed as a percentage and are determined by summing the total lane miles of good or poor highway segments and dividing by the total lane miles of all highway segments on the applicable system. Pavement in good condition suggests that no significant investment is needed. Pavement in poor condition suggests reconstruction investment is needed in the near term.

The two bridge condition performance measures refer to the percentage of bridges by deck area on the NHS that are in good or poor condition. Bridge owners are required to inspect bridges on a regular basis and report condition data to FHWA. The measures assess the condition of four bridge components: deck, superstructure, substructure, and culverts.

Each bridge component has a metric rating threshold to establish good, fair, or poor condition, and each bridge on the NHS is evaluated using these ratings. If the lowest rating of the four metrics is greater than or equal to seven, the structure is classified as good. If the lowest rating is less than or equal to four, the structure is classified as poor. If the lowest rating is five or six, it is classified as fair.

The bridge condition measures are expressed as the percent of NHS bridges in good or poor condition. The percent is determined by summing the total deck area of good or poor NHS bridges and dividing by the total deck area of the bridges carrying the NHS. Deck area is computed using structure length and either deck width or approach roadway width.

Bridges in good condition suggests that no major investment is needed. Bridges in poor condition are safe to drive on; however, they are nearing a point where substantial reconstruction or replacement is needed.

ASSESSMENT OF PROGRESS IN ACHIEVING TARGETS

Pavement and bridge condition performance is assessed over a series of four-year performance periods. The first performance period began on January 1, 2018, and runs through December 31, 2021. NYSDOT must report baseline performance and targets at the beginning of each period and update performance at the midpoint and end of each performance period.

The PM2 rule requires performance targets for all six measures as follows:

- Four-year statewide targets for the percent of Interstate pavements in good and poor condition
- Two-year and four-year statewide targets for the percent of non-Interstate NHS pavements in good and poor condition
- Two-year and four-year targets for the percent of NHS bridges (by deck area) in good and poor condition

The two-year and four-year targets represent expected pavement and bridge condition at the end of calendar years 2019 and 2021, respectively.

NYSDOT established statewide PM2 targets on May 20, 2018. In supporting the targets, NYMTC programs federal funding for projects and activities that help to achieve the targets.

During the October 2020 mid-period performance review of the targets, NYSDOT maintained the targets set in in 2018. ***Table 3-2 presents baseline, two-year targets, and mid-period performance for each PM2 measure for New York and for the NYMTC planning area as well as the four-year statewide targets established by NYSDOT and supported by NYMTC.***

Table 3-2

Pavement and Bridge Condition (PM2) Performance and Targets

Performance Measures	Baseline	2-Year Target	2-Year Condition/ Performance	4-Year Target	Significant Progress Made? (Y/N)
Percentage of Pavements of the Interstate System in Good Condition*	*	*	51.1%	47.3%	N/A
Percentage of Pavements of the Interstate System in Poor Condition*	*	*	1.1%	4%	N/A
Percentage of Pavements of the Non-Interstate NHS in Good Condition**	36.7%	**	37.2%	**	Yes
Percentage of Pavements of the Non-Interstate NHS in Good Condition (Full Distress + IRI)**	**	14.6%	**	14.7%	Yes
Percentage of Pavements of the Non-Interstate NHS in Poor Condition**	26.7%	**	26.3%	**	Yes
Percentage of Pavements of the Non-Interstate NHS in Poor Condition (Full Distress + IRI)**	**	12.0%	7.5%	14.3%	N/A
Percentage of NHS Bridges Classified as in Good Condition	22.8%	23.0%	26.0%	24.0%	Yes
Percentage of NHS Bridges Classified as in Poor Condition	10.6%	11.6%	9.6%	11.7%	Yes

**For the first performance period only, baseline condition and 2-year targets are not required for the Pavements on the Interstate System measures.*

***For the first performance period, states were evaluated based on the IRI performance for this measure. NYSDOT has established targets based on the full distress measure and IRI.*

System preservation is a major focus of both *Moving Forward* and of NYMTC's TIP, as described in the financial forecasts contained in ***Chapter 5*** and as evidenced by the proportion of funding proposed for this purpose.

To support progress toward approved pavement and bridge targets, *Moving Forward* forecasts a total of $87 billion to address system preservation during the planning period, an average of approximately $3 billion per year in year-of-expenditure dollars.

3.2.3 SYSTEM PERFORMANCE, FREIGHT, AND CONGESTION MITIGATION AND AIR QUALITY IMPROVEMENT PROGRAM PERFORMANCE

FHWA's final System Performance, Freight, and Congestion Mitigation and Air Quality (CMAQ) Program Performance Management (PM3) rule established six performance measures to assess the performance of the NHS, freight movement on the Interstate system, and traffic congestion and on-road mobile source emissions for the CMAQ program. The performance measures are:

- Percent of person-miles on the Interstate system that are reliable, determined through Level of Travel Time Reliability (LOTTR)
- Percent of person-miles on the non-Interstate NHS that are reliable, determined through LOTTR
- Truck Travel Time Reliability Index (TTTR)
- Annual hours of peak hour excessive delay per capita (PHED)
- Percent of non-single occupant vehicle travel (non-SOV)
- Cumulative two-year and four-year reduction of on-road mobile source emissions for CMAQ-funded projects

Each performance measure listed above is described in more detail below.

Level of travel time reliability (LOTTR) refers to the consistency or dependability of travel times on a roadway from day to day or across different times of the day. For example, if driving a certain route always takes about the same amount of time, that segment is reliable. It may be congested most of the time, not congested most of the time, or somewhere in between, but the conditions do not differ very much from time period to time period. On the other hand, if driving that route takes 20 minutes on some occasions but 45 minutes on other occasions, the route is not reliable.

LOTTR is defined as the ratio of the longer travel times, represented at the 80th percentile of all trips, to a normal travel time measured at the 50th percentile of all trips over applicable roads during four time periods that cover the hours of 6:00 a.m. to 8:00 p.m. each day (AM peak, midday, PM peak, and weekends). LOTTR is calculated for each roadway segment, which is judged as reliable if its LOTTR is less than 1.5 during all four periods. If one or more periods has a LOTTR of 1.5 or above, that segment is unreliable.

These two LOTTR measures are expressed as the percent of person-miles traveled on the Interstate or non-Interstate NHS system that are reliable. By using person-miles, the measures consider the total number of people traveling in buses, cars, and trucks over these roadway segments. To obtain total person-miles traveled, the length of each segment is multiplied by an average vehicle occupancy for each type of vehicle on the roadway. The sum of person-miles on reliable segments is divided by the sum of person-miles on all segments to determine the percent of person-miles traveled that are reliable.

Truck travel time reliability (TTTR) assesses travel time reliability for trucks traveling on Interstate roadway. TTTR is calculated by dividing the 95th percentile of truck travel time by a normal travel time at the 50th percentile for each segment of the Interstate system over five periods throughout weekdays and weekends (AM peak, midday, PM peak, weekend, and overnight). The periods cover all hours of the day.

For each Interstate segment, the highest TTTR value among the five periods is multiplied by the length of the segment. The sum of these length-weighted segments is then divided by the total length of Interstate to generate the TTTR Index.

FHWA provides the travel time data used to calculate LOTTR and TTTR via the National Performance Management Research Data Set, which contains historical travel times, segment lengths, and annual average daily traffic for Interstate and non-Interstate NHS roads.

Peak hour excessive delay (PHED) represents the hours of delay resulting from traffic congestion on the NHS during morning and afternoon peak travel times on Mondays through Fridays. FHWA defines the morning peak travel hours as 6:00 a.m. to 10:00 a.m. and the afternoon peak as either 3:00 p.m. to 7:00 p.m. or 4:00 p.m. to 8:00 p.m. FHWA also defines excessive delay as travel time at 20 mph on a segment or 60 percent of the posted speed limit, whichever is greater, during 15-minute intervals that cover peak travel times on Mondays through Fridays for the entire calendar year. Excessive delay is totaled and is then weighted by vehicle volumes and occupancy to be expressed as the annual hours of excessive delay during the peak hours on a per capita basis to measure person-hours of delay rather than vehicle-hours.

Non-SOV travel represents the percentage of person travel within the UZA not undertaken in an SOV. Non-SOV travel, includes ridesharing via carpool and commuter van, as well as travel using public transportation, commuter rail, walking and bicycling, and telecommuting. The percentage non-SOV travel for the New York-Newark, NY-NJ-CT UZA is calculated using the U.S. Census Bureau's ACS five-year dataset of journey-to-work trips for residents of the UZA. While all trips (not just journey-to-work) would be ideal to track, this regularly updated, approved dataset is recognized as the best available input to the calculation of the measure. The data reflects five-year averages, with a time lag. Thus, the two-year target refers to 2014–2018 and the four-year target refers to 2016–2020.

CMAQ emission reduction represents the total on-road mobile source emissions reductions of applicable criteria pollutants (as defined by the Clean Air Act Amendments of 1990) and their precursors resulting from all CMAQ-funded projects and programs. Total reduction is calculated by summing the cumulative two-year and four-year emission reductions of applicable pollutants resulting from CMAQ projects and is expressed in kilograms per day.

The NYMTC planning area is part of several nonattainment or maintenance areas designated under the Clean Air Act Amendments of 1990 for mobile source emissions of ground-level ozone, carbon monoxide, and fine particulate matter ($PM_{2.5}$). As such, for NYMTC the measure applies to two ozone precursors (i.e., volatile organic compounds and nitrogen oxides), as well as carbon monoxide and $PM_{2.5}$ emissions.

ASSESSMENT OF PROGRESS IN ACHIEVING TARGETS

PM3 performance is assessed over a series of four-year performance periods. States must report baseline performance and targets during the first part of the performance period and update performance at the midpoint and end of each performance period.

For the LOTTR, TTTR, PHED, and non-SOV travel measures, the first performance period began on January 1, 2018, and runs through December 31, 2021. For the CMAQ emission reduction measure, the first performance period began on October 1, 2017, and ends on September 30, 2021.

The PM3 rule requires that agencies establish performance targets for each measure and monitor progress towards achieving the targets. Two-year and four-year targets must be established for the Interstate LOTTR, TTTR, non-SOV travel, and CMAQ emission reduction measures, while four-year targets must be established for the non-Interstate NHS LOTTR and PHED measures.

The current two-year and four-year targets represent expected performance at the end of calendar years 2019 and 2021, respectively. For the CMAQ emission reduction measure, the two-year and four-year targets represent cumulative emission reductions from CMAQ-funded projects from October 1, 2017, to September 30, 2019 (for the two-year target) and October 1, 2017, to September 30, 2021 (for the four-year target).

The PHED and non-SOV travel measures apply to an UZA as defined by the U.S. Census Bureau. For these measures, states and MPOs are required to work together to mutually establish a single, unified PHED and non-SOV travel target for the UZA within their boundaries, as a whole or in part. Two- and four-year targets must be established for the non-SOV travel measure, and a four-year target must be established for the PHED measure. For the New York-Newark, NY-NJ-CT UZA, coordination between NYMTC, the North Jersey Transportation Planning Authority, the Delaware Valley Regional Planning Commission, and the state departments of transportation of New York and New Jersey is needed to establish PHED and non-SOV travel.

NYMTC supports statewide PM3 performance targets by programming federal funds for projects and programs that assist in achieving the targets. The statewide targets set in 2018 did not change at the mid-performance period review.

Table 3-3 presents baseline performance for the LOTTR, TTTR, and CMAQ emission reduction measures for New York and for the NYMTC planning area as well as the two- and four-year targets established by NYSDOT. Baseline performance and two- and four-year targets for PHED and non-SOV travel measures for the New York-Newark, NY-NJ-CT UZA are also provided.

Table 3-3

System Performance, Freight, and CMAQ (PM3) Performance and Targets

Performance Measures	Baseline	2-Year Target	2-Year Condition/ Performance	4-Year Target	Significant Progress Made? (Y/N)
Percent of Person-Miles Traveled on the Interstate that are Reliable	83.2%	73.1%	78.8%	73.0%	Yes
Percent of Person-Miles Traveled on the Non-Interstate that are Reliable*	N/A	N/A	80.3%	63.4%	N/A
TTTR Index	1.39	2.00	1.47	2.11	Yes
Annual Hours of Peak Hour Excessive Delay per Capita (UZA 1)**	N/A	N/A	22.3	22.0	N/A
Percent of Non-SOV Travel (UZA 1)	51.6%	51.6%	51.6%	51.7%	Yes
Total Emission Reductions PM2.5 (daily kilograms)	5.480	10,740	89.576	20.484	Yes
Total Emission Reductions Nitrogen Oxide (daily kilograms)	83.606	160.523	925.308	294.914	Yes
Total Emission Reductions Volatile Organic Compounds (daily kilograms)	32.452	62.957	602.290	117.088	Yes
Total Emission Reductions PM10 (daily kilograms)	12.885	25.512	N/A***	49.642	N/A***
Total Emission Reductions Carbon Monoxide (daily kilograms)	611.939	1,199.401	1,5117.400	2,298.835	Yes

**For the first performance period only, baseline condition and 2-year targets are not required for the Non-Interstate NHS reliability measure.*

***There was no evaluation of this measure in the first performance period.*

****FHWA does not evaluate the performance of this measure.*

The targets for the PHED and non-SOV travel were jointly developed by the participating states and MPOs that are part of the New York-Newark, NY-NJ-CT UZA. The methodologies employed ensured that there was full agreement from each member on policies, programs, and assumptions used in developing the targets. The UZA achieved its two-year target for non-SOV travel. In spring 2020, the UZA-participating states and MPOs met and agreed that given current progress and many uncertainties, the UZA would not adjust the four-year targets for PHED and non-SOV travel.

Moving Forward includes projects, programs, strategies, and actions to address system performance, freight reliability, mobile source emissions, and traffic congestion. The Plan identifies funding for targeted improvements in these areas. NYMTC supports the statewide PM3 targets and will continue to monitor and track the current performance of the roadway network. NYSDOT and NYMTC, working with the Albany Visualization and Informatics Lab at SUNY have combined National Performance Management Research Data Set data with other data sources, such as traffic count and employer data. These tools allow NYSDOT and NYMTC to better understand the sources of back-ups (e.g., bottlenecks) and the impacts of accidents and analyze the benefits of infrastructure investments and operational strategies through before and after analyses. Incorporation of the system performance measures into existing planning and data monitoring processes for the roadway network are ongoing, as it the collaboration within the UZA for the relevant performance measures.

3.2.4 TRANSIT ASSET PERFORMANCE

Federal transit asset performance regulations apply to all recipients and subrecipients of federal transit funding that own, operate, or manage public transportation capital assets. A variety of transit service providers that receive transit funding serve the NYMTC planning area. These provides include:

- MTA
- Nassau County (NICE), Suffolk County (Suffolk County Transit), the City of Long Beach (City of Long Beach Transit), and the Town of Huntington (Huntington Area Rapid Transit) on Long Island
- Putnam County (PART), Rockland County (TOR), and Westchester County (Bee-Line System) in the Lower Hudson Valley
- NYC DOT (Staten Island Ferry)

Figure 3-1 shows the Transit Asset Management (TAM) plan elements that are required by Tier I and Tier II providers as defined by their service levels. The tiers are established by the size of the transit system that is submitting the TAM plan.

Figure 3-1

Transit Asset Management Plans

1. Inventory of Capital Assets	Tier I & II
2. Condition Assessment	
3. Decision Support Tools	
4. Investment Prioritization	
5. TAM and State of Good Repair Policy	Tier I Only
6. Implementation Strategy	
7. List of Key Annual Activities	
8. Identification of Resources	
9. Evaluation Plan	

All assets used by these providers for public transit services are expected to be included in the TAM plan asset inventory. This includes (except for equipment) assets that are owned by a third party or shared resources. The inventory must include all service vehicles and any other owned equipment assets over $50,000 in acquisition value. Agencies only need to include condition assessment for assets for which they have direct capital responsibility.

TAM plans must measure the current condition and forecast the future conditions of the transit assets contained in the inventory. *Table 3-4* identifies the federal transit asset performance measures.

Table 3-4

FTA Transit Asset Management Performance Measures

**Only for assets for which the agency has direct capital responsibility.*

Asset Category*	Performance Measure and Asset Class
Rolling Stock Revenue vehicles by mode	Percentage of revenue vehicles within a particular asset class that have either met or exceeded their useful life benchmark
Equipment Non-revenue support-service and maintenance vehicles	Percentage of non-revenue, support-service, and maintenance vehicles that have met or exceeded their useful life benchmark
Infrastructure Only rail fixed-guideway, track, signals, and systems	Percentage of track segments with performance restrictions
Facilities Maintenance and administrative facilities; and passenger stations (buildings) and parking facilities	Percentage of facilities within an asset class rated below condition 3 on the Transit Economic Requirement Model (TERM) scale

ASSESSMENT OF PROGRESS IN ACHIEVING TARGETS

Public transportation agencies are required to establish and report TAM targets annually for the following fiscal year. Each responsible public transportation provider must share its targets, TAM, and asset condition information with NYMTC. In turn, NYMTC is required to establish TAM targets within 180 days after the public transportation providers establish initial targets and update its targets when it adopts a new regional transportation plan or TIP. When establishing TAM targets, NYMTC can either agree to program projects that will support the transit provider targets or establish separate regional TAM targets for its planning area.

The public transportation providers in the NYMTC planning area have established the TAM targets listed in the following tables. NYMTC is supporting the providers' individual TAM targets for each of the nine transit providers in the NYMTC planning area. ***Tables 3-5*** through ***3-15*** describe the targets for the ***Tier I*** and ***Tier II*** operators for each of the four TAM performance measures.

TIER I PROVIDERS

Table 3-5

MTA Selected Systems

Source: MTA

		NYCT		Staten Island Railway		MTA Bus	
Asset Category - Performance Measure	Asset Class	ULB (Years)	Targets	ULB (Years)	Targets	ULB (Years)	Targets
Rolling Stock Age - % of revenue vehicles within a particular asset class that have met or exceeded their Useful Life Benchmark (ULB)	Articulated buses	12	0%	N/A	N/A	12	0%
	Over the road buses	12	9%	N/A		12	96%
	Buses	12	8%	N/A		12	46%
	Heavy rail passenger cars	40	11%	40	100%	N/A	N/A
Equipment Age - % of non-revenue vehicles within a particular asset class that have met of exceeded their ULB	Trucks and other rubber tire vehicles	7-11	20%	7-11	44%	7-11	12%
	Steel wheel service vehicles	Various	58%	15-35	29%	N/A	
	Automobiles	7-11	18%	7-11	17%	7-11	15%
Infrastructure % of track segments with performance restrictions (as applicable)	Rail fixed guideway track	25-65	2%	28	0%	N/A	N/A
Facilities Condition - % of facilities with a condition rating below 3.0 on the FTA TERM Scale	Passenger facilities	Various	53%	Various	70%	N/A	N/A
	Parking facilities	N/A	N/A	N/A	N/A	N/A	N/A
	Maintenance & administration facilities	Various	57%	Various	22%	75	5%

Table 3-6

MTA Long Island Rail Road

Asset Category - Performance Measure	Asset Class	Useful Life Benchmarks (Years)	Targets
Rolling Stock Age - % of revenue vehicles within a particular asset class that have met or exceeded their ULB	RS - Commuter rail, self-propelled passenger car	39	0%
	RP - Commuter rail passenger coach	39	0%
	Commuter rail locomotive	39	0%
	Heavy rail passenger cars	31	0%
Equipment Age - % of non-revenue vehicles within a particular asset class that have met of exceeded their ULB	Trucks and other rubber tire vehicles	14	14%
	Steel wheel service vehicles	25	74%
	Automobiles	8	14%
Infrastructure % of track segments with performance restrictions (as applicable)	Rail fixed guideway track	25-65	1.65%
Facilities Condition - % of facilities with a condition rating below 3.0 on the FTA TERM Scale	Passenger/parking facilities	Various	15.9%
	Administrative/maintenance facilities	Various	38.3%

Table 3-7

MTA Metro-North Railroad

Source: MTA

Asset Category - Performance Measure	Asset Class	Useful Life Benchmarks (Years)	Targets
Rolling Stock Age - % of revenue vehicles within a particular asset class that have met or exceeded their ULB	RS - Commuter rail, self-propelled passenger car	35	0%
	RP - Commuter rail passenger coach	35	0%
	RL - Commuter rail locomotive	35	34%
Equipment Age - % of non-revenue vehicles within a particular asset class that have met of exceeded their ULB	Trucks and other rubber tire vehicles	8-14	61%
	Steel wheel service vehicles	35	73%
Infrastructure % of track segments with performance restrictions (as applicable)	Track segments, signals, and systems	25-65	2%
Facilities Condition - % of facilities with a condition rating below 3.0 on the FTA TERM Scale	Passenger facilities	Various	40%
	Parking facilities	Various	24%
	Administrative facilities	Various	34%
	Maintenance facilities	Various	28%

Table 3-8

Nassau Inter-County Express (NICE) Bus

Source: Nassau County

Asset Category - Performance Measure	Asset Class	Useful Life Benchmarks (Years)	2022 Targets
Revenue Vehicles Mileage - % of revenue vehicles within a particular asset class that have met or exceeded their Useful Life benchmark (ULB)	Bus	14	5%
	Cutaway bus	10	5%
	Articulated bus	14	5%
	Van	8	10%
	Automobile	8	10%
Equipment Age - % of equipment that has met or exceeded its Useful Life Benchmark (ULB)	Sedans/SUV	6-8	15%
	Van/trucks and other rubber tire vehicles	10-13	15%
Facilities Condition - % of facilities with a condition rating below 3.0 on the FTA Economic Requirements Model (TERM) Scale	Passenger and parking	3	0%
	Administrative and maintenance	3	10%

Table 3-9

Suffolk County Transit

Source: Suffolk County

Asset Category - Performance Measure	Asset Class	Useful Life Benchmarks (Years)	Targets
Rolling Stock Age - % of revenue vehicles within a particular asset class that have met or exceeded their ULB	Bus	14	10%
	Cutaway bus	10	10%
Equipment Age - % of non-revenue vehicles within a particular asset class that have met of exceeded their ULB	Non-revenue/service automobile	8	20%
Infrastructure % of track segments with performance restrictions (as applicable)	Rail fixed guideway	N/A	N/A
Facilities Condition - % of facilities with a condition rating below 3.0 on the FTA TERM Scale		N/A	N/A

Table 3-10

Westchester County Bee-Line System

Source: Westchester County DOT

Asset Category - Performance Measure	Asset Class	Useful Life Benchmarks (Years)	2023 Targets
Rolling Stock Age - % of revenue vehicles within a particular asset class that have met or exceeded their Useful Life Benchmark (ULB)	Fixed-route buses	14-17	20%
	Paratransit vehicles	5-6	20%
Equipment Age - % of non-revenue vehicles within a particular asset class that have met of exceeded their ULB	Non-revenue/service automobiles	10	60%
	Trucks and other rubber tire vehicles	8-10	60%
	Maintenance equipment	40-50	60%
Facilities Condition - % of facilities with a condition rating below 3.0 on the FTA Economic Requirements Model (TERM) Scale	Maintenance-related assets	N/A	0%

Table 3-11

New York City Department of Transportation

Source: NYC DOT

Asset Category - Performance Measure	Asset Class	Useful Life Benchmarks (Years)	2023 Targets
Rolling Stock Age - % of revenue vehicles within a particular asset class that have met or exceeded their ULB	Ferryboat	42	50%
Equipment Age - % of equipment that has met or exceeded its Useful Life Benchmark (ULB)	Trucks and other rubber tire vehicles	8-10	65%
Facilities Condition - % of facilities with a condition rating below 3.0 on the FTA TERM Scale	Maintenance-related assets	N/A	50%

TIER II PROVIDERS

Table 3-12

Putnam Area Rapid Transit (PART)

Source: NYSDOT

Asset Category - Performance Measure	Asset Class	Useful Life Benchmarks (Years)	2023 Targets
Rolling Stock Age - % of revenue vehicles within a particular asset class that have met or exceeded their ULB	Fixed Route	5	40%
	Paratransit	5	65%
Equipment Age - % of non-revenue vehicles within a particular asset class that have met of exceeded their ULB	Maintenance Related Assets	15	60%
Facilities Condition - % of facilities with a condition rating below 3.0 on the FTA TERM Scale	All Facilities	40	0%

Table 3-13

Transport of Rockland (TOR)

Source: NYSDOT

Asset Category - Performance Measure	Asset Class	Useful Life Benchmarks (Years)	2023 Targets
Rolling Stock Age - % of revenue vehicles within a particular asset class that have met or exceeded their ULB	BU1 35 and 40 feet	10	40%
	CU - TRIPS BUSES	5	65%
	BR1	12	0%
	CU - CMT	5	65%
	BR1 - Monsey	12	0%
	BR1 - ShortLine	12	0%

Table 3-14

Huntington Area Rapid Transit

Source: NYSDOT

Asset Category - Performance Measure	Asset Class	Useful Life Benchmarks (Years)	2023 Targets
Rolling Stock Age - % of revenue vehicles within a particular asset class that have met or exceeded their ULB	BU1 - Bus (5307)	10	100%
Equipment Age - % of non-revenue vehicles within a particular asset class that have met of exceeded their ULB	All Equipment (5307)	8	60%
Facilities Condition - % of facilities with a condition rating below 3.0 on the FTA TERM Scale	Maintenance (5307)	N/A	0%

Table 3-15

City of Long Beach Transit

Source: NYSDOT

Asset Category - Performance Measure	Asset Class	Useful Life Benchmarks (Years)	2023 Targets
Rolling Stock Age - % of revenue vehicles within a particular asset class that have met or exceeded their ULB	BU1 - Bus (5307)	10	100%
Facilities Condition - % of facilities with a condition rating below 3.0 on the FTA TERM Scale	Maintenance (5307)	N/A	25%
	Passenger Facilities	N/A	50%

Moving Forward's Vision Goals include the goal of preserving the existing transportation system. As part of the ongoing coordination efforts to fulfill TAM requirements, the progress of the transit providers toward achieving their TAM targets will be monitored and reported. Additionally, federal funding will be programmed toward achieving the TAM targets of the transit providers.

Moving Forward forecasts the cost of transit system preservation over the life of the Plan at approximately $664 billion, or roughly 88 percent of the Plan's total projected system preservation costs for the entire transportation system in the NYMTC planning area. The Plan estimates that most of these costs will be met through a combination of federal, state, and local resources.

3.2.5 TRANSIT SAFETY PERFORMANCE

FTA-established transit safety performance management requirements in the Public Transportation Agency Safety Plan final rule require providers of public transportation systems that receive federal financial assistance under 49 U.S.C. Chapter 53 to develop and implement a Public Transportation Agency Safety Plan based on a Safety Management Systems approach.

Each Public Transportation Agency Safety Plan includes performance targets for the performance measures established by FTA in the National Public Transportation Safety Plan, including:

- Total number of reportable fatalities and rate per total vehicle revenue miles by mode
- Total number of reportable injuries and rate per total vehicle revenue miles by mode
- Total number of reportable safety events and rate per total vehicle revenue miles by mode
- System reliability measured as the mean distance between major mechanical failures by mode

The targets set by some of the transit operators in the NYMTC planning area are displayed in Tables *3-16* through *3-21*. Other will be added as they become available. It should be noted that the FTA Public Transportation Safety Plan Rule 49 CFR Part 673 states "Pursuant to § 673.11(f), agencies that operate passenger ferries regulated by United States Coast Guard (USCG) or rail fixed guideway public transportation service regulated by Federal Railroad administration (FRA) are not required to develop safety plans for those modes of service." As a result, targets for MTA LIRR, MTA MNR, and ferries are not reported here.

Table 3-16

Metropolitan Transportation Authority (MTA) Bus Systems

	Fatalities	Customer Accident Injury Rate (per million customers)	Collisions with Injury Rate (per million vehicle miles)	Employee Lost Time & Restricted Duty Rate (per 100 employees)	System Reliability: Mean Distance Between Failures (miles)	System Reliablility (% of completed trips)
MTA New York City Transit	0.00	1.19	6.47	5.42	6,413.00	99.40
MTA Bus Company	0.00	1.06	5.51	6.67	6,880.00	99.40

Table 3-17

Metropolitan Transportation Authority (MTA) Subway

	Fatalities	Injuries	Safety Events	System Reliability Mean Distance Between Failure
Employee Safety Performance Targets	Reduction by 5%	Reduction by 5%	Reduction by 5%	150,000 Miles
MTA Bus Company	Reduction by 3%	Reduction by 3%	Reduction by 3%	N/A

Table 3-18

Westchester County – Bee-Line System

Mode of Transit Service	Fatalities (Total)	Fatalities (Rate)	Injuries (Total)	Injuries (Rate)	Safety Events (Total)	Safety Events (Rate)	System Reliability (Miles Between Major Failures)
Fixed-Route Bus	0.0	0.0	63.0	8.2	48.0	6.2	3,600
Paratransit	0.0	0.0	4.0	1.2	4.0	1.2	40,000

Table 3-19

Nassau Inter-County Express (NICE)

Mode of Transit Service	Fatalities (Total)	Fatalities (Rate)	Injuries (Total)	Injuries (Rate)	Safety Events (Total)	Safety Events (Rate)	System Reliability (Miles Between Major Failures)
Fixed Route	0.0	0.0	43.0	0.42	76.00	0.80	9,000
Paratransit	0.0	0.0	3.0	0.16	18.00	0.95	28,702

Table 3-20

City of Long Beach

Mode of Transit Service	Fatalities (Total)	Fatalities (Rate)	Injuries (Total)	Injuries (Rate)	Safety Events (Total)	Safety Events (Rate)	System Reliability (Miles Between Major Failures)
Fixed Route / Deviated Route	0	0	0	0	0	0	0
Paratransit	0	0	0	0	0	0	0

Table 3-21

Town of Huntington

Mode of Transit Service	Fatalities (Total)	Fatalities (Rate)	Injuries (Total)	Injuries (Rate)	Safety Events (Total)	Safety Events (Rate)	System Reliability (Miles Between Major Failures)
Fixed Route / Deviated Route	0	0	0	0	0	0	0
Paratransit	0	0	0	0	0	0	0

3.3 AN OVERVIEW OF THE FORECASTS

NYMTC's socioeconomic and demographic (SED) forecasts establish the likelihood that the multi-state metropolitan region will experience significant growth in population, jobs, economic activity, and travel over the planning period. This likelihood presents a challenge to the regional transportation system and highlights the importance of accommodating future growth while safeguarding the quality of life and health of residents and visitors.

The following sections describe the wide range of historical and current SED trends for the region, with a focus on the NYMTC planning area and, as applicable, contextualize these data within a broader 31-county forecasting region drawn from New York City's multi-state metropolitan area. Typically, NYMTC uses U.S. Census data to describe trends and to serve as a basis for forecasting methods that project these trends to the Plan's horizon year. Additional technical detail is available in **Appendix C**.

Although the forecasts incorporate recent SED trends, the COVID-19 pandemic, whose impacts in the forecasting region were first felt in March 2020, has significantly disrupted these trends as of this writing. While adjustments have been made to the forecasts to reflect this short-term impact and resulting economic uncertainty, the ongoing conditions and effects of the pandemic are largely speculative. Nonetheless, the primary purpose of the forecast is the long-term outlook, which is less suspectable to short-term volatility. As new data become available regarding the impacts of the pandemic on regional employment and population trends, it will be incorporated in the next set of SED forecasts.

The current SED forecast produces metrics including population, employment, labor force, and number of households, in five-year intervals projected out to the Plan's horizon year. The forecast geography comprises 31 counties in the multi-state metropolitan region, consisting of the following subregions:

- New York City
- Long Island
- Lower- and Mid-Hudson Valley
- Northern New Jersey
- Southwestern Connecticut

Although the SED forecast produces data for the entire 31-county forecasting region, much of this chapter will focus on the 10-county NYMTC planning area, which is disaggregated into the following subregions:

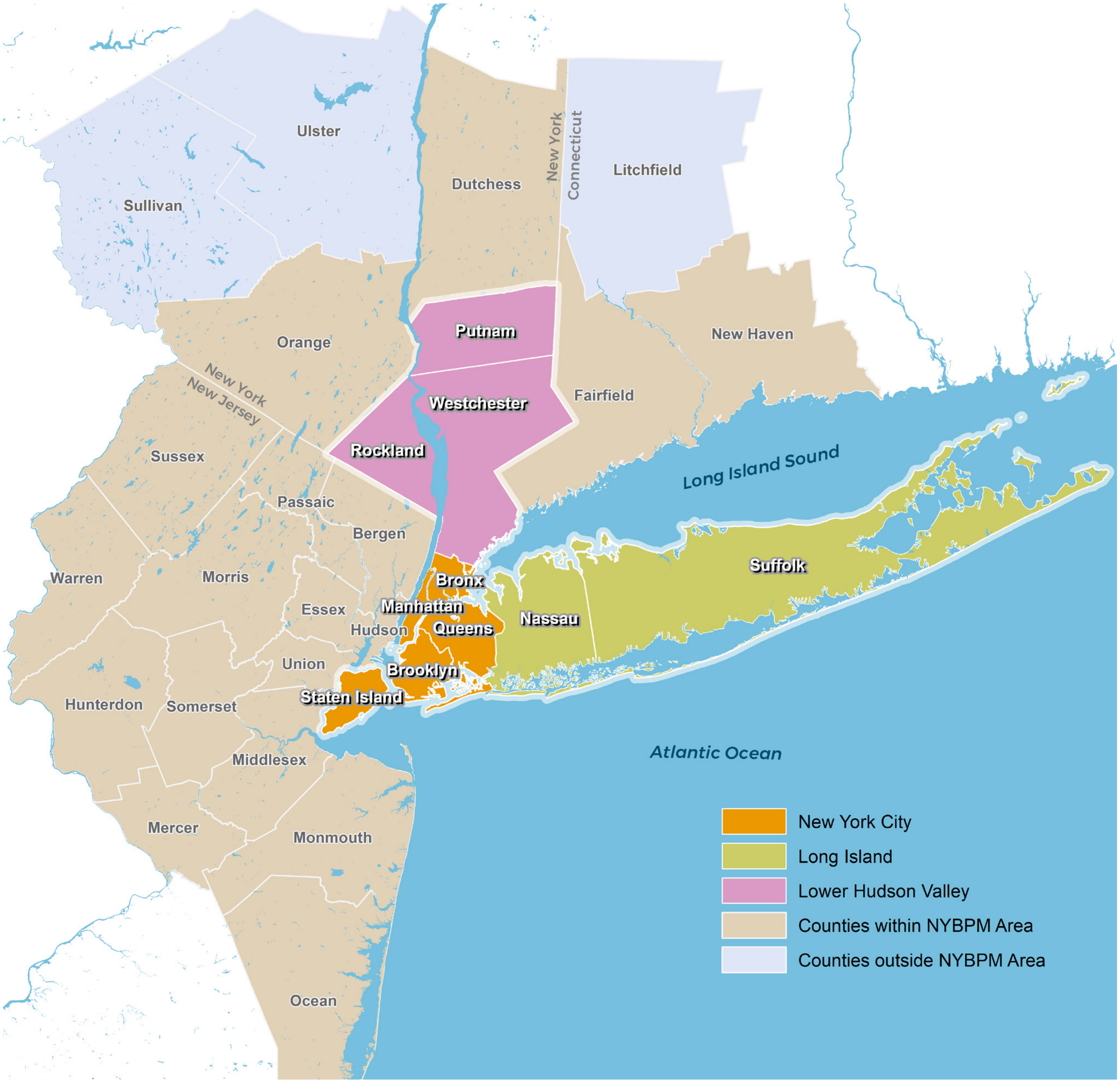
- New York City, consisting of Bronx, Queens, Manhattan, Brooklyn, and Staten Island
- Long Island, consisting of Nassau and Suffolk counties
- The Lower Hudson Valley, consisting of Putnam, Rockland, and Westchester counties

A map of the 31-county forecasting region and the NYMTC planning area is shown in ***Figure 3-2*** on the next page.

Figure 3-2

31-County Forecasting Region and NYMTC Planning Area

Source: NYMTC



Because of the interdependencies between the 31-counties and the NYMTC planning area, forecasting for the broader 31-county region is important for understanding the NYMTC planning area's prospective SED trends and future needs. In addition, understanding potential regional growth patterns will help strengthen integrated development and achieve more balanced growth.

The 31-county region will continue to experience population and employment growth through the planning period, but this growth will slow slightly over time as a result of perceived growth constraints across the region. As a mature region, new population and jobs are being absorbed into built out areas, slowing their rates of growth. However, as a large region, slowing growth rates still represent large absolute gains; by 2050, the region is expected to be home to a population of 25.5 million people, representing a population gain of 2.6 million over the 2017 base year, and 13.6 million jobs, an increase of 1.6 million from 2017.

The forecasts also assume a modest reversion to balanced regional growth between New York City and the surrounding suburban counties. Throughout the second half of the 20th century, population and employment growth in the forecasting region heavily favored suburbs where low-density housing and auto-oriented office campuses were prevalent. During the last decade, population and employment growth concentrated disproportionately in New York City, and to a lesser extent, in close-in suburban areas. A combination of housing and transportation constraints in the core, combined with planned land use and market improvements in other areas, results in forecasts that anticipate more even splits of growth within and outside New York City.

Within the NYMTC planning area, population is expected to grow by 10.2 percent over the 2017 base year through 2050, representing an additional 1.3 million residents. Meanwhile, growth rates for employment and the civilian labor force are expected to be about 14 percent and 11 percent, respectively. The breakdown of these metrics for the NYMTC planning area and their forecasts for 2017 and 2050 is shown in ***Table 3-22.***

Table 3-22

Aggregate SED Forecasts for the NYMTC Planning Area

	2017	2050	Percent Change 2017 to 2050
Population	12.82 million	14.13 million	10.23%
Employment	7.08 million	8.07 million	13.95%
Civilian Labor Force	6.50 million	7.22 million	10.99%
Average Household Size	2.75	2.71	-1.38%

Among the NYMTC subregions, Long Island is expected to have the highest rate of growth in population and civilian labor force, increasing by 11.7 percent and 12 percent, respectively. New York City is forecast to experience the highest rate of job growth and add the highest total numbers for all indicators except average household size, adding more than 850,000 to its population, more than 770,000 jobs, and 300,000 more people to the civilian labor force. Average household size is expected to decrease for all three subregions and will shrink by 1.38 percent across the NYMTC planning area.

Table 3-23 presents the SED forecasts for the NYMTC planning area disaggregated by subregion. When considering the broader 31-county forecasting region, growth rates in northern New Jersey are expected to exceed that of any part of the NYMTC planning region. From 2017 to 2050, northern New Jersey is forecast to experience growth of 15 percent for total population, 13 percent for labor force, and 13 percent for employment. Southwestern Connecticut's growth is expected to grow by a comparatively slower rate, with population increasing by 10 percent, labor force by 6 percent, and employment by 8 percent over the planning period.

Although the NYMTC planning area is expected to experience significant growth, growth in the surrounding region influences growth in the NYMTC planning area and future travel patterns. The SED forecast implies that larger shares of New York City jobs will be filled by in-commuters from the region because of population growth constraints in New York City. Northern New Jersey will experience the highest rate of population and civilian labor force growth through the planning period and will likely play a significant role in supplementing New York City's labor force demand ***(Table 3-23***) on the next page.

Table 3-23

SED Forecast for the NYMTC Planning Area by Subregion

		2017	2050	Percent Change 2017 to 2050
Population (in millions)	New York City	8.56	9.41	10.0%
	Long Island	2.86	3.19	11.7%
	Lower Hudson Valley	1.39	1.52	8.7%
Employment (in millions)	New York City	5.11	5.89	15.2%
	Long Island	1.32	1.46	10.8%
	Lower Hudson Valley	0.64	0.78	10.6%
Civilian Labor Force (in millions)	New York City	4.30	4.76	10.7%
	Long Island	1.48	1.66	12.0%
	Lower Hudson Valley	0.71	0.78	10.4%
Average Household Size	New York City	2.57	2.53	-1.6%
	Long Island	2.93	2.89	-1.5%
	Lower Hudson Valley	2.75	2.72	-1.1%

3.4 HISTORICAL AND CURRENT TRENDS

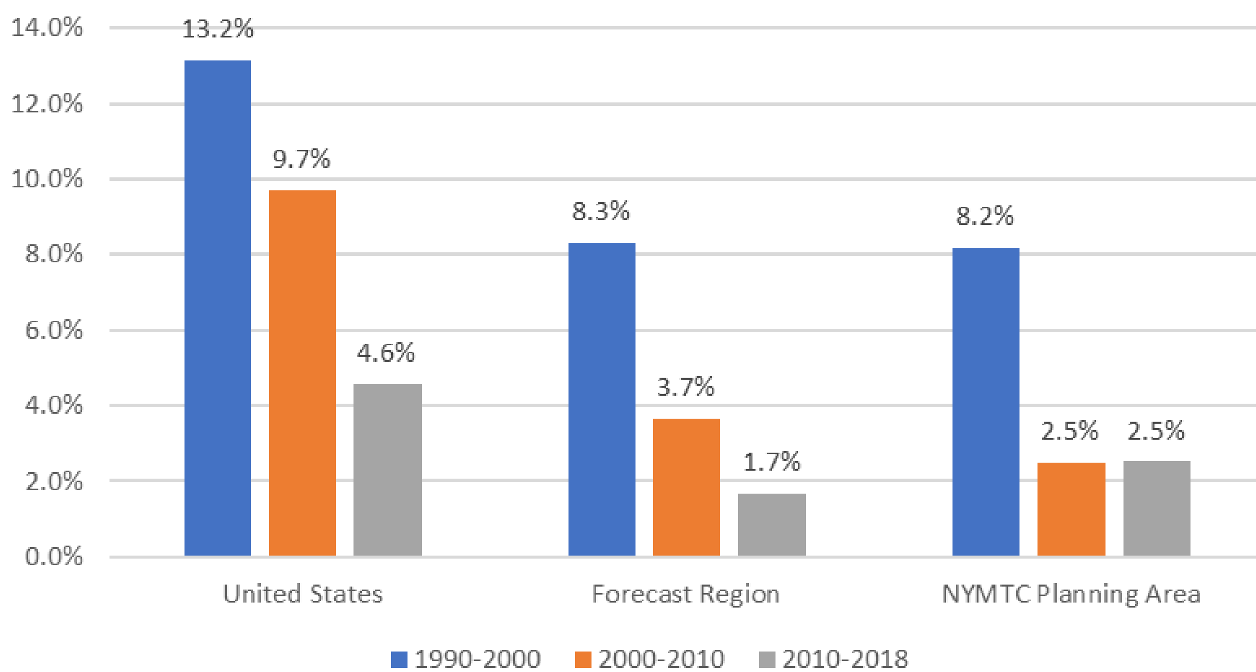
The historical trends described below provide a context and a basis for the long-term SED forecasts. However, it should be noted that trends in population, employment, and income are largely discussed through the 2017 base year of the forecasts. As noted earlier, the COVID-19 pandemic has significantly disrupted the described trends. With the pandemic still altering economic and social life in the forecasting region as of this writing, it is important to note that the trends described below have been interrupted in the immediate term.

3.4.1 POPULATION

Population growth across the NYMTC planning area has experienced similar growth patterns as the forecasting region and the United States, but with varying proportions (See *Figure 3-3*). The decade of the 1990s saw rapid population growth across the United States. From 1990 to 2000, the national population grew by 13.2 percent. Similar to the NYMTC planning area and the forecasting region, national population growth slowed during the decade of the 2000s, but less dramatically. From 2000 to 2010, national population growth slowed to approximately 9.7 percent. Between July 2010 and July 2018, national population growth continued to slow, increasing by 4.6 percent. This represents an average annualized population growth of 0.6 percent, compared to an average of 0.9 percent last decade, and 1.2 percent between 1990 and 2000.[1]

Figure 3-3

Percent Growth of Total Population, 1990–2018



U.S. population growth is a function of natural increase (or births minus deaths) plus net migration, with the largest contribution through natural increase. However, since 2009, the natural increase of the U.S. population has been slowing overall, with international migration increasing in proportion.[2] Since 2016, international migration has been declining each year, with the result that the population growth rate has slowed.[3] Between 2018 and 2019, net international migration (net exchanges with the rest of the world) added 595,000 to nation's population, the smallest number this decade. This is a significant drop, compared to the decade high of 1.04 million between 2015 in 2016.[4]

In addition, the U.S. population continues to age, with the number of people age 65 and older growing rapidly as a proportion of the population over most of the 20th century and into the 21st century. In 2018, there were 52 million people age 65 and older, representing 16 percent of the U.S. population, compared to 35 million in 2000, which was 12.4 percent of the nation's population.[5] This trend is likely to continue in the coming decades, with the Baby Boom generation increasingly moving into older age cohorts.

The forecasting region experienced sizable population growth from 1990 to 2000. In 2000, the total population of the 31-county region grew to about 21.4 million, an increase of 8.3 percent over 1990 levels. Between 2000 and 2010, population growth in the forecasting region slowed to about 3.7 percent. The population growth in the forecasting region continued to slow to about 1.7 percent between 2010 and 2018, reaching a total population of 22.6 million. This represents an average annualized population growth of 0.2 percent, compared to an average of 0.4 percent during the 2000s, and 0.8 percent between 1990 and 2000.

The NYMTC planning area experienced rapid population growth in 1990s. The total population of the NYMTC planning area grew to roughly 12.1 million in 2000, an increase of 8.2 percent over 1990 levels (an annualized growth rate of 0.79 percent). Between 2000 and 2010, population growth in the NYMTC planning area slowed to 2.5 percent, but that growth rate persisted from 2010 to 2018. However, since 2015, population growth in the NYMTC planning area, similar to the United States and the forecasting region, slowed every year relative to the previous. In 2018, the population in the NYMTC planning area decreased by 1.1 percent, which aligns with patterns of population decline in the northeast United States during the same time period.[6]

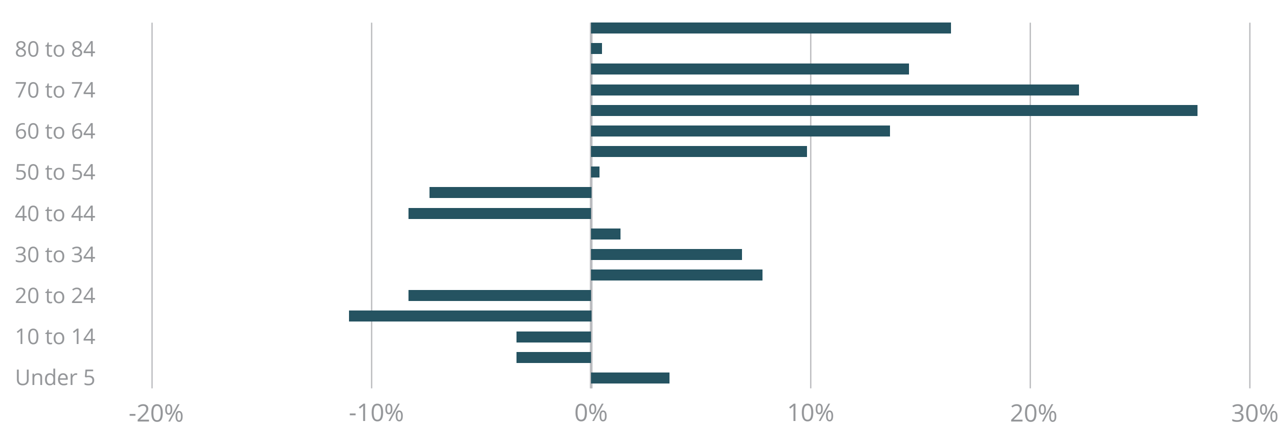
International migration is a major contributor of population growth in the forecasting region and the NYMTC planning area, even though net migration (i.e., the sum of net domestic migration and net international migration) continues to be negative for the region. International migration has resulted in larger shares of foreign-born residents across the forecasting region. In 2018, foreign-born residents represented 27 percent of the forecasting region's total population, compared to 18.5 percent in 1990, and 24.2 percent in 2000. However, like the U.S. trend, international migration has slowed within the forecasting region since 2010.

Due to lower birth rates, less immigration, and aging populations living longer and aging in place, the forecasting region and the NYMTC planning area have experienced an overall increase in its older populations since 2010. From 2010 to 2018, the most significant population growth occurred within the 55-to-79 and 80-and-over age cohorts, with significant decreases observed in the population of young children and teenagers for the NYMTC planning area (see *Figure 3-4*). **Appendix C** contains additional information on aging populations.

Figure 3-4

Change in Population by Age Cohort in the NYMTC Planning Area, 2010–2018

Source: 2006–2010 ACS; 2014–2018 ACS



3.4.2 EMPLOYMENT

In 2017, approximately 7.1 million jobs were located within the NYMTC planning area, representing an increase of approximately 740,000 jobs, or 11.6 percent, over 2010 employment levels. The NYMTC planning area's employment growth was comparable during this period to the U.S. average and was greater than employment growth in other major city metropolitan areas along the East Coast. However, this growth was slower than metropolitan regions in the West and Southwest. Approximately 72 percent of all the jobs in the NYMTC planning area in 2017 were in New York City. Roughly 2.8 million jobs were in Manhattan, more than the rest of New York City combined and about a quarter of all regional jobs.

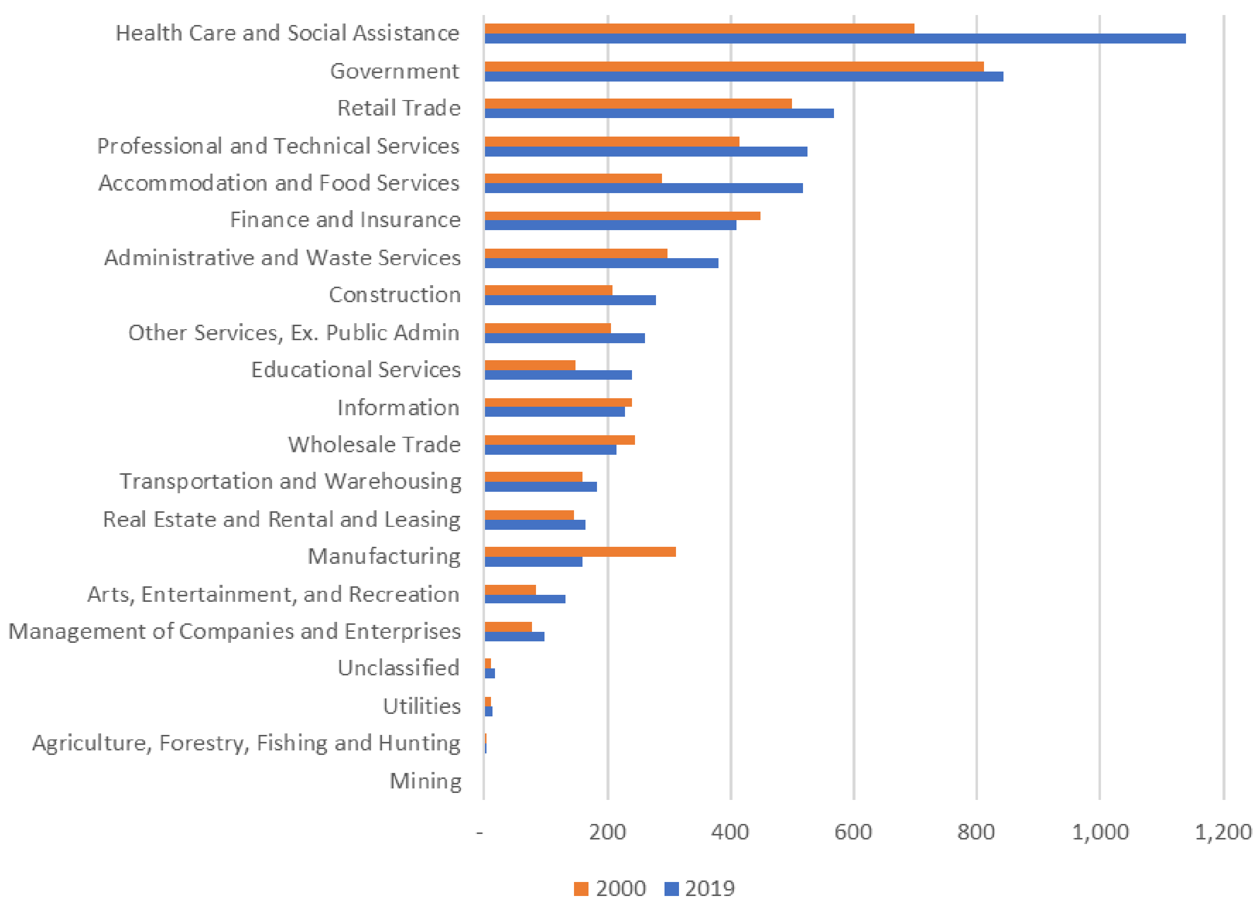
Over the period 2010 to 2017, the number of jobs in all three subregions of the NYMTC planning area grew, but 79 percent of the jobs added during this period were in New York City, representing a shift from prior periods. Within New York City, job growth remained strong in Manhattan, in addition to strong job growth in the outer boroughs. Manhattan jobs, which were the largest share in the NYMTC planning area in 2017, increased by 344,000, or by 13.8 percent, from 2010 to 2017, while the other boroughs gained approximately 244,000 jobs, roughly half of which were in Brooklyn.

Manufacturing employment continues to decline in the nation and the forecasting region, continuing a global realignment towards goods manufacture in low-cost areas. Manufacturing jobs in the nation declined by approximately 26 percent between 2000 and 2019, while the NYMTC planning area lost close to 49 percent of its manufacturing jobs, with a decline from more than 300,000 to approximately 160,000 jobs (see *Figure 3-5*).

Figure 3-5

Total Number of Jobs by Major Industry in the NYMTC Planning Area, 2000–2019 (in 000s)

Source: BLS QCEW



The NYMTC planning area has experienced the most job growth in services. Employment in the Accommodation and Food Services industry has the highest percentage increase of all major service industries, while Health Care and Social Assistance had the greatest increase in the number of jobs and total employment since 2000.

Retail trade still plays a significant role in the NYMTC planning area's economy, but job growth in the retail trade sector has slowed dramatically over the past four years, as the sector undergoes fundamental changes in the way business is conducted.[7]

3.4.3 INCOME

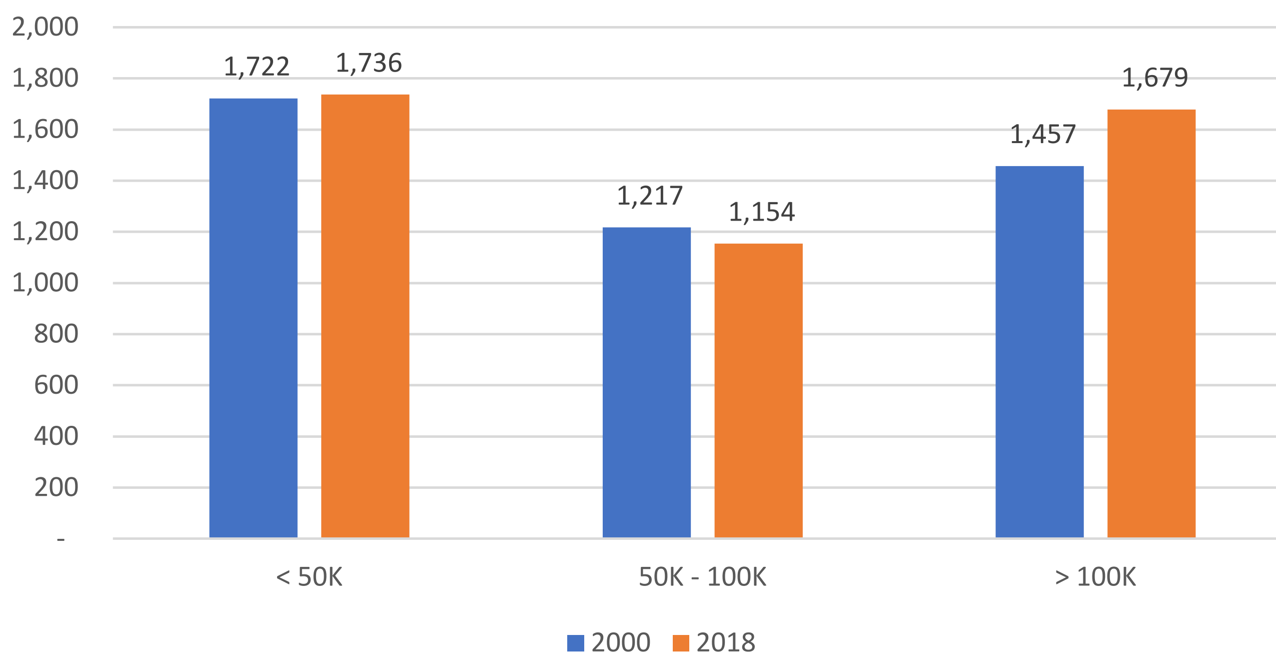
In 2018, real median household income in the NYMTC planning area was $87,824, well above the U.S. average of $60,293. Similar to U.S. trends, median household income for the NYMTC planning area has been increasing since 2013. By 2018, median household income surpassed 2010 median household income for the planning area. In 2018, the suburban Long Island subregion had the largest median household income at $103,958 of the three subregions in the NYMTC planning area, followed by the Lower Hudson Valley at $95,351 and New York City at $64,163. Nassau County had the highest median household income at $111,240, while the Bronx had the lowest at $38,085.[8]

Additionally, over the period from 2000 to 2018, there was a moderate change in the distribution of household income across the planning area. In 2000, nearly 40 percent of the region had household incomes less than $50,000, followed by 33 percent with household incomes greater than $100,000, and 28 percent with household incomes between $50,000 and $100,000. By 2018, the share of households with incomes over $100,000 (38 percent) was nearly on par with the share of households with incomes less than $50,000 (37 percent). From 2000 to 2018, there was a marginal increase of 0.8 percent in households with incomes less than $50,000, a 5 percent decrease in households with incomes between $50,000 and 100,000, and an increase of 15 percent in households with incomes over $100,000, as shown in *Figure 3-6*.[9]

Figure 3-6

Total Number of Households in Each Income Bracket for the NYMTC Planning Area (in 000s)

Source: U.S. Census Bureau, 2000 Census; 2006–2010 ACS; 2014–2018 ACS



The New York City subregion continues to have the highest share of households with incomes less than $50,000, while Long Island further distanced itself from the Lower Hudson Valley as the subregion with the greatest share of households with incomes greater than $100,000 (*Table 3-24*).

Table 3-24

Percent Share of Household Income by Subregion

Source: U.S. Census Bureau, 2000 Census; 2006–2010 ACS; 2014–2018 ACS

		<$50,000	$50,000–$99,999	>$100,000
2000	New York City	46%	28%	26%
	Long Island	22%	28%	50%
	Lower Hudson Valley	26%	26%	48%
2018	New York City	43%	26%	31%
	Long Island	24%	25%	51%
	Lower Hudson Valley	29%	24%	47%

3.5 FORECASTS THROUGH 2050

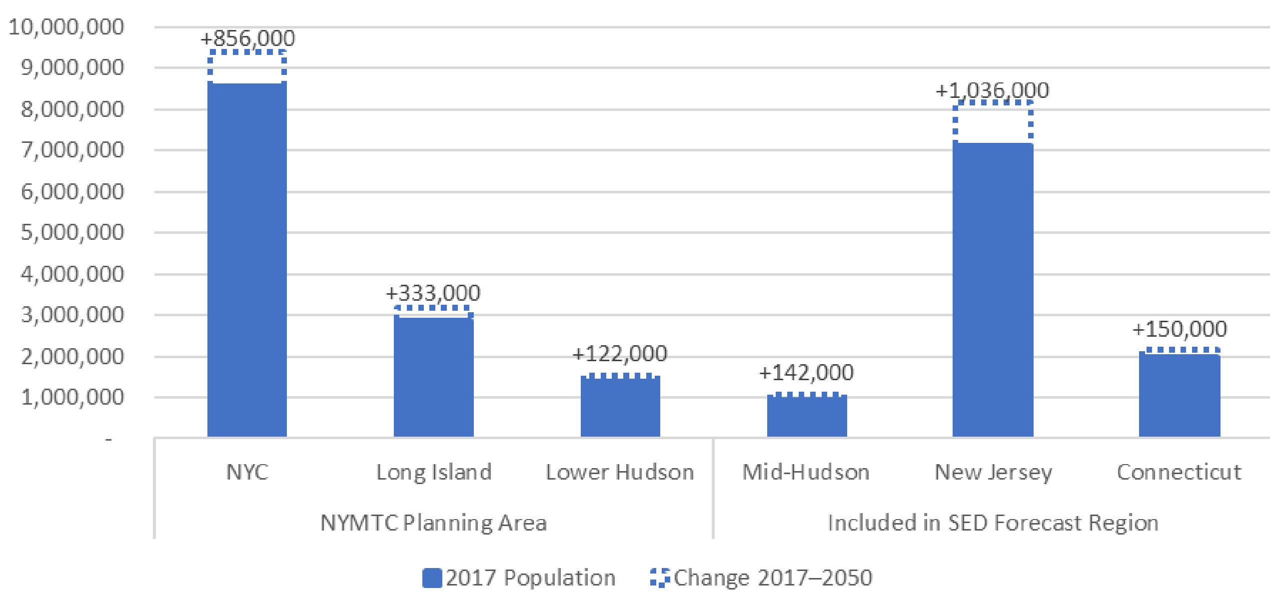
As described above, NYMTC's SED forecasts incorporate recent economic and demographic trends. However, the immediate effects of the COVID-19 pandemic have significantly disrupted those trends. Therefore, adjustments have been made to the forecasts to reflect short-term economic uncertainty brought on by the pandemic. However, the ongoing, longer-term impacts of the economic crisis caused by the pandemic are largely speculative. The primary purpose of the forecasts is the long-term outlook through the Plan's horizon year, which is less suspectable to short-term volatility. As new data become available regarding the pandemic impacts on regional employment and population trends, they will be incorporated in the next set of SED forecasts.

3.5.1 POPULATION

Population is expected to grow over the next three decades, but at a slowing rate (***Figure 3-7***). The NYMTC planning area's population is forecast to increase by 10.2 percent, or by almost 1.31 million people from 2017 to 2050. The New York City subregion is forecast to grow by approximately 10 percent, adding 856,000 people in the next three decades. The population on Long Island is expected to grow by 11.7 percent, or by about 333,000 people. The Lower Hudson Valley subregion is expected to grow by 8.7 percent, or by almost 122,000 people. Although the projection is showing overall growth for the region, the rate of growth is expected to slow through 2050.

Figure 3-7

Population Growth by Subregion, 2017–2050



Forecast population growth rates in Long Island and the Lower Hudson Valley are expected to exceed recent historical averages, while New York City's population is expected to grow at a decreasing rate (***Table 3-25*** and ***Figure 3-8***). Population growth in each subregion is based in part on market conditions, local housing pipelines, as well as an assessment of future potential land use conditions that may enable or constrain growth. In New York City, the large number of housing units produced or permitted in the previous decade increased short-term population forecasts, while long-term constraints affect the slowing growth over time. In Long Island and the Lower Hudson Valley, stronger growth is anticipated in the coming decade, with longer-term growth constraints.

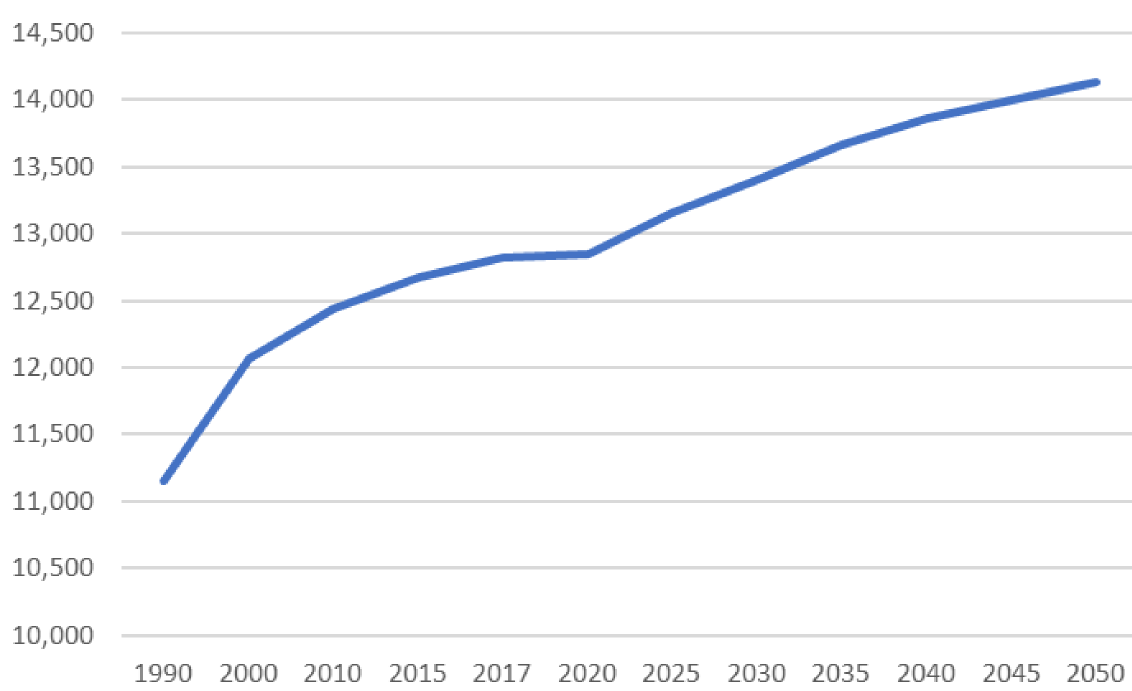
Table 3-25

Population Trends and Forecasts by County/Borough and Subregion (in 000s)

Area Name	1990	2000	2010	2015	2017	2020	2025	2030	2035	2040	2045	2050
New York City	7,322	8,008	8,242	8,425	8,562	8,604	8,883	9,063	9,171	9,261	9,349	9,418
Bronx	1,203	1,332	1,385	1,423	1,443	1,454	1,515	1,548	1,573	1,595	1,616	1,633
Brooklyn	2,300	2,465	2,552	2,593	2,650	2,647	2,760	2,820	2,860	2,894	2,928	2,956
Manhattan	1,487	1,537	1,585	1,636	1,663	1,668	1,698	1,735	1,754	1,768	1,781	1,791
Queens	1,951	2,229	2,250	2,294	2,323	2,349	2,418	2,463	2,483	2,500	2,517	2,528
Staten Island	378	443	468	477	482	484	491	495	498	502	505	507
Long Island	2,609	2,753	2,832	2,855	2,860	2,855	2,879	2,918	3,034	3,112	3,146	3,194
Nassau	1,287	1,334	1,339	1,354	1,363	1,354	1,363	1,383	1,440	1,479	1,493	1,520
Suffolk	1,321	1,419	1,493	1,501	1,497	1,500	1,515	1,535	1,593	1,632	1,653	1,673
Lower Hudson Valley	1,224	1,305	1,360	1,387	1,399	1,389	1,400	1,420	1,459	1,491	1,507	1,521
Putnam	83	95	99	99	99	98	99	101	104	106	107	108
Rockland	265	286	311	320	325	321	332	343	360	376	390	405
Westchester	874	923	949	967	975	968	969	975	995	1,008	1,009	1,008
Region	11,156	12,068	12,436	12,669	12,823	12,849	13,163	13,401	13,665	13,865	14,003	14,134

Figure 3-8

Population Forecast for the NYMTC Planning Area

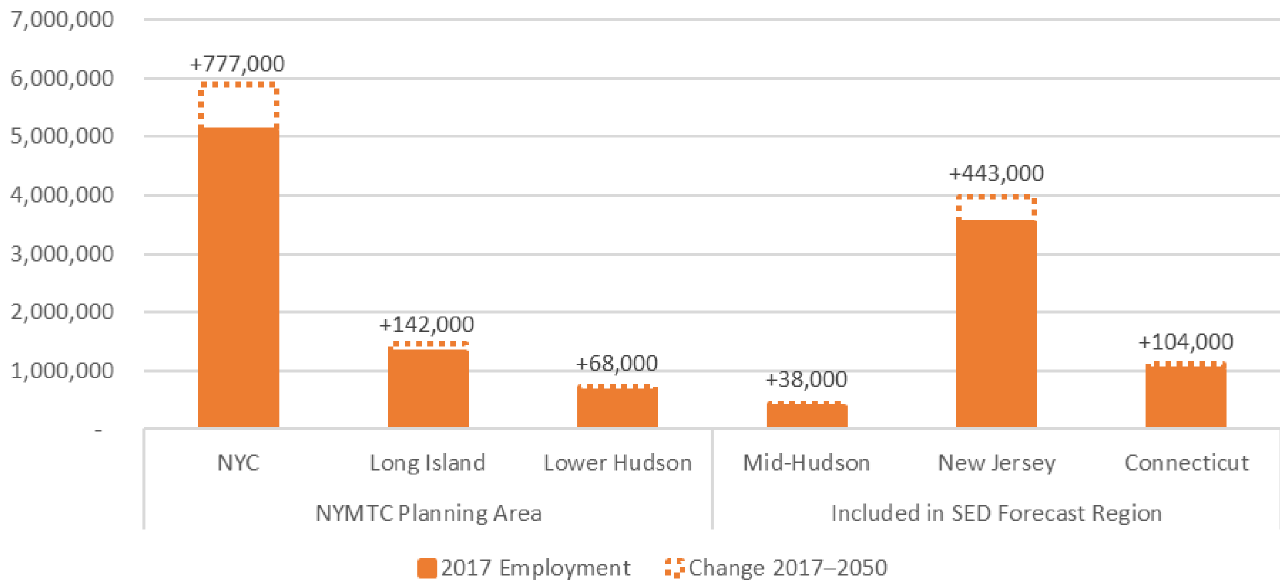


3.5.2 EMPLOYMENT

Employment growth is forecast to continue over the planning period in a slower and more balanced pattern than seen in the past. Overall, the forecasting region grew at 0.9 percent annually from 2008 through 2018, and this explosive growth is forecast to moderate over the planning period to 0.4 percent a year through 2050, factoring in assumptions of several economic cycles over the next three decades. This annual growth results in a total increase of 13 percent, or 1.57 million jobs, from 2017 to 2050.

Employment in the New York City subregion is forecast to grow by 777,000 between 2017 and 2050 (*Figure 3-9*). Within New York City, the centralization of job growth in the Manhattan core is anticipated to moderate, although Manhattan will continue to see the largest numerical increase in jobs. Employment growth in the outer boroughs is expected to continue as Brooklyn and Queens grow as regional job centers. Nearly half of the total number of jobs added during this period are forecast to be in New York City.

Figure 3-9
Employment Change by Subregion, 2017–2050



Continued strong employment growth is also expected outside New York City, and the employment forecast anticipates some rebalancing of growth throughout the NYMTC planning area. Employment in suburban Long Island and the Lower Hudson Valley are each forecast to grow by 11 percent, while the Mid-Hudson and southwestern Connecticut subregions are expected to grow by 10 percent each. Northern New Jersey is expected to see the largest numerical and proportional increase in jobs, with nearly 13 percent growth between 2017 and 2050. ***Table 3-26*** and ***Figure 3-10*** summarize employment growth forecasts for each subregion of the NYMTC planning area. Note that given the immediate economic uncertainty related to the COVID-19 pandemic, employment forecasts were lagged in the near term to acknowledge the economic slowdown caused by the pandemic and subsequent assumed recovery.

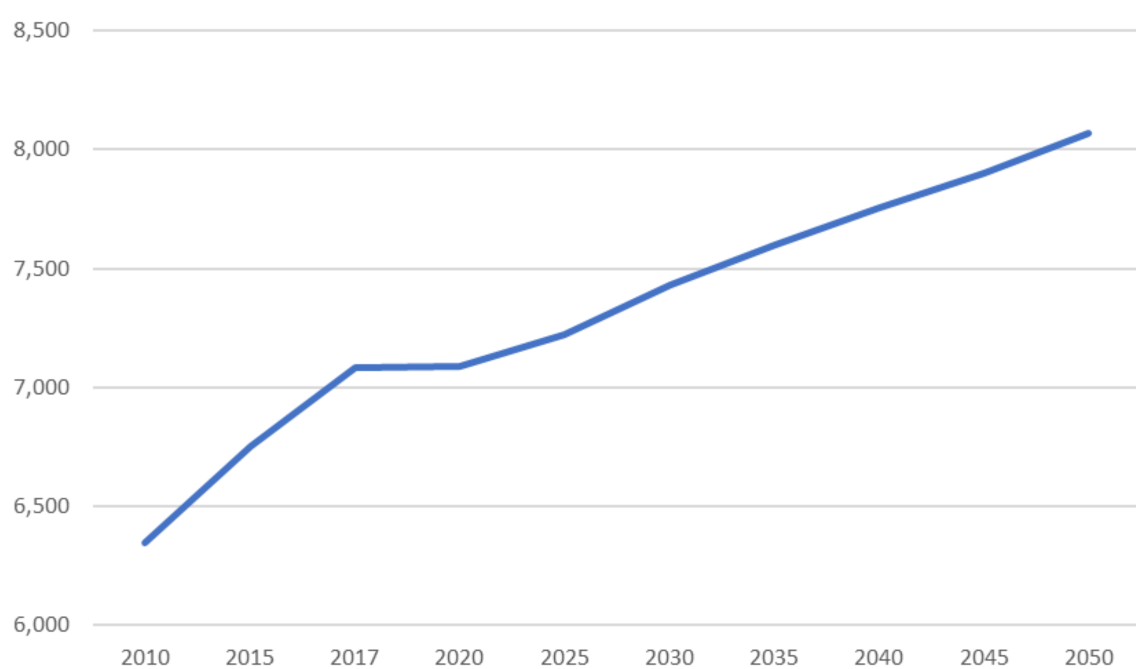
Table 3-26

Employment Trends and Forecast by County/Borough and Subregion (in 000s)

Area Name	2010	2015	2017	2020	2025	2030	2035	2040	2045	2050
New York City	4,527	4,850	5,114	5,144	5,242	5,395	5,520	5,641	5,752	5,891
Bronx	380	401	413	417	431	447	462	474	487	508
Brooklyn	822	902	940	942	973	1,013	1,049	1,084	1,116	1,149
Manhattan	2,488	2,654	2,832	2,860	2,890	2,942	2,983	3,010	3,038	3,066
Queens	708	753	787	784	803	841	869	911	945	998
Staten Island	126	138	140	140	143	150	155	159	164	168
Long Island	1,227	1,284	1,323	1,306	1,331	1,370	1,402	1,423	1,443	1,465
Nassau	590	613	631	625	639	664	684	697	710	723
Suffolk	636	671	692	680	691	706	718	725	733	742
Lower Hudson Valley	589	618	645	638	651	665	679	690	704	713
Putnam	28	29	29	29	29	30	31	31	31	32
Rockland	116	122	129	130	134	138	142	145	148	151
Westchester	444	466	485	478	486	496	505	513	524	529
Region	6,344	6,753	7,083	7,090	7,225	7,431	7,602	7,755	7,900	8,071

Figure 3-10

Employment Forecast for the NYMTC Planning Area, in 000s



3.5.3 HOUSEHOLDS

The number of households in the NYMTC planning area is projected to increase by 12.0 percent between 2017 and 2050, translating to approximately 564,000 new households. The number of households on Long Island is predicted to grow by 13.2 percent, which is slightly faster than the average growth rate in households for the region. The number of households in New York City and in the Lower Hudson Valley is predicted to grow by 12 percent and 9.6 percent, respectively. New York City, in absolute terms, is expected to add more than 390,000 households—the most of all three subregions. Although the Lower Hudson Valley is forecast to have the slowest growth, Rockland County is projected to have the largest percent increase (23.6 percent) in the number of households of all counties in NYMTC planning area (see *Table 3-27).*

At the subregional level, average household sizes are expected to decline marginally between 2017 and 2050 from 2.75 to 2.71. Household size in the Lower Hudson Valley subregion is expected to shrink from 2.75 to 2.72, in Long Island it is expected to shrink from 2.93 to 2.89, and New York City is expected to shrink from about 2.57 to 2.53 (see Figure 3-11).

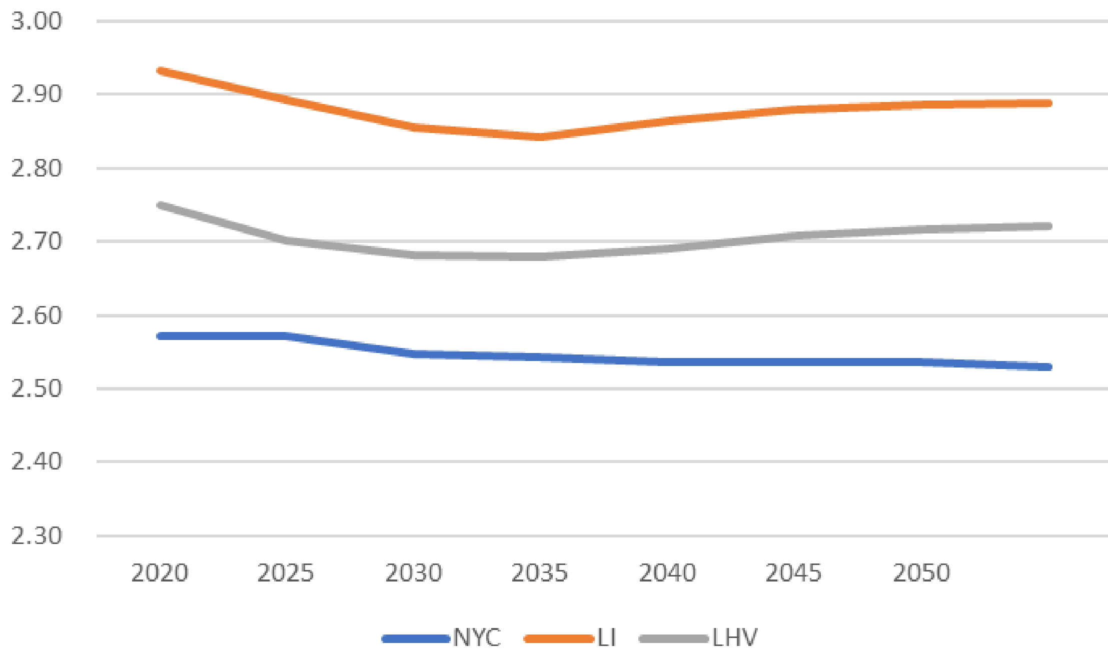
Table 3-27

Total Number of Households by County/Borough and Subregion (in 000s)

Area Name	2010	2015	2017	2020	2025	2030	2035	2040	2045	2050
New York City	3,135	3,201	3,258	3,273	3,414	3,492	3,541	3,577	3,613	3,648
Bronx	483	494	501	506	530	542	551	558	566	573
Brooklyn	934	958	981	979	1,031	1,056	1,074	1,089	1,103	1,118
Manhattan	763	778	793	795	826	845	855	861	867	872
Queens	787	801	812	821	853	872	883	889	896	903
Staten Island	165	167	169	170	173	174	176	177	178	180
Long Island	948	954	957	968	989	1,007	1,039	1,059	1,068	1,083
Nassau	448	451	449	453	460	468	481	490	494	503
Suffolk	499	503	507	514	528	539	557	568	574	580
Lower Hudson Valley	481	495	495	499	507	514	526	534	538	542
Putnam	35	35	35	36	37	37	38	39	39	39
Rockland	99	102	103	103	106	109	114	119	123	127
Westchester	347	357	356	359	363	366	373	376	376	375
Region	4,565	4,651	4,711	4,741	4,911	5,014	5,107	5,171	5,219	5,275

Figure 3-11

Average Household Size by Subregion



3.5.4 LABOR FORCE

Overall, the number of eligible workers in the NYMTC planning area is predicted to grow to 7.2 million in 2050. The labor force is predicted to grow by 11 percent from 2017 to 2050, slightly slower than the rate of the number of jobs for the region (see *Figure 3-12* and *Table 3-28*). The largest growth in labor force during this period is expected to occur in Long Island, at 12 percent. The lowest rate is expected to occur in Lower Hudson Valley, at approximately 10.4 percent. New York City's labor force growth rate of 10.7 is slightly greater than Lower Hudson Valley's, but New York City will account for almost 65 percent of the total NYMTC labor force growth, translating to approximately 462,000 eligible workers (see *Table 3-28*). Across the region, an aging workforce is expected to contribute to labor force growth. In 2017, approximately 51 percent of the region's total population was in the labor force, and the percentage is expected to remain stable through 2050.

Employed residents refers to residents of a place who are employed regardless of job location, whereas "employment" is a measure of the number of jobs in the region. NYMTC's forecast also predicts that the number of employed residents in the region will increase to approximately 6.8 million in 2050 (see **Appendix C** for more details). The growth of employed residents is expected to outpace the growth of the labor force, which could indicate an economic recovery for the planning area throughout the projection horizon.

Figure 3-12

Labor Force Change by Subregion (in 000s)

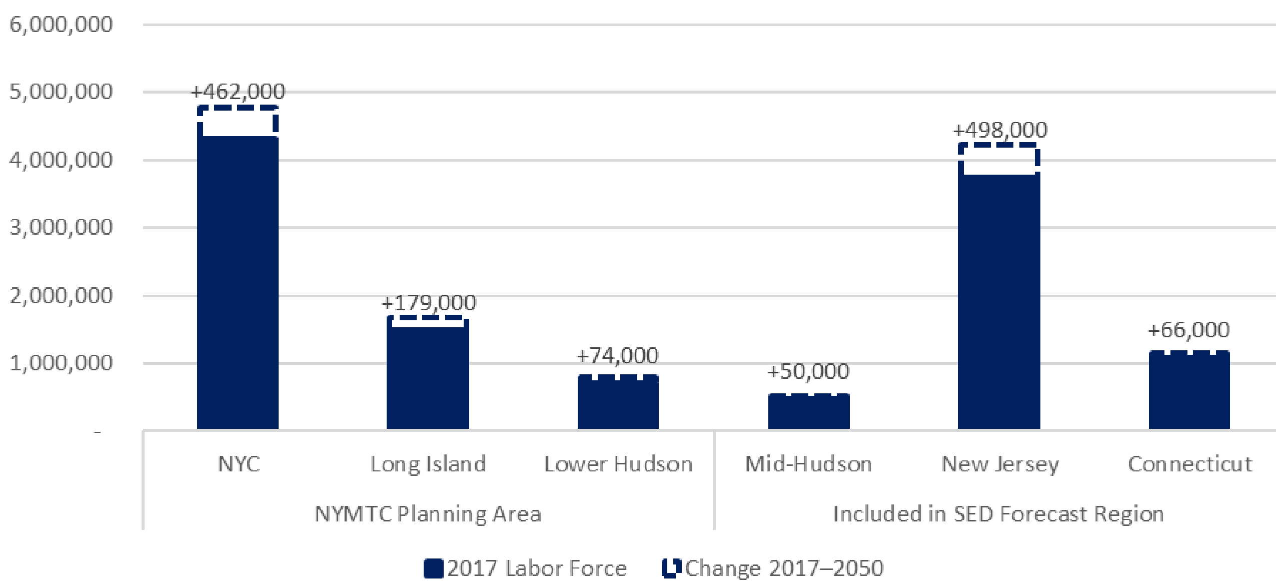


Table 3-28

Labor Force Trends and Forecasts by County/Borough and Subregion (in 000s)

Area Name	2010	2015	2017	2020	2025	2030	2035	2040	2045	2050
New York City	4,179	4,339	4,306	4,247	4,525	4,584	4,640	4,703	4,749	4,768
Bronx	617	664	664	662	718	730	743	757	769	777
Brooklyn	1,236	1,281	1,269	1,247	1,339	1,360	1,383	1,403	1,415	1,418
Manhattan	921	961	949	929	985	999	1,012	1,027	1,039	1,041
Queens	1,185	1,205	1,198	1,185	1,254	1,266	1,274	1,284	1,292	1,296
Staten Island	217	226	224	221	227	226	227	229	232	234
Long Island	1,473	1,495	1,487	1,475	1,481	1,477	1,546	1,594	1,625	1,667
Nassau	688	709	704	697	702	706	751	778	791	812
Suffolk	784	785	783	778	778	770	794	815	834	854
Lower Hudson Valley	703	715	712	708	714	720	738	756	771	781
Putnam	54	57	53	52	52	52	52	54	55	56
Rockland	150	159	157	156	160	166	175	184	193	202
Westchester	497	503	501	499	501	502	510	518	522	527
Region	6,355	6,551	6,506	6,432	6,721	6,782	6,925	7,054	7,146	7,221

3.6 WHERE GROWTH WILL OCCUR

The NYMTC planning area is forecast to continue to experience population and employment growth throughout the planning period; however, the rate of growth is forecast to slow slightly over time. This slowdown is mainly the result of likely growth constraints across the planning area. The forecast also assumes more balanced geographic growth, compared to the last 10 years of more centralized growth in the core of the planning area.

3.6.1 SUBREGIONAL GROWTH PATTERNS

At the subregional level, the New York City subregion will likely experience the most growth in employment, while northern New Jersey will see the largest growth in population, civilian labor force, and total households during the planning period. As a result, New York City's employment will increasingly rely on regional in-commuting, and New Jersey will supplement New York City's labor force demand. In the long term, suburban Long Island will experience rising job growth through 2050 supported by transportation investment, while the Lower Hudson Valley will grow more steadily as new workers are attracted to the subregion. In addition, new job centers will appear across the region to help support the increase in the labor force.

3.6.2 COUNTY/BOROUGH GROWTH PATTERNS

At the county/borough level, Brooklyn will likely lead all counties/boroughs in population growth, total household growth, and civilian labor force growth during the planning period, while Manhattan will lead employment growth. Brooklyn and Queens will likely grow as centers of regional employment, with projected increases of more than 200,000 jobs added in each borough through 2050. The Bronx will experience the highest proportional increases in population, total households, and civilian labor force in the New York City subregion through 2050.

For the Long Island subregion, Nassau County will likely experience significant growth in employment and the civilian labor force, while Suffolk County will experience most of its growth in population and total household trends. In the long term, suburban Long Island counties will see steadily rising job growth through 2050 supported by transportation investment.

In the Lower Hudson Valley, Rockland County will experience the highest proportional increase in population, total households, and average household size through 2050. It will also experience a large proportional increase in job growth, with only the four outer boroughs of New York City experiencing greater proportional growth. Westchester County is forecast to add the most jobs through 2050.

Outside the NYMTC planning area, Hudson County in northern New Jersey is expected to have the most population and employment growth, while in southwestern Connecticut, Fairfield County is anticipated to see the most growth overall.

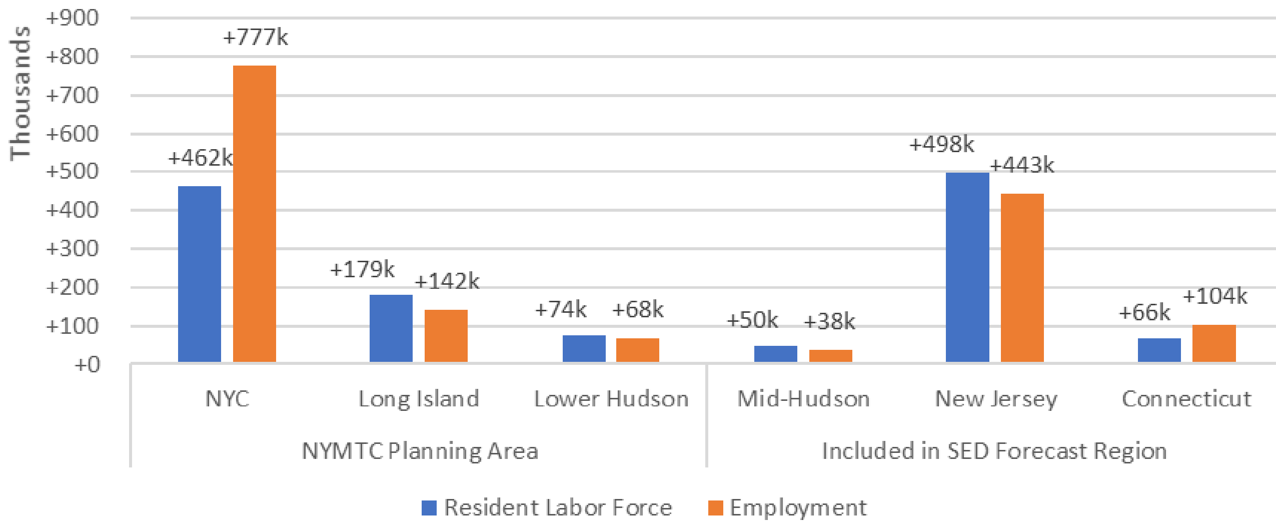
3.6.3 EMPLOYMENT AND LABOR FORCE GROWTH BALANCE

Comparing the forecasted growth in employed residents versus employment provides insight into how commuting patterns might change in the region (***Figure 3-13***). New York City job growth is expected to outpace the number of employed residents, suggesting increased reliance on commuters from outside New York City to fill its workforce. Much of New York City's employment growth is expected to be sourced from increases in the resident labor force west of the Hudson River, increasing New York City's long-term labor force dependence on northern New Jersey. Long Island and the Lower Hudson Valley are expected to see resident labor force growth exceed that of employment through 2050 (see **Appendix C**).

In addition to changes in commuting patterns, other factors—such as increases in labor force participation rates, residents staying in the workforce longer, and increases in the rates of residents holding multiple jobs—are expected to play a role in filling workforce demand.

Figure 3-13

Labor Force Growth vs. Employment Growth in the Forecasting Region, 2017–2050 (in 000s)



3.7 TRAVEL DEMAND TRENDS AND FORECASTS

SED trends and forecasts are the basis for forecasts of travel demand in the NYMTC planning area. The SED forecasts described above (and in more detail in **Appendix C**) are key inputs into the NYBPM, the travel demand simulation model used to generate forecasts of passenger and freight travel demand. NYMTC forecasts travel for people and goods in the multi-state metropolitan using complex algorithms that predict the travel and modal choices made by each household and consequently each person who resides in the NYBPM coverage area. The model also forecasts auto trips coming from outside the coverage area or passing through, as well as all truck and commercial vehicle trips. Forecasts of travel, average travel time, travel origins and destinations, and modal choice are aggregated for the NYMTC planning area as a whole and then by subregion and county/borough.

3.7.1 IMPACTS OF THE COVID-19 PANDEMIC

The COVID-19 pandemic has disrupted travel patterns and trends throughout the forecasting region with large shares of the workforce working remotely and/or shifting travel modes. While transit ridership fell off dramatically—up to 90 percent on some systems—during the first wave of the pandemic in spring 2020, ridership levels have slowly grown, although they are still well below normal levels. Given the nature of the pandemic and uncertainty at this writing regarding when and how it will ultimately end, it is too early to determine its medium- and long-term impacts on travel patterns. As noted above, adjustments have been made to the SED forecasts to account for the impacts of the pandemic and posit a recovery period. Future SED forecasts, which will incorporate new employment and population data and updated labor force projections, will better ascertain these impacts and forecast future travel probabilities.

3.7.2 HISTORICAL TRENDS

VEHICLE MILES TRAVELED

VMT, which is the sum of distances traveled by all vehicles in a specified area, is a metric that defines the extent of vehicular use on a daily or annual basis. In the NYMTC planning area, forecasts of daily VMT are an important indicator of the effects of growth as defined through the SED forecasts.

In 2018, almost 2.72 million households in the NYMTC planning area had regular access to a vehicle, which was about 59.7 percent of all households in the planning area (or an aggregate number of about 4.6 million vehicles accessible to households in the NYMTC planning area). Compared to 2000, households with vehicle access increased by 5 percent, or by an additional 131,100 households. The aggregate number of vehicles in the planning area increased by 7 percent, or an additional 323,000 vehicles.

Even though there has been an increase in households with regular access to a vehicle, there has been little change in the proportion of households with such access (see ***Table 3-29*** and ***Figure 3-14***). In addition, the share of total vehicles available for each subregion has not changed: 43 percent in New York City, closely followed by suburban Long Island at 40 percent, and the Lower Hudson Valley at 17 percent. In the forecasting region, 39 percent of vehicles are in northern New Jersey, a share that has increased between 2010 and 2018. These trends in the increased access to vehicles and the growth in the total number of vehicles will most likely persist long term and may in fact be amplified by the COVID-19 pandemic.

Table 3-29

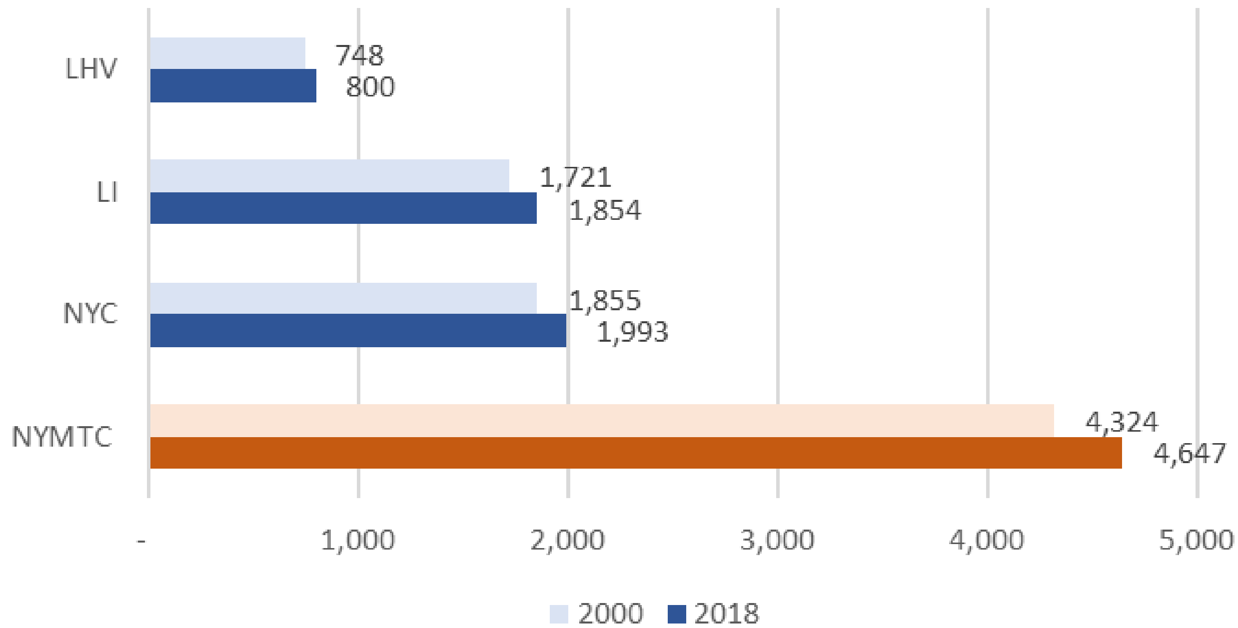
Percent Change of Households with Vehicle Access by Subregion, 2000–2018

Source: U.S. Census Bureau, 2000 Census; 2006–2010 ACS; 2014–2018 ACS

	2000	2010	2018
New York City	44.3%	45.4%	45.4%
Long Island	93.5%	94.0%	93.9%
Lower Hudson Valley	86.9%	87.5%	87.0%

Figure 3-14

Aggregate Number of Vehicles to Households in the NYMTC Planning Area by Subregion (in 000s)



As described earlier, the NYMTC planning area is forecast to experience a significant increase in the total number of households and jobs through the forecast period, which will contribute to a greater number of vehicles being used for work and non-work-related trips. This is especially true for the Lower Hudson Valley and Long Island subregions, which have a much higher proportion of vehicular travel relative to shared ride modes and public transit.

In 2018, except for Manhattan and the Bronx,[10] automobiles were the predominant mode choice for trips within and between subregions in the forecasting region. Moreover, predicted job growth in New York City generally and Manhattan specifically will likely lead to higher in-commuter trips from across the region. Additionally, the subregions in the forecasting region outside the NYMTC planning area have experienced higher rates of growth in the total number of vehicles over the preceding decades compared to the NYMTC planning area, especially within northern New Jersey. New York City jobs will continue to rely on in-commuters, especially from northern New Jersey, to fill workforce demand. So, although public transit and other alternative modes should continue to grow in usage, VMT will likely continue to grow as the total number of households increases, especially in areas that are not well served by transit, and as New York City job growth attracts more in-commuters from the region.

PUBLIC TRANSIT USAGE

Up until the onset of the COVID-19 pandemic, NYMTC's planning area had experienced a steady increase in public transit ridership. From 2000 to 2018, the number of people using public transit has increased by 30 percent or nearly 575,000 people according to U.S. Census figures (*Table 3-30*). This is largest increase for all travel modes used for work during this time period. New York City residents' accessibility to various jobs centers by public transit is a significant contributor to the continued growth in public transit usage in the NYMTC planning area.

Table 3-30

Means of Transportation to Work for the NYMTC Planning Area, 2000–2018

Source: U.S. Census Bureau, 2000 Census; 2014–2018 ACS

Year	Car, Truck, or Van	Public Transportation	Bicycle	Walked	Taxicab, Motorcycle, or Other Means	Worked at Home
2000	50.7%	37.9%	0.4%	7.5%	0.6%	3.0%
2018	44.4%	41.6%	0.9%	7.4%	1.4%	4.2%

Public transit ridership for residents in the Long Island and Lower Hudson Valley subregions is also forecast to increase due to service improvements and worsening traffic congestion. For most of the NYMTC planning area, residents who live in areas underserved by rail with low automobile accessibility rates rely heavily on bus transit. Increases in public transportation ridership in preceding decades have also been accompanied by increases in cycling and alternate modes to work.[11] As the planning area continues to grow, the availability of public transit and other alternative modes will continue grow in importance.

COMMUTING PATTERNS

U.S. Census Bureau data provide a snapshot of recent commuting patterns (See ***Table 3-31***). In 2015, in the five boroughs of New York City, the majority of workers commuted within their home county or to Manhattan.[12] In 2018, approximately 84 percent of Manhattan resident-workers commuted within Manhattan.[13] Staten Island, the Bronx, Queens, and Putnam County had the highest percentages of workers who commuted outside their home county/borough.[14] In addition to workers from within the NYMTC planning area, a significant number of travelers from other areas in the forecasting region commute to New York City each day. For example, in 2018, approximately 12 percent of New Jersey workers and 16 percent of workers from Fairfield County, Connecticut, were employed in New York City.[15]

The large influx of in-commuters to New York City, roadway congestion, and long-distance travel contribute to long commutes for a significant portion of NYMTC planning area workers. In 2018, more than a third of workers employed in New York City and 40 percent of Manhattan workers made commutes of longer than 60 minutes in each direction.[16] These commuting patterns are evidence of the continued imbalance between the locations of the NYMTC planning area's labor force and its employment opportunities (***Table 3-31***).

Table 3-31

Top Work Location by Residence, 2015

Source: U.S. Census Bureau, 2011–2015 ACS

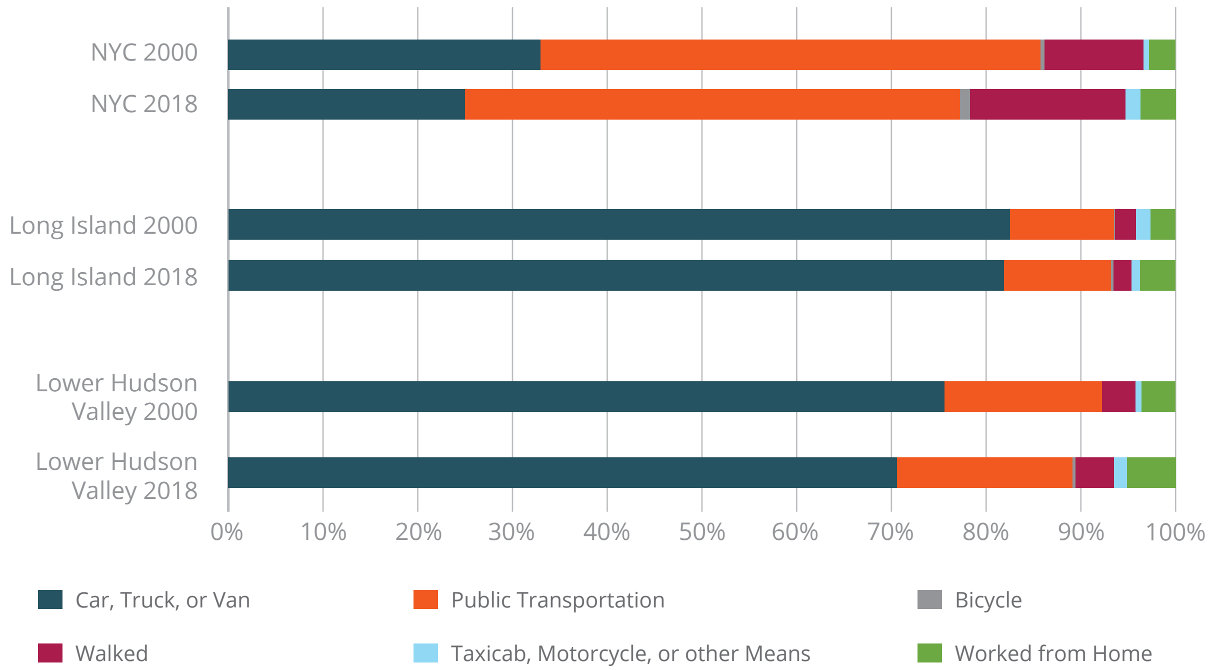
Residence	Work Location	Share of Total Workers
Bronx	Bronx	44%
	Manhattan	37%
Brooklyn	Brooklyn	50%
	Manhattan	38%
Manhattan	Manhattan	84%
	Bronx	3%
Queens	Queens	42%
	Manhattan	36%
Staten Island	Richmond	51%
	Manhattan	24%
Nassau	Nassau	58%
	New York	15%
Suffolk	Suffolk	76%
	Nassau	12%
Putnam	Westchester	40%
	Putnam	29%
Rockland	Rockland County	59%
	Manhattan	11%
Westchester	Westchester County	62%
	New York County	19%

Other notable commuting trends include the increase in the number of people working from home. Between 2010 and 2018, the NYMTC planning area saw an increase in workers who worked from home from approximately 216,000 to 254,000, an 18 percent increase.[17] This trend will most likely see a spike because of COVID-19 on worker preferences and telework capability (*Figure 3-15*).

Figure 3-15

Transportation Mode Choice for Daily Commuting Trips by Subregion

Source: U.S. Census Bureau, 2000 Census; 2014–2018 ACS



3.7.3 TRAVEL FORECASTS

TRAVEL DEMAND

Figure 3-16 displays NYBPM travel forecasts for the planning period. Growth in travel is expected to occur in the NYMTC planning area and its subregions across all modes. Total daily trips are forecast to reach approximately 31 million by 2050, an increase of nearly 10 percent. Daily auto trips are expected to grow by 8 percent, while daily transit trips are forecast to grow by 12 percent. Growth in daily VMT and vehicle hours traveled (VHT) is expected to continue, as more trips taken on the transportation system add to vehicle use and congestion (*Table 3-32*).

Figure 3-16

Travel Forecasts for the NYMTC Planning Area

Source: NYMTC

	2019	2050
Total Daily Trips	28,187,462	31,205,281
Daily Auto Trips	17,304,150	18,831,966
Daily Transit Trips	10,883,313	12,373,315
Daily VMT	116,635,983	130,504,446
Daily VHT	3,347,283	3,830,484

Percentage Change 2019 to 2050

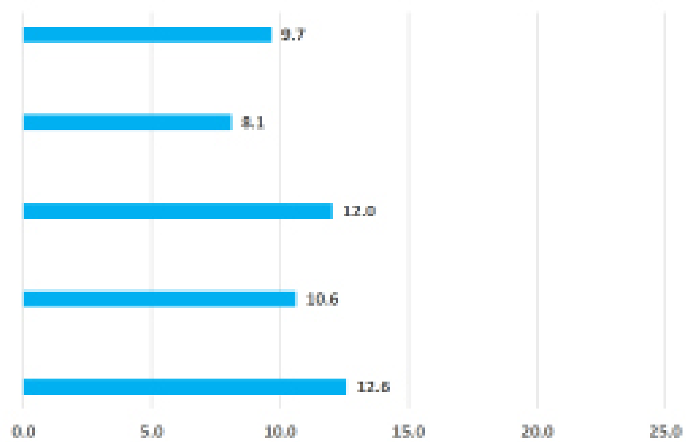


Table 3-32

Daily Auto Trip Origins and Destinations

Source: NYMTC

2019	Manhattan	Queens	Bronx	Kings	Staten Island	Nassau	Suffolk	Westchester	Rockland	Putnam
Manhattan	1,635,737	165,215	105,297	70,955	17,312	13,733	6,026	20,079	4,770	1,973
Queens	193,862	1,574,275	43,909	216,396	14,022	300,216	35,949	21,806	4,823	1,992
Bronx	104,918	44,008	746,871	26,172	4,921	17,873	5,033	159,612	4,645	1,455
Kings	63,234	216,921	26,100	1,715,177	33,641	66,986	14,390	7,976	3,478	1,105
Staten Island	19,594	16,399	5,611	38,463	367,227	6,513	2,316	2,605	676	140
Nassau	7,329	286,741	18,823	64,129	5,088	2,259,984	332,478	2,767	747	352
Suffolk	3,923	33,554	5,516	15,562	2,507	334,419	3,062,679	1,404	561	213
Westchester	14,660	22,548	147,590	8,793	2,553	3,185	1,484	1,737,510	41,637	35,365
Rockland	4,153	4,674	4,342	3,595	659	707	444	48,121	435,360	1,783
Putnam	1,703	2,070	1,479	1,196	152	341	187	36,201	2,074	128,402

2050	Manhattan	Queens	Bronx	Kings	Staten Island	Nassau	Suffolk	Westchester	Rockland	Putnam
Manhattan	1,619,668	145,702	105,763	72,667	12,358	23,455	21,086	25,253	3,693	1,823
Queens	160,944	1,746,117	47,646	250,510	13,693	316,981	44,897	25,594	3,637	2,411
Bronx	102,768	47,427	852,166	31,136	4,960	16,901	6,111	173,680	3,704	1,704
Kings	62,628	248,303	31,275	1,937,911	26,069	70,467	17,906	9,424	2,383	1,317
Staten Island	9,889	14,847	5,181	26,541	357,332	5,991	2,647	2,588	627	135
Nassau	9,575	308,745	17,669	66,193	4,766	2,508,709	378,415	3,513	590	322
Suffolk	11,590	40,592	6,689	19,432	2,896	382,980	3,482,947	1,716	605	209
Westchester	17,344	26,016	161,513	10,354	2,530	4,016	1,837	1,740,707	38,592	35,155
Rockland	2,656	3,455	3,283	2,393	599	588	478	43,921	583,093	1,947
Putnam	1,537	2,453	1,688	1,413	133	334	180	36,210	2,206	139,269

VEHICULAR USAGE

Daily VMT is expected to rise by approximately 11.9 percent during the planning period (*Table 3-33*). At the subregional level, Long Island is projected to have the highest percentage growth in VMT at 17.0 percent based on an additional 7.6 million daily VMT by 2050. Daily VMT for the Lower Hudson Valley is forecast to increase by 10.0 percent, followed by New York City with a forecasted daily VMT increase of 3.5 million or 8 percent.

Table 3-33

Daily VMT By County/Borough and Subregion

Source: NYMTC

	2019	2050	Change
Bronx	6,597,978	7,534,060	14.2%
Brooklyn	10,660,200	11,423,249	7.2%
Manhattan	7,779,894	7,908,354	1.7%
Queens	16,156,802	17,814,638	10.3%
Staten Island	3,239,365	3,288,452	1.5%
New York City Total	44,434,238	47,968,753	8.0%
Nassau	20,240,591	23,311,277	15.2%
Suffolk	24,462,524	28,980,730	18.5%
Long Island Total	44,703,115	52,292,007	17.0%
Putnam	2,818,118	2,872,551	1.9%
Rockland	6,216,861	7,307,444	17.5%
Westchester	18,463,651	20,063,691	8.7%
Lower Hudson Valley Total	27,498,630	30,243,686	10.0%
NYMTC Planning Area	116,635,983	130,504,446	11.9%

VHT reflects the efficiency and reliability of vehicular travel, primarily in terms of travel speed. In the NYMTC planning area, VHT is projected to rise by 14.4 percent by 2050. Among the subregions, Long Island will experience the greatest percentage growth in VHT, increasing by nearly 22 percent by 2050, compared to 12.6 percent for the Lower Hudson Valley and 10 percent for New York City (*Table 3-34*).

Table 3-34

Daily VHT by County/Borough and Subregion

Source: NYMTC

	2019	2050	Change
Bronx	193,282	227,713	17.8%
Brooklyn	423,874	466,155	10.0%
Manhattan	397,996	413,163	3.8%
Queens	515,738	586,032	13.6%
Staten Island	88,083	88,368	0.3%
New York City Total	1,618,973	1,781,431	10.0%
Nassau	530,693	638,218	20.3%
Suffolk	598,456	736,072	23.0%
Long Island Total	1,129,149	1,374,290	21.7%
Putnam	54,122	54,983	1.6%
Rockland	132,601	163,435	23.3%
Westchester	412,437	456,346	10.6%
Lower Hudson Valley Total	599,160	674,764	12.6%
NYMTC Planning Area	3,347,283	3,830,484	14.4%

COMMODITY FLOWS

The Regional Freight Element of *Moving Forward* is contained in Appendix H. The Freight Element contains a detailed discussion of recent trends and forecast for commodity flows during the planning period.

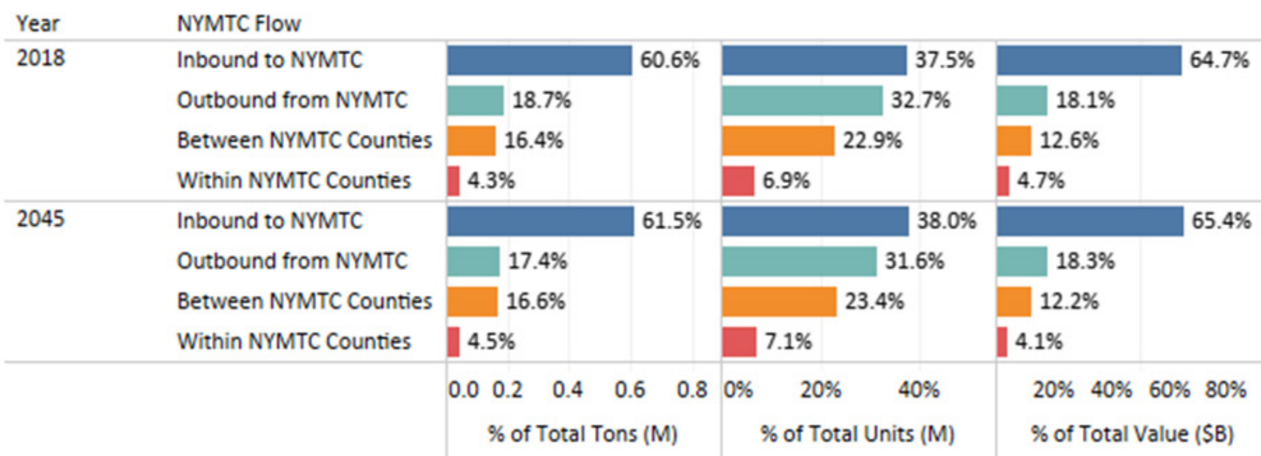
Overall, more than 300 million tons of domestic freight worth more than $430 billion moves into, out of, and within the NYMTC planning area by truck, rail, water, air, and pipeline annually; around 18 million tons of international freight worth $211 billion is imported to and exported from the NYMTC planning area annually. Trucks are responsible for moving more than 92 percent of domestic tonnage and nearly 88 percent of domestic value. Around 61 percent of tonnage and 65 percent of value is moving inbound to the NYMTC planning area; around 19 percent of tonnage and 18 percent of value is moving outbound; and the remainder is moving between or within NYMTC counties (*Figure 3-17*).

Figure 3-17

Region-Level Domestic Freight Flows by Direction (2018 and 2045)

Source: Analysis of NYSDOT Transearch Data

Year	NYMTC Flow	Tons (M)	Units (M)	Value ($B)
2018	Inbound to NYMTC	183.0	9.09	$278.53
	Outbound from NYMTC	56.6	7.93	$77.76
	Between NYMTC Counties	49.4	5.54	$54.12
	Within NYMTC Counties	13.1	1.68	$20.32
	Total	302.1	24.24	$430.72
2045	Inbound to NYMTC	263.7	13.20	$476.94
	Outbound from NYMTC	74.7	10.99	$133.68
	Between NYMTC Counties	71.4	8.12	$88.91
	Within NYMTC Counties	19.1	2.45	$29.74
	Total	429.0	34.77	$729.27



By far the largest trading partners for inbound and outbound tonnage and value are the states of New York, New Jersey, and Pennsylvania; however, there is substantial trade with the remainder of New England and the East Coast, as well as the Midwest states. The NYMTC planning area is expected to gain another 127 million tons of domestic freight worth nearly $300 billion by 2045 and experience substantial growth in international freight.

TOURISM

Like other generators of travel demand, the COVID-19 pandemic severely affected tourism throughout the NYMTC planning area. As of this writing, with the uncertainty surrounding the current and future status of the pandemic and recovery period that will follow, it is not possible to reasonably predict when and how the trends described will resume. However, the pre-pandemic trends are instructive when considering the longer-term future.

Tourism was a significant travel generator in the NYMTC planning area prior to the pandemic, and it played an important role in the regional and subregional economies by contributing tax revenues, driving purchases at businesses, and helping to create or sustain jobs. Tourism also contributed to travel demand, sometimes significantly.

New York State's tourism economy expanded in 2018 with a 6.2 percent growth in traveler spending, reaching a new high of $71.8 billion.[18] The New York State Industry Association identified tourism as New York's third-largest private sector industry, supporting 959,900 jobs in 2019 and local tax revenues of $9.1 billion, or the equivalent of $1,248 per New York State household.[19]

In 2020, the COVID-19 pandemic was responsible for 47.6 percent decline in the Leisure and Hospitality industry. Looking at New York State Department of Labor's Current Employment Statistics 12-month comparison from December 2019 to 2020 in the Leisure and Hospitality Industry, Long Island showed a drop of 30.7 percent,[20] while the Hudson Valley experienced a 36.2 percent drop.[21]

SUBREGIONAL TRAVEL IMPACTS

Prior to the COVID-19 pandemic, New York City was a major tourist destination, consistently ranking as one of the most visited cities in the world. In 2019, New York State had 265 million visitors, the tourism industry had $73 billion in direct spending due to tourism, and the total economic impact of tourism in New York City was $117 billion.[22] According to NYC and Company, New York City began 2020 with a strong performance in the travel industry for January, February, and March, prior to closures due to the pandemic.[23]

Tourism affects travel in New York City. In fact, some the New York City's iconic transportation infrastructure and services are tourist destinations themselves, including the Staten Island Ferry and Grand Central Terminal. Various tour bus operators offer "hop-on, hop-off" tours for visitors and make curbside stops throughout Manhattan. Tourists also joined commuters on subway, buses, and commuter rail systems, in addition to taxis and ride-hailing services. Some international travelers to New York City took regional rail or bus service to attractions in other parts of the multi-state metropolitan region.

One of the main impacts of tourism on Long Island was an increase in vehicular traffic and rail and bus ridership. Many of Long Island's attractions are dispersed, and private vehicles were the preferred mode of travel to these locations. In the warmer months, the MTA LIRR and ferry services experience increased ridership for access to popular beaches and barrier islands. In 2018, visitors spent $6.1 billion on Long Island. There are more than 60 wineries on Long Island's North and South Forks, drawing more than 1.3 million annual visitors to the region, 45 licensed craft breweries, beautiful beaches, parks, wildlife, and a 300-year old history of farming and fishing.[24]

The Lower Hudson Valley experienced marked growth in its tourism sector, and now ranks third in visitor spending in New York State (behind New York City and Long Island). According to Tourism Economics, traveler spending in 2018 for the Hudson Valley was $4.4 billion, with 45 percent of the region's tourism sales coming from Westchester County, $2.0 billion in traveler spending, and $1.1 billion in labor income.[25]

The Lower Hudson Valley is well known for its hiking trails, historic estates and sites, national parks, farms and farmers markets, and innovative art. Westchester County has seen significant growth in its agritourism sector. The 17-mile "Westchester-Grown" Farm Trail is a New York State designated route that provides visitors with a chance to explore more than a dozen farms in Westchester County.

3.8 FUTURE CHANGES LIKELY TO AFFECT TRANSPORTATION

3.8.1 OVERVIEW

During the planning period, it is likely that technological, behavioral, economic and environmental changes, the beginnings of which are evident today, will affect the region's overall mobility. Some of these changes will be the result of the COVID-19 pandemic. Others have been underway and will carry forward once the pandemic is over. These trends have the potential to transform the nature and means of travel for people and goods in the multi-state metropolitan region.

The increasing uncertainty that transformative change introduces into future forecasts is not simply a methodological issue. Planning the future mix of transportation infrastructure and services, as well as the design of specific improvement projects, depends on reasonable assumptions of how transformative change will influence how, when, where, why, and how often people and goods will be moving in and around the multi-state region.

A reasonable understanding of the potential for transformative change is crucial not only to developing a constructive response to that change but also to shaping that change to meet regional goals. In the book Three Revolutions, author Daniel Sperling and various contributors underscore this imperative in their description of possible futures resulting from transformative change:

> *In one vision of the future, the three revolutions (i.e., shared, clean, automated vehicles) are steered toward the common good with forward-thinking strategies and policies. Citizens have the freedom to choose from many clean transportation options...Now imagine a very different future that could come about if our community is unprepared for the three revolutions. Traffic congestion gets worse... greenhouse gas emissions increase...transit services diminish.*[26]

Simply put, anticipating future transformative change and shaping its outcomes are significant challenges to the NYMTC planning process. They are also challenging to the NYMTC members' shared vision of a more equitable and efficient transportation future with a smaller carbon footprint in the face of climate change.

3.8.2 DRIVERS OF TRANSFORMATIVE CHANGE

The development of reasonable expectations for future transformative changes is essential to *Moving Forward's* role in identifying transportation needs and guiding the preservation and enhancement of the transportation system. The following are significant drivers of anticipated transformative change.

THE COVID-19 PANDEMIC

As of this writing, the regional, national, and global economic impacts of the COVID-19 pandemic have been severe. According to the Brookings Institute, COVID-19–related job losses wiped out 113 straight months of job growth, with total nonfarm employment falling by 20.5 million jobs in April. The COVID-19 pandemic and associated economic shutdown created a crisis for all workers, but the impact was greater for women, people of color, lower-wage earners, and those with less education. The COVID-19 crisis also led to dramatic swings in household spending and damaged U.S. industrial production.[27]

The scale of the crisis brought about by the pandemic has resulted in major disruptions to many of the drivers of transformative change described above. With the pandemic entering a pronounced second (or third in some cases) wave in fall 2020 and on into winter 2021, the nature and pace of recovery from these severe economic and social shocks is simply unknown.

In the multi-state metropolitan region, as travel declined significantly, the pandemic has triggered a financial crisis for providers of transportation services and operators of transportation facilities. A largely successful ad hoc experiment in large-scale telework has eased some of the economic pain, while a high proportion of telework persists among the remote-capable workforce despite the phased reopening of the regional economy. The essential workforce, including transportation and public transit workers, have paid a high price in terms of exposure to the virus.

PERSONAL MOBILITY

Personal mobility is the capacity for individuals employed, residing, or having business in the NYMTC planning area to move about using available transportation services, including privately owned or shared vehicles or conveyances. The factors described below are important to transformative change in personal mobility.

THE EVOLUTION OF SHARED MOBILITY

Shared mobility can be defined as transportation services and resources that are shared among users, either concurrently or one after another. This includes public transit; taxis and limos; bikesharing; carsharing (round-trip, one-way, and peer-to-peer); ridesharing (i.e., non-commercial services like carpooling and vanpooling); ride-sourcing or ride-hailing; ride-splitting; scooter sharing (now often grouped with bikesharing under the heading of micromobility); shuttle services and microtransit; jitneys and dollar vans; and more.[28]

Advances in electronic and wireless technologies have made sharing transportation assets easier and more efficient. Automobile manufacturers, rental car companies, venture-backed start-ups, and government-sponsored programs have sprung up with new solutions ranging from large physical networks to mobile applications designed to alter routes, fill empty seats, and combine fare media with real-time arrival and departure information.[29]

There is overlap between the definition of shared mobility and other terms used to describe broadly similar groupings of services and resources. *Moving Forward* includes these terms in the overall category of shared mobility:

- **Mobility management** is an approach to designing and delivering transportation services that starts and ends with the customer. (National Center for Mobility Management)
- **Mobility-on-Demand** is an innovative, user-focused approach that leverages emerging mobility services, integrated transit networks and operations, real-time data, connected travelers, and cooperative intelligent transportation system (ITS) to allow for a more traveler-centric approach. (USDOT)
- **Mobility-as-a-Service** is the integration of various forms of transport services into a single mobility service accessible on demand. (MaaS Alliance)

Shared mobility represents a conjunction of transportation services and resources available to travelers on a pay-per-use basis. As FHWA indicates, the growing ubiquity and use of smartphone and internet-based platforms facilitate shared mobility and multimodal transportation options more broadly.

As a means of personal transportation, shared mobility has developed and will likely continue to develop at a rapid pace. A 2016 report from Deloitte forecasts that personally owned driver-driven cars will still have seven-eighths of the market in 2025. By 2050, shared mobility will account for 80 percent of the market, according to the report's forecast. Further:

> *If shared and autonomous vehicles are adopted as quickly as other technologies (like smartphones, cellphones, and the Internet), our modeling finds that significant change will begin within five years and that the market for personal mobility could transform dramatically over the next 25 years.*[30]

Indeed, that shift has already begun and can be seen in the following statistics:

- High Volume for Hire Vehicles, which include companies such as Uber and Lyft, have more than doubled the overall size of the for-hire ride services sector since 2012, making the for-hire sector a major provider of urban transportation services.
- High Volume for Hire Vehicles ridership is highly concentrated in large, densely populated metro areas. Riders are relatively young and mostly affluent and well-educated.
- High Volume for Hire Vehicles dominate for-hire operations in large urban areas. Residents of suburban and rural areas, people with disabilities, and those without smartphones continue to be reliant on traditional taxi services.[31]

THE PACE OF TECHNOLOGICAL DEVELOPMENT

Technology is an influential current driver of transformative change for personal mobility. The pace of the adoption of a technology can be represented as an "S" curve that shows market penetration over time and represents the technology adoption life cycle over which a new product or innovation is adopted, according to the demographic and psychological characteristics of defined adopter groups. The model indicates that the first group of people to use a new product are "innovators," followed by "early adopters." Early majority and late majority follow, and "laggards" are the last group to eventually adopt a product.[32]

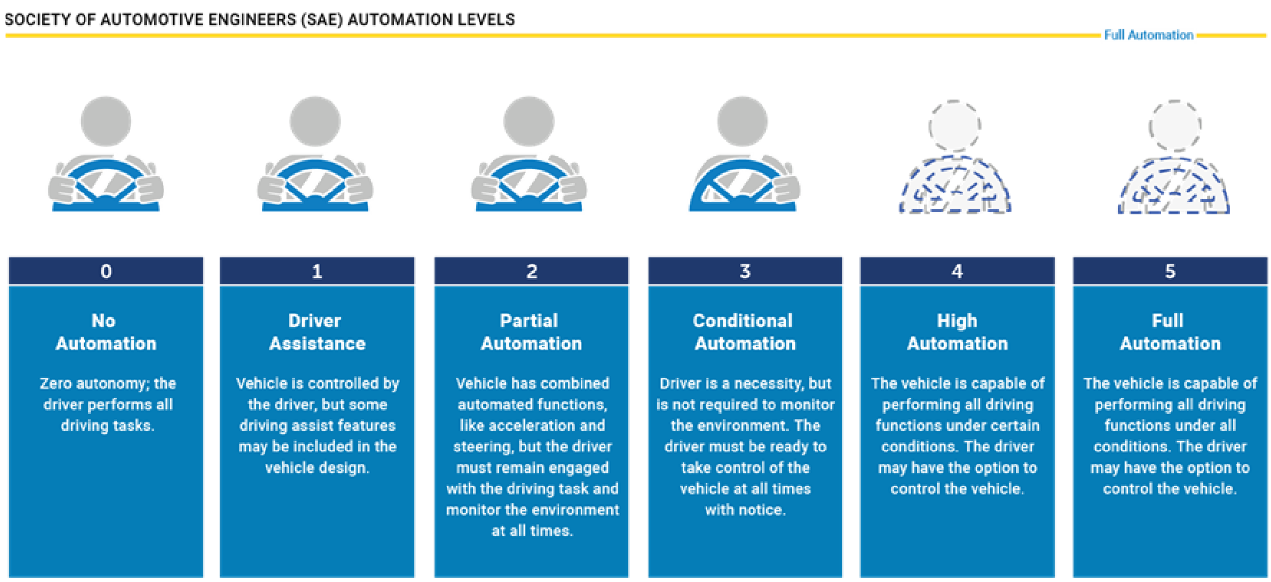
For example, the relatively rapid adoption of smartphone technology over the last two decades has made possible the emergence of transportation network companies offering ride-hailing services of all types, as well as car- and bike sharing, and e-commerce. Similarly, the development of global positioning system (GPS) technology and its adoption by vehicle manufacturers and computer application developers, among others, has made enhanced trip planning capabilities available to travelers, either in-vehicle, via those same smartphones, or through tablet, laptop or desktop computers.

Apart from further enhancements to computer applications or the accessibility of wireless data over various computer types, the continued development of vehicle automation and cleaner vehicle power systems via electricity or other sources could be two of the most influential technology drivers of future transformative change. Of the two, full vehicle automation (i.e., levels 4 and 5 according to *Figure 3-18*) could have a large impact on the future of personal mobility and the movement of goods, particularly when integrated with more well-developed computer, data, and GPS technologies. Therefore, the vehicle automation adoption life cycle could be a particularly significant to future forecasts of transformative transportation change.

Figure 3-18

Levels of Automation

Source: NHTSA



THE DEVELOPMENT OF VEHICLE AUTOMATION

In the early 2010s several automotive and tech companies, among them Tesla and Waymo, announced plans to develop consumer-ready vehicle automation technology in a short timeframe.[33, 34] These aggressive timelines did not materialize,[35] with several carmakers and technology companies stating that vehicle automation is going to be harder, slower, and costlier than they thought.

Like other ground-shifting technologies, vehicle automation struggles to climb the curve of adoption because the complexities (and therefore costs) involved are not fully understood or even visible until the later stages of technology development. Several automation road tests conducted by researchers highlighted how the unpredictable nature of other human drivers and other road users like pedestrians are a substantial challenge for a self-driving car. Additionally, safety concerns must be addressed for the technology to be fully developed.

Most states do not yet have clear regulations governing the safety testing and deployment of driverless cars. The National Highway Traffic Safety Administration (NHTSA) released new federal guidelines for automated driving systems in 2019, but these guidelines are currently voluntary. Regulating entities are faced with the challenge of a new and complex issue. For example, automated vehicles that are not fully autonomous present the "hand-off" problem: the technology itself is likely to make drivers less attentive and thus less likely to respond to a vehicle's notice of a potential problem. As a result, the intermediate phases can be even more complicated to regulate. Creative legal problem-solving will be needed to navigate the road through global, national, state, and local laws, regulations, and policies, and to guide industry standards and best practices for automated vehicles and connected cars.

The trajectory of vehicle automation adoption is complex and uncertain. It faces many hurdles beyond technological development, including legal and regulatory developments, consumer acceptance and human behavior, public opinion on safety and liability, taxation, and infrastructure funding. Forecasts for automation adoption rates vary, but most seem to agree that the share of automated vehicles on American roads will only be a couple percentage points in 2020–2030. After that, automated vehicles might start penetrating the market, until they reach 100 percent in the long term. Most studies do not expect this to happen before 2050–2070, with a 10–30 percent adoption rate by 2035, and a 30–50 percent adoption rate by 2045.[36, 37, 38, 39] The Victoria Transport Policy Institute posits that vehicle automation will likely be adopted most quickly for transportation services in which a driver is a significant cost factor, such as long-haul trucking, ride-hailing, and possibly public transit. However, other factors—such as public transport worker unions—could play a significant role in curbing the near- and medium-term adoption of vehicle automation.

While most research focuses on the positive impact of vehicle automation, it is critical to consider how this new technology could negatively affect the future of mobility. Sam Schwartz, who served as New York City's traffic commissioner in the 1980s, addresses several issues linked to future automation technology.[40] Schwartz notes that while automation is likely to reduce traffic fatalities, it will exacerbate the conflict of shared space between cars and pedestrians/bicyclists, potentially creating even more segregation of the right-of-way between vehicle lanes and sidewalks or bikeways.

Another critical impact of wide adoption of automation is the risk of increasing VMT and encouraging urban sprawl as riders acquire a greater tolerance for long commutes. Vehicles might also run empty to look for new riders or avoid parking fees. Several studies estimate an increase in VMT,[41, 42, 43] with some ranging up to 50 percent[44] if little regulation is applied. Other concerns include the impact driverless vehicles will have on the work metro areas are doing to encourage transit to reduce VMT. People who can catch a ride door-to-door might not want to walk to or wait for buses and trains, let alone pay premium rents to live or work near subway stations.

A study[45] of the potential energy consumption impacts of automated vehicles concludes that while individual vehicle efficiency may improve, this does not imply a system-wide fuel consumption decrease. Existing research predicts that the cumulative energy impacts accounting for all the potential changes could range from a 90 percent decrease to a 200 percent increase in fuel consumption by 2050. While automation is often touted to cause fewer crashes and smoother traffic flow, it may also lead to increased highway speeds, a greater willingness to commute long distances, and an increased demand for delivery services. This might translate to high and unsustainable energy usage, unless vehicle automation includes electric/hybrid and the energy comes from renewable sources.

GOODS MOVEMENT

The companies and agencies that carry, send, receive, or manage the movement of goods within the NYMTC planning area and around the world are developing and deploying new technologies and new processes to improve the efficiency of goods movement, reduce costs, comply with regulatory or customer-driven demands, and/or improve profitability. New business models are being developed and will likely continue to be developed to adapt to and capitalize on opportunities that technological developments create.

The extent to which such technologies and processes are adopted and implemented, and the potential effects on goods movement demand and travel patterns within the NYMTC planning area specifically, are difficult to gauge. Additionally, a recent Reuters report that surveyed nearly 600 supply chain executives revealed that 58 percent of logistics service providers had shortened their technology roadmaps because the COVID-19 pandemic has accelerated the adoption of new technologies and innovative business processes that improve supply chain efficiency and resilience. The pandemic has been pulling demand away from services towards goods and placing greater demands on supply chains.[46]

E-COMMERCE AND DISTRIBUTION INNOVATIONS

The Freight Element of *Moving Forward* (see **Appendix H**) contains a full description of the current and anticipated impacts of e-commerce on the movement of goods in and around the NYMTC planning area. E-commerce shipments are defined by the U.S. Census Bureau as online orders for manufactured products where price and terms of sale are negotiated over the internet or another online system. U.S. e-commerce sales have been rapidly expanding since the late 1990s, rising from $4.5 billion in the fourth quarter of 1999 to $130.9 billion in the third quarter of 2018, according to data from the U.S. Census Bureau. Growth in online sales has widely outpaced overall retail sales growth. Between the fourth quarter of 1999 and the third quarter of 2018, quarterly e-commerce sales increased by an average of 18.9 percent year-over-year, compared to a pace of just 3.4 percent for total retail sales. As a result, e-commerce accounted for nearly 10 percent of total U.S. retail sales prior to the pandemic, compared to less than 1 percent in 1999. Moreover, recent years have not indicated a slowdown in e-commerce's penetration of the retail market. On the contrary, the e-commerce portion of overall retail sales increased by nearly 1 full percentage point during each of the last three years for which data are available; the impacts of the pandemic are likely accelerating this trend.

The rise in e-commerce and direct-to-consumer (D2C) retail is having significant repercussions on product distribution and delivery, with many more shipments going directly to individual residences, rather than brick-and-mortar storefronts. D2C refers to selling products directly to customers, bypassing any third-party retailers, wholesalers, or any other middlemen.[47] In 2019, D2C e-commerce sales reached $14.28 billion in the United States and were forecasted to grow by 24.3 percent in 2020 before the onset of the COVID-19 pandemic, to $17.75 billion.[48] Many retailers are using large package delivery companies such as UPS, FedEx, and USPS to handle these deliveries, significantly altering the business model for such companies. For example, D2C shipments now represent more than 50 percent of UPS's total domestic volumes.

The shift toward D2C delivery has forced many retailers to focus more on last-mile logistics, which is generally considered to be the most complex and costly portion of the delivery process. While many continue to outsource this service to one of the big three delivery companies (UPS, FedEx, and USPS), some are opting for their own delivery service. The result of these developments is that the rise in e-commerce has produced a significant number of new participants in the distribution network, as well as additional vehicles and vehicle types on the road delivering goods.

While durable goods led e-commerce sales prior to the COVID-19 pandemic, many consumable goods, most notably groceries, experienced significant growth—a trend that is expected to continue and be amplified by the pandemic. According to Unata's 2018 Grocery E-commerce Forecast, 36 percent of people surveyed planned to order groceries online in 2018, up from the 22 percent who reported grocery shopping online in 2017, a growth rate of 64 percent. Amazon's purchase of Whole Foods in 2017 is undoubtedly contributing to the expansion. Wal-Mart has also been aggressive in the online grocery space, announcing plans in early 2018 to expand its online grocery delivery service to 100 metropolitan areas by year's end. At the same time, Kroger is in the testing stage for the first fully self-driving grocery delivery service with no human being in the vehicle.

Prior to the pandemic, the rapid growth in e-commerce and the D2C market combined with faster delivery standards was having significant repercussions on warehouse location decisions. There was a notable shift away from the practice of using a small number of enormous facilities located at a considerable distance from the urban areas they serve, toward using more numerous, smaller industrial spaces located closer to the end consumer. For the NYMTC planning area, this has resulted in several new facilities in the outer boroughs of New York City. One result of this trend is greater stress and congestion on local roadways, both from trucks and small vehicles.

DISTRIBUTED MANUFACTURING

The Freight Element of *Moving Forward* (see **Appendix H**) also contains a full description of current and anticipated impacts of distributed manufacturing on the movement of goods in and around the NYMTC planning area. Distributed manufacturing refers to the potential for three-dimensional (3D) printing to permit efficient production of goods near the points of demand, leading to many small factories situated in and serving many local markets. This contrasts with the long-standing imperative for factories to achieve economies of scale through mass production and to locate large plants in limited numbers where the availability of raw materials, affordable skilled labor, vendors, or other factors of production make the achievement most efficient. Shipments to the NYMTC planning area of large volumes from some external sites in the United States or abroad could be replaced by local shipments from points of production inside NYMTC's planning area.

3D printing is a type of additive manufacturing (AM) by which products are formed by layering materials, as opposed to subtractive (cutting away) or formative (molding) techniques (AM and 3D are terms used interchangeably, although technically the latter is a category of the former). The 2019 AM industry, consisting of all AM products and services worldwide, grew 21.2 percent to $11.867 billion. The Wohlers Report 2019 projected that AM industry revenues would hit $35.6 billion by 2024.[49] When the AM market is compared to the $13 trillion in economic activity from global manufacturing, its small size understates its significance because it is a radically different form of production.

Dedicated 3D manufacturing requires industrial printers purchased by producers, whether for higher volume components or for integration into a larger manufacturing process. The scale of the factory can be smaller, depending on the other tooling required, because of the versatility of the technology. This helps in urban locations with expensive real estate. The deeper question is the business strategy companies employ to exploit the virtues of AM. Supply chain managers are rethinking their sourcing in the face of AM and could rethink their production methods. Concurrently, the management consultants AT Kearney[50] argue that the intrinsic advantages of 3D and its offsetting of lower foreign production costs could on-shore to United States manufacturing $330-500 billion in import product value in five sectors—automotive, aerospace, consumer products, health care and medical devices, and general industrials. This would reflect 3D penetration claiming between 23 and 40 percent of production in these sectors over the next 10 years.

3.8.3 POTENTIAL IMPACTS OF THESE DRIVERS

THE COVID-19 PANDEMIC

In some cases, the pandemic appears to have accelerated some of the drivers described above. Some shared mobility options have seen some growth as conveyances for personal mobility during the emergency. Initial attempts at greater integration of shared mobility modes with public transit have been accelerated in some cases. Although supply chains have been stressed by the COVID-19 pandemic, e-commerce and D2C retail have experienced new and heightened demands as a result of both the pandemic and requirements for social distancing. Additionally, AM has been called into play to fill some production gaps, notably for personal protective equipment.

Although it is not possible at this writing to predict the end of the COVID-19 pandemic, the length of the recovery and any long-term impacts of these unprecedented and ongoing events on the drivers of transformative change, it appears at least likely that the economic, social, and technological impacts of the pandemic will have some impacts on business practices and residential and commercial development patterns at least into the medium-term future.

PERSONAL MOBILITY

Given the research undertaken to date, the following developments are possible during the period of the Plan with regard to vehicle automation and its integration with shared mobility and the potential application of Autonomous Traffic Management, a research field of ITS that aims to decrease traffic congestion based on vehicle automation's cooperation and capacities.[51]

DURING THE DECADE OF THE 2020s

- The legal/regulatory framework for vehicle automation will likely continue to develop at the federal and state levels, while vehicle automation pilots will likely continue and expand.
- It is likely that full vehicle automation (levels 4 and 5, in ***Figure 3-18***) will be introduced in services (i.e., ride-hailing, long-haul trucking) where the driver is a cost factor.
- Shared mobility will likely continue to evolve and expand, while the companies providing services may consolidate around a smaller number of profitable companies.
- Micromobility legal/regulatory issues will be resolved and usage of the relevant modes will likely increase while transportation facilities adapt to increased usage.
- Shared mobility and generational changes will likely increasingly affect private vehicle ownership.
- Shared mobility will likely continue to become increasingly integrated with public transit services.
- Transportation network companies and shared mobility companies will either reach profitability or in some cases cease providing services. Consideration will likely be given to possible public financing of these services.

2030 AND BEYOND

- Vehicle automation will likely expand in market share to perhaps as high as 50 percent of vehicle travel by the mid-2040s.
- Automated vehicles will likely comprise an increasing proportion of the shared and private vehicle fleets (i.e., ride-hailing, taxis and car services, long-haul trucking).
- The legislative/regulatory framework will likely continue to evolve to accommodate a mixed human-operated/automated fleet.
- Infrastructure improvements/innovations will likely be implemented to accommodate a mixed human-operated/automated fleet.
- Autonomous Traffic Management will also likely evolve to accommodate a mixed human-operated/autonomous fleet and eventually be optimized for a majority automated fleet during the decade of the 2050s.
- Greater integration with vehicle automation will emerge in ride-hailing, public transit, and goods movement.

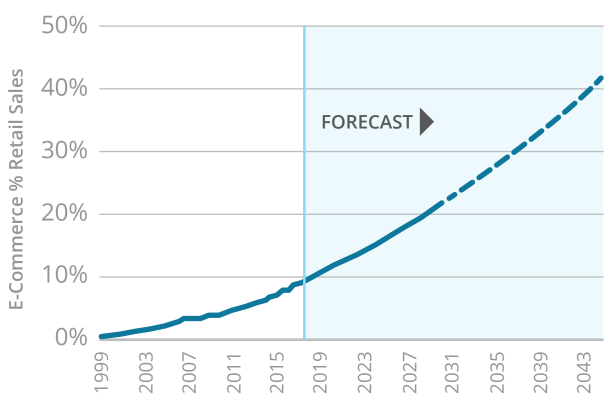
E-COMMERCE

Accelerated by the COVID-19 pandemic, technological advances will likely continue to support online sales growth by allowing consumers greater access to product information; quick and easy price comparisons; and faster, cheaper, personalized delivery options. Moreover, as same-day delivery and free shipping on returns become more commonplace, the allure of brick-and-mortar stores will diminish further. Thus, there is little reason to expect a slowdown in the growth of online sales market penetration in the next five years. Indeed, eMarketer is forecasting a continuation of robust growth, with online sales expected to account for more than 15 percent of total retail sales by 2022 (*Figure 3-19*). While there is no doubt a saturation point in terms of e-commerce as a percent of overall retails sales, it is unlikely to be reached soon.

Figure 3-19

Long-term Forecast for E-commerce Retail Sales

Sources: eMarketer, CBRE Research, US Census Department, Cheng Solutions LLC



The continued rise in e-commerce sales has significant implications on warehouse demand. The D2C market translates into fewer goods inventories in retail stores and greater volumes of goods on warehouse racks for delivery. CBRE Research estimates that for every $1 billion increase in e-commerce sales, an estimated 1.25 million square feet of warehouse space is needed to keep up with demand. Using eMarketer's online sales forecast, CBRE estimates that e-commerce generated warehouse demand could grow, nationally, by an additional 191 million square feet from 2018 to 2020.[52] That additional warehousing could generate 115,000 additional daily truck trips in the United States.[53]

There are significant barriers to the commercial integration of levels 3-5 (*Figure 3-18*) automated trucks. In terms of technology, the hardware issues, such as sensors, vehicle-to-vehicle communication, and vehicle control, are relatively minor. However, the software issues, including spatial issues, human-machine-interface, and mapping and path planning/control, need advanced development.[54] Significant infrastructure, legal, and liability issues also must be resolved.

DISTRIBUTED MANUFACTURING

Additive Manufacturing is an actively evolving technology: in printers, materials, applications, and in accumulated experience of its use for the fabrication of goods. It makes a decidedly minor contribution to manufacturing processes today, yet its contribution is larger for some goods, and its use is growing rapidly. Adoption is stimulated by delivered cost advantages for local, domestic production versus overseas sourcing. Adoption could be accelerated by the risks to trade brought on by tariff policies and the International Maritime Organization fuel mandate.

In sum, the course of development should play out over 10 to 20 years. However, the growth curve could become steeper because of trade factors. In the recessionary economic shock and economic restructuring generated by the COVID-19 pandemic and resulting public health emergency, the demand for goods has dropped, but the business need for competitive advantage has risen. The medium-term impact of this global emergency could create another stimulus for adoption of 3D technology, with the volume effects not felt until economic recovery begins.

3.8.4 LARGER-SCALE DISRUPTERS

NYMTC's planning area, along with the multi-state metropolitan region, will continue to face challenges from the impacts of the following larger-scale disrupters.

CLIMATE CHANGE AND EXTREME WEATHER EVENTS

Mandated at least every four years by the Global Change Research Act of 1990, the U.S. National Climate Assessment documents climate change related impacts and responses for various sectors and regions, with the goal of better informing public and private decision making at all levels.[55]

According to the fourth U.S. National Climate Assessment in 2018:

> *Earth's climate is now changing faster than at any point in the history of modern civilization, primarily as a result of human activities. The impacts of global climate change are already being felt in the United States and are projected to intensify in the future—but the severity of future impacts will depend largely on actions taken to reduce greenhouse gas emissions and to adapt to the changes that will occur.*[56]

Among the assessment's key findings of the assessment regarding transportation:

> *Transportation is the backbone of economic activity, connecting manufacturers with supply chains, consumers with products and tourism, and people with their workplaces, homes, and communities across both urban and rural landscapes. However, the ability of the transportation sector to perform reliably, safely, and efficiently is undermined by a changing climate.*
>
> *Transportation is not only vulnerable to impacts of climate change but also contributes significantly to the causes of climate change. In 2016, the transportation sector became the top contributor to U.S. greenhouse gas emissions. The transportation system is rapidly growing and evolving in response to market demand and innovation. This growth could make climate mitigation and adaptation progressively more challenging to implement and more important to achieve. However, transportation practitioners are increasingly invested in addressing climate risks, as evidenced in more numerous and diverse assessments of transportation sector vulnerabilities across the United States.*[57]

As the fourth assessment underscores, it is prudent to assume an increase in extreme, climate-related weather events over the course of the planning period. This assumption is especially significant to the NYMTC planning area, given (1) its location along several coastlines; (2) the configuration of the coastal New York Bight; and (3) the topography of islands and river valleys throughout the planning area. During the decade of the 2010s, extreme weather events increased consideration of resiliency and climate adaptation at all levels of planning, changing the way system-wide transportation planning is being conducted as transportation agencies look for ways to better prepare for extreme events. This imperative will surely continue through the period of the Plan and will likely need to remain dynamic as new challenges arise or are anticipated.

Technological development can help enhance the resiliency of the transportation system in the NYMTC planning area to extreme weather events and improve emergency response, infrastructure robustness, and redundancy in extreme weather situations. Techniques to harden or equip transportation infrastructure against weather effects such as inundation, flooding, and extreme heat are becoming available or are being developed to protect the region's transportation assets. Additionally, simulation modeling technology will continue to enable planners to identify vulnerabilities in the transportation system, target infrastructure and equipment for hardening, and develop emergency plans in response to extreme events.

ENERGY TRANSFORMATION

According to the U.S. Bureau of Labor Statistics, gasoline prices (all types) in the New York-Newark-Jersey City, NY-NJ-PA Metropolitan Statistical Area exceeded $3 per gallon on a monthly basis from November 2010 through November 2014. During that period, the average monthly price exceeded $4 for three individual months in 2012. The $3 threshold was again exceeded from May through July 2018 and hovered above $2.80 through November of that year. The May through July period also saw prices approach $3 per gallon before leveling off at approximately $2.70.

Gasoline price variability over the last decade, along with periods of consistently high prices, have placed an onus on improved fuel-efficiency. According to USEPA, average real-world fuel economy for all vehicle types reached 25.4 miles per gallon for the 2018 model year compared with 22.6 miles per gallon for the 2010 model year, a 12.4 percent increase.

Energy prices have also resulted in increased manufacture and sales of vehicles propelled fully or partially by electric motors powered by rechargeable battery packs. Electric vehicles (EVs) can be charged from standard electricity sources. Hybrid electric vehicles (HEVs) combine an internal combustion engine with an electric motor. Both EVs and HEVs also convert energy from coasting and braking into electricity, which is stored in the batteries. Compared to regular vehicles, EVs have greater energy efficiency, produce lower emissions, and cost less to operate. However, there are still issues with the range of EVs that limit their practicality.

In the medium-term, hybrid and plug-in EVs and supporting infrastructure could have a great impact on personal and commercial transportation. These EVs and HEVs have gained presence in the NYMTC planning area: the first hybrid electric buses and taxis entered service in New York City in 2004 and 2005, respectively.[58] New York State's initiative to get more electric cars and trucks on the road, ChargeNY, has supported the installation of over 2500 charging stations[59] for EVs and HEVs since 2013. New York State has also revised regulations to clarify charging station ownership rules and supported research and demonstration projects on new EV technologies and policies.[60] The cost of electric charging infrastructure for public transit services can be significant.

CHANGING DEMOGRAPHICS AND LIFESTYLE/ WORKSTYLE EXPECTATIONS

Demographic changes over the past decade have altered the way people travel, resulting in the emergence of new patterns and demands. One of the most prominent demographic trends during the period of this Plan will be the aging of the population in NYMTC's planning area. In 2018, the population 65 years and older living in the NYMTC planning area was 1.9 million or 14.9 percent of the total residential population.[61] This figure is expected to continue to increase with the aging of the Baby Boom generation and continued development of longevity medicine. According to the NYMTC population forecasts, by 2050 nearly 17 percent of the population in the NYMTC planning area is projected to be 65 and older.

Changes to the age structure of the population will likely influence travel patterns in the region. In general, older adults have a higher incidence of disabilities and a lower rate of workforce participation, which results in an overall reduction in travel and a higher demand for assisted and accessible transportation. In 2013, AARP reported that more than 20 percent of adults over the age of 65 do not drive and do not have good access to public transit facilities,[62] although earlier reports found that they are using public transit more and more.[63] According to FHWA, the percentage of licensed drivers who were 65 and older in 2018 in New York was 21 percent. In the United States, 45 million licensed drivers were 65 and older in 2018.[64]

Measures that can accommodate an aging population's mobility needs include more specialized public transportation, Complete Streets, older driver safety measures, and accessible design at public transportation stations. Generational changes will also likely affect the acceptance and use of new technologies, which in turn can affect travel patterns. The future development of application-based, demand-responsive transportation services will continue to be influenced by their acceptance by younger generational cohorts. Taken as a whole, these technologies have and will continue to change Americans' travel behavior.

Another trend distinguishing younger Americans is their preference for transit and active transportation, such as walking and biking. Research shows that Millennials (those born between 1980 and 2000) tend to drive less, take transit more, bike and walk more, and seek out places to live in cities and walkable communities that encourage walking and biking.[65] According to the Urban Land Institute, 19 percent of Millennials bike at least once a week, compared with 16 percent of Generation X and 12 percent of Baby Boomers.[66]

Other research has found that Millennials, although they rode fewer vehicles than Baby Boomers (those born between 1946 and 1964), had more vehicle miles traveled. The results suggest that while Millennial vehicle ownership and use may be lower early on in life, these differences are only temporary and, in fact, lifetime vehicle use is likely to be greater.[67]

Generation Z, also known as Zoomers and iGen, (born between 1997 and 2015) tend not to have the same connection as older generations to vehicles. They are starting to try different modes of transportation, including shared mobility like Millennials. A working paper published by Econstor showed that:

> *Millennials and those in the younger cohort of Gen Z are more than twice as likely than Gen X (1964-81) and Boomers to question whether they need to own a vehicle going forward and are less willing to buy a car than other generations (Vitale et al., 2019). Only 64% of Millennials said that their preferred mode of transport was the car they own, in comparison to 81% of consumers from other generations.*[68]

A report by Allison & Partners based on a 2019 online survey of 1,035 people in the United States over the age of 16 also showed that:

> *70 percent of Gen Z respondents do not have their driver's licenses and 30 percent of those who do not currently possess their driver's license have no intention or desire to get one. This decline in driving sentiment points to evidence that alternatives to personal transportation have gained momentum. In fact, nearly one-third of those surveyed (31 percent) reported regular use of rideshare services as an alternative method of transportation, and more than half (56 percent) used public transit.*[69]

In terms of work styles, the 2018 *Future of Jobs Report* of the World Economic Forum included the following relevant findings for employers: technological change drivers and accelerated technology adoption; a changing geography of production, distribution and value chains; changing employment types due to automation; and a reskilling imperative.[70]

Employment and productivity have a significant impact on the transportation network because demand is determined in large part by the number of people who need to travel for work, the volume of goods that need to be transported, and where those goods originate and are destined.

Changes in methods and locations of production will affect travel demand. In particular, 3D printing could supersede supply chains and distribution networks for certain types of goods and allow more decentralized production. Similarly, changes in the form of employment that may be brought about by evolving technologies will affect where, when, and how people are employed and perform their work, thus affecting their mobility needs. Related economic factors that would be affected include tax rates and bank regulations, which influence business location decisions and thus where general economic activity and population growth occur.

CHANGING LAND USE PATTERNS

Various factors, including continued regional growth, local land use preferences, real estate market conditions, the development of transportation technologies and services, and the impacts of sea level rise and extreme weather events will likely influence land development patterns, which in turn influence the type and amount of travel demand.

According to the U.S. Census Bureau's annual population estimates, New York City's population growth slowed and began to reverse over the decade of the 2010s. New York City's population grew at roughly 1 percent from 2010 to 2011. By 2016, that annual growth had slowed to roughly 0.1 percent over 2015. The 2016–2017 and 2017–2018 comparisons showed small population losses—0.4 percent and 0.5 percent, respectively. In that same 2017–2018 period, suburban population growth in the New York-Newark-Jersey City, NY-NJ-PA Metropolitan Statistical Area was 0.15 percent, which was roughly the same level of annual suburban growth at the beginning of the 2010s. These data suggest the beginnings of a reversal of the previous period of significant growth in New York City and the re-emergence of a level of suburbanization.

In the NYMTC planning area, significant transit-oriented development initiatives have been undertaken or are under development by New York State, New York City, suburban counties and municipalities, MTA, and private developers as a way to achieve more sustainable development patterns. Examples on Long Island include Wyandanch Rising, which is transforming one of Long Island's most economically distressed communities into a transit-oriented downtown with excellent access to the MTA LIRR, affordable housing units, and commercial uses offering daily amenities. Similar concepts are in progress or under study in East New York and the east Bronx in New York City; and around MTA MNR stations in the Lower Hudson Valley suburban cities of Yonkers, Mount Vernon, and New Rochelle.

Additionally, the advent of shared mobility and e-commerce is beginning to affect land use patterns and may continue to do so. Information and communication technologies, as well as vehicle technologies, could significantly influence future locations and distribution of residential, commercial, and industrial land uses. This is particularly true given the growth of e-commerce, which is altering commercial land use at various locations in New York City's multi-state metropolitan region through siting of intermodal centers, warehouses, and distribution centers, as well as industrial properties.

Climate change and the impacts of sea level rise and extreme weather events are also beginning to impact land use patterns, particularly in the wake of Hurricane Sandy in 2012 and Hurricane Irene and Tropical Storm Lee in 2011. Taken together, these extreme storms subjected the NYMTC planning area and the multi-state metropolitan region to a wide range of weather impacts from storm surge, heavy rainfall, wind, and resulting erosion and flooding. Communities throughout the NYMTC planning area have been considering land use patterns in their recovery and resiliency planning. Several examples are listed below:

- New York State's Community Risk Reduction and Resiliency Act requires decision-makers to use the best available science in order to proactively consider sea level rise, storm surge, and flooding when issuing certain state funding and permits. State agencies are required to assess potential future climate risks related to storm surges, rising sea levels, and any other conditions when making certain permitting, funding, and regulatory decisions.
- New York City has undertaken zoning text amendments and neighborhood rezonings in areas of high-risk flooding. The Department of City Planning created special zoning rules for the floodplain to allow for recovery and promote rebuilding. It has also undertaken several neighborhood and citywide studies to understand specific resiliency issues relating to residential, commercial, and industrial areas.

- New York City's Waterfront Revitalization Program establishes New York City's policies for waterfront planning, preservation, and development projects to ensure consistency over the long term.
- Under the auspices of the New York State Governor's Office of Storm Recovery, two projects—on Long Island and on Staten Island—were funded under the U.S. Department of Housing & Urban Development's innovative Rebuild by Design competition.
- The New York State Governor's Office of Storm Recovery also administers New York Rising Communities Reconstruction and its Buyout and Acquisition Program. The Buyout Program improves the resiliency of the larger community by transforming parcels of land into wetlands, open space, or stormwater management systems, creating a natural coastal buffer to safeguard against future storms. The coastal buffer areas are intended to address those who live in areas that regularly put homes, residents and emergency responders at high risk due to repeated flooding.

While land use patterns are determined by many factors, including generational preferences, local land use policies, changing business models, regional transportation infrastructure, and real estate cost trends, it is clear that land use patterns are important drivers of change by determining where people live, and where and how they travel.[71]

3.8.5 *MOVING FORWARD'S* ASSUMPTIONS ON TRANSFORMATIVE CHANGE

While acknowledging the disruption brought about by the COVID-19 pandemic, *Moving Forward* recognizes both the continuing transportation transformation *for the longer term,* as well as the impacts of major global trends on future mobility, through the following assumptions:

- Personal mobility is assumed to continue to evolve toward shared mobility—with an increased use of shared, on-demand, and ultimately cleaner and more automated vehicles of all types, ranging from micromobility options such as scooters and bicycles to ride-hailing using cars and microtransit arrangements using vans to trunk services through public transit options using buses, and light and heavy rail.
- Technological development will continue to be a driver of transformative change in areas such as personal mobility, goods movement, and adaptation to climate change.
- Technological changes such as AM (also known as 3D printing), commercial vehicle automation, the continuing automation of goods production and shipment, and the emergence of new delivery modalities such as drones and cargo bikes will affect the movement of goods. Changes in business models and practices will also impact how commodities move, such as the continuing growth of e-commerce and multi-stage distribution, reverse logistics, sprawl development of fulfillment centers, and shared use lockers.
- Challenges from the impacts of major global trends are assumed to continue to impact NYMTC's planning area, along with the multi-state metropolitan region. These trends include climate change, the future availability and cost of energy, the

development of new technologies and energy sources, changing demographics and lifestyle/workstyle expectations, and changes in land use patterns, brought about at least in part by extreme weather events and sea level rise.

In positing these assumptions about transformative changes, *Moving Forward* acknowledges the continuing impracticality of attempting to quantitatively predict their impacts on its forecasts for the transportation system. However, there is a significant degree of certainty that transformative changes will alter the demand for transportation and/or the way transportation services are provided in some fashion during the planning period. This section will explore those potential impacts.

Moving Forward also acknowledges that a degree of caution must be exercised. Despite current trends implying that continued technological, economic, and societal developments will transform how, when, where, why, and how often people and goods move, different perspectives remain and must be considered when assessing the future impacts of transformative changes. For example, the Victoria Transport Policy Institute has identified significant reservations concerning the duration and pace of the development of vehicle automation and related behavioral change.

In comparison, the evolution of shared mobility and e-commerce may be somewhat more predictable than vehicle automation in the short and medium term, given current trends and the reality that much of the enabling technology is already in place. Yet there are still risks of both overestimating and underestimating future transformational changes, particularly because there is little consensus on the pace of that change among researchers, planners, technology experts, and policy makers.

3.8.6 IMPLICATIONS FOR THE TRANSPORTATION PLANNING PROCESS

Transformational changes and the future of mobility will influence *Moving Forward's* strategic framework. Some possible outcomes will likely influence how NYMTC as an organization and its members individually seek to fulfill the goals of their Shared Vision for Regional Mobility. Other potential outcomes, such as evolving forms of shared mobility, will affect the way these goals are pursued. *Moving Forward* attempts to lay the groundwork for anticipating these developments and formulating approaches. However, greater attention will be needed going forward to better understand current trends, potential futures, and possible outcomes, as outlined below.

EQUITY

As the transportation systems evolve, equity among all citizens, particularly on those who have been underserved by the current transportation system, is an increasing focus. The concept of equity implies a fair distribution of costs and benefits that serve users.

An ideally equitable transportation network, for example, would provide transportation that serves the needs of those who are low-income, racial/ethnic minorities, older individuals, or who have physical and cognitive disabilities.
The biggest challenges about new transportation technologies and services involve cost and access. While these transformations in the movement of goods and people bring more options, there are uncertainties regarding where and to whom the benefits will accrue.

UNCERTAINTY

As noted above, various attempts have been made to anticipate the impact of transformative changes on the methods and amount of future travel. However, it is not yet possible to comprehensively assess the effect of these predictions on the socioeconomic and demand forecasts described earlier in the Plan or on the operation of the transportation system in the NYMTC planning area. However, preliminary predictions suggest that transformational changes will affect the future demand for transportation and/or the way transportation services are provided.

The transformational changes and their potential impacts outlined above are important and emerging realities that will continue to shape the future of transportation globally, nationally, regionally, and within the NYMTC planning area. In general terms, NYMTC's members will continue to monitor these changes and respond as needed to make the regional transportation system safer, more sustainable, more equitable, and more efficient during the planning period. Additionally, transportation planning as practiced through the NYMTC process and individually by NYMTC's members will itself be transformed, as data and technical tools are modified or overhauled in response to changing technological and operational capabilities.

Although quantitative predictions of the impacts of transformational changes on future transportation demand and supply remain elusive, *Moving Forward* acknowledges the following qualitative assessment of change during the planning period.

THE PLAN'S FIRST 10 YEARS

It is likely that the impacts of transformative change on the Plan's socioeconomic and transportation demand forecasts will be somewhat muted during the first 10 years of the Plan (FFYs 2022 through 2031), due mainly to the recovery from the COVID-19 pandemic, the pace of development of relevant technologies, *and* the behavioral change that will mature along with the technologies and through generational change. Specifically:

- Given the forecasts presented earlier in this section and the acceleration experienced during the pandemic, the continued growth in e-commerce seems to be the most certain and impactful possibility during this initial period, adding potentially significant new truck/commercial travel to the network.
- Less certain will be the growth in shared mobility, which has itself been impacted by the pandemic, along with greatly reduced usage of public transit ridership. A rebound in shared mobility amidst continuing safety concerns about public transit in the aftermath of the pandemic could add significantly to vehicular travel during this initial period.
- Although vehicle automation during this period will emerge and is likely to grow, the forecasts indicate that automated travel will likely not reach significant levels during this period.
- Although fossil fuel costs or supply constraints cannot be confidently predicted during this initial period, particularly in light of the economic shocks caused by the pandemic, electric vehicle technology will likely show increasing growth that will require attention to supporting facilities and infrastructure as a result of greater production levels that lower costs and increased regulation in response to climate change.
- Finally, during this initial period of the Plan, continued impacts from sea level rise and extreme weather will likely be felt.

Additionally, generational changes that are already manifesting themselves in altered economic and travel behavior will continue and mature during this initial period:

- The mid-range of the Baby Boomers will be moving into their 70s during this period and the vanguard will be in their early-to-mid 80s. As these number increase, new mobility needs will present themselves, which will likely translate into a higher demand for specialized transportation services.
- The vanguard of the Millennials will be moving into and past their 50s during this period and their travel behavior and locational preferences will likely be modified as they age, as will the mid-

range of the cohort moving towards and into their 40s.

- The vanguard of the following generation—often referred to as *Gen Z*—will be in the work force during this period and the mid-range of this cohort will begin to enter it. It is unclear how they will adapt to the developing technology, although higher adoption rates are probable.

THE BALANCE OF THE PLANNING PERIOD

Beyond this initial 10-year period (beginning with FFY 2032) and onward through the 2050 horizon year, the impacts of transformational changes on transportation demand and supply are increasingly uncertain. Some of these impacts may be far reaching, but it is not yet possible to reasonably forecast when and how the drivers of transformational change will mature, what they will ultimately become, and whether new unanticipated drivers—technological, economic, social—will emerge and in what form.

A case in point is AM (3D printing). This technology has the potential for far reaching, even transformative commercial impacts that could revolutionize economic activity and the movement of goods. Similarly, vehicle automation, shared mobility, and micromobility also have the potential to significantly change personal mobility in the longer term, moving away from a vehicle-based system into a more trip-based system in which private ownership of vehicles is greatly reduced and private and public transport have been melded together entirely. And finally, the continued evolution of the "Internet of Things" may transform both the mobility needs of people *and* the efficiency with which transportation resources are used.

This longer-term uncertainty argues for a degree of sensitivity testing for the period beyond the first 10 years of *Moving Forward*, since it is generally unknowable whether and how the most transformative of these changes will be realized within the planning period.

NEW RESEARCH

Exploring research that has measured recent changes in mobility attributable to transformational change is an important step in preparing for the next planning cycle. Prominent examples of recent efforts include the following:

- The University of California's Davis Institute of Transportation Studies completed the first-ever study with representative data from major cities across the United States on online ride-hailing services and their impact on travel decisions. The research suggests that ride-hailing complement public transit, but the net effect is an overall reduction in public transit use and a shift towards travel by lower occupancy vehicles. One caveat to this overall finding is that the study found that the complementary effect has been greatest with commuter rail service, so that it can be inferred that the impacts across the NYMTC planning area likely vary with location. The study also found that land use mix and population/job density impact the frequency of use of ride-hailing services._
- Schaller Consulting (2017) completed a detailed analysis of online ride-hailing services in New York City from 2014 to 2016. The analysis found that ride-hailing ridership tripled between June 2015 and fall 2016 and that ride-hailing services accounted for the net addition of 600 million miles of vehicular travel to New York City's roadway network during this period.
- Walker Consultants (2017) found that a strong correlation exists between high parking costs in urban metropolitan areas and ride-hailing market penetration. Strong markets for ride-hailing services are found in dense urban centers with a bigger pool of potential customers and in places where parking costs become prohibitive.

IMPROVED PREDICTIVE CAPABILITIES

Several aspects of future mobility warrant additional research and improved predictive capabilities so that the planning process can anticipate future conditions and potential scenarios. These include:

- **Vehicle Technology:** Legal and technical developments in vehicle technology must be monitored closely to define future scenarios for market penetration by connected and automated vehicles and the potential impacts of that market growth through 2050. These future scenarios would involve assumed timeframes for connected and automated vehicles to be in operation as a proportion of overall vehicle fleets—personal, public, and commercial. As these vehicles become an increasing proportion of the vehicle fleets in operation, advanced traffic management technologies could increase the throughput of roadways and bus transit facilities and significantly influence both transportation demand and supply. Additionally, pilot testing of various levels of vehicle autonomy for automobiles, trucks, vans, and buses must be monitored to track the evolution of the technology as a means of predicting its possible maturation. Similar attention must be paid to scenarios for the expanded use of electricity and lower-carbon fuels like hydrogen, renewable natural gas, and renewable diesel to power light- and heavy-duty vehicles.
- **Shared Mobility:** New data on and analyses of the impacts of the continuing evolution of shared mobility on key metrics such as VMT, transit ridership, carsharing and bikesharing rates, and private vehicle ownership must be monitored. This information will be used, where feasible, to adjust NYMTC's forecasting tools for such key parameters as trip-making characteristics, trip generation rates, and modal choice characteristics to improve forecasts of travel demand as a basis for this Plan.
- **E-commerce:** The companies and agencies that carry, send, receive, or manage the movement of goods are developing and deploying new technologies and new processes to improve the efficiency of goods movement, reduce costs, comply with regulatory or customer-driven demands, and/or improve profitability. This could result in increased goods movement demand and/or greater concentration of that demand in certain areas and requires monitoring.

- **Land Development:** The advent of shared mobility and e-commerce is beginning to affect land use patterns and may continue to do so in the future. Information and communication technologies, as well as vehicle technologies, could significantly influence future locations and distribution of residential, commercial, and industrial land uses. This is particularly true given the growth of e-commerce, which is altering commercial land use at various locations in the multi-state metropolitan region through siting of intermodal centers, warehouses, and distribution centers, as well as industrial properties, often in a manner that increases regional sprawl and contributes to increases in VMT.

3.8.7 ADAPTING THE PLANNING APPROACH

Specific tools, techniques, and approaches can be employed during the period of the Plan to better anticipate the impacts of transformative change on the future of mobility, including the following:

- **Planning for Uncertainty:** Several tools and techniques need to be employed to accommodate future uncertainties, including the following, which are neither mutually exclusive nor listed in order of priority:
    - Using "big data" for monitoring trends and defining potential future conditions. The availability of new data sources—crowd-sourced through social media, collected by mobile phone operators and through GPS, and gathered from the "Internet of Things"—will be critical to adapting NYMTC's forecasting tools and simulation models to better predict potential changes in future travel.
    - Using sensitivity analyses and developing alternate future scenarios. These planning techniques alter key parameters in future forecasts to test the impact of these changes on outcomes such as travel patterns, transit ridership, goods movement, and VMT.
    - Benchmarking and networking with similar organizations in other metropolitan regions across the country. Such collaboration will take on increased importance in providing guidance for defining uncertain futures. Greater collaboration will also assist in monitoring trends and emerging concepts.
- **Upgrading Analytical Tools and Predictive Capabilities:** As described earlier, deployment and market penetration of new technologies take time and, in many cases, require legal, policy, behavioral, and societal adaptations. Transformational technologies that have only minor impacts in the short term may result in major impacts to land use and transportation in the long term. To better predict the transportation outcomes of these changes, NYMTC's analytical tools and forecasting capabilities will need to be upgraded to account for transformational changes that are expected to impact travel demand. Travel surveys and the use of big data to measure travel activity and monitor trends will need to explore metrics specific to shared mobility, e-commerce, and socioeconomic factors. This will continue to be a challenging, and to some degree speculative, task given the uncertainties of how current trends will sustain themselves over the long term.
- **Planning Integration:** Better planning integration among different levels of government—local, county, regional, state, and federal—can enable more cohesive approaches between policy areas, planning jurisdictions, or functional areas, and between neighboring jurisdictions or planning areas with

shared interests in infrastructure, resources, or both. In recent years, NYMTC and its members have explored this kind of planning integration through innovative study methodologies and outreach approaches and through partnering. Given future uncertainty about the scale of the mobility changes that may occur through technological, economic, and societal developments, greater planning integration between jurisdictions and policy areas will likely be needed to accommodate and shape the future of mobility.

- **Improved Public-Private Partnerships:** Proactively engaging and developing public-private partnerships will increase in importance. These partnerships can inform and anticipate needs of the transportation system for mobility of people and goods. Proactive engagement of businesses, tech companies and start-ups, and real estate development can help to support the development and transportation to service those needs.

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