A critical element of high quality transit service is reliable subway car performance. Riders do not want to be delayed by a train being taken out of service because a car breaks down or suffer an unpleasant ride because a car’s heating or air conditioning is not functioning. Keeping subway cars in good condition, defined as a state of good repair, requires regular inspections and preventive maintenance as well as scheduled replacement based on expected useful life.

The Metropolitan Transportation Authority (MTA) and its subway division, New York City Transit (NYCT), have a mixed record in sustaining subway car reliability and now face a serious challenge in restoring the car fleet to a state of good repair. The agency’s past performance can be divided into three periods:

- From 1981, when reliability hit an all-time low, to 1993 the MTA made large investments to bring the entire fleet to a state of good repair. It purchased 1,775 new cars and overhauled another approximately 4,100 cars.

- From 1994 to 2009 NYCT implemented a new system of scheduled inspections and maintenance to keep cars in good repair, and the MTA capital program kept pace with the replacement of cars nearing or at the end of their useful life. The result was record levels of reliability.

- From 2010 to 2016 NYCT stretched inspection and maintenance cycles to meet savings targets and the MTA capital program replaced fewer cars at a slower pace than was necessary to replace all cars reaching the end of their useful life. The result was a significant drop in reliability contributing to the steady drumbeat of complaints that led Governor Andrew Cuomo to declare a state of emergency at the transit system in 2017.
In 2017 and 2018 MTA leadership announced plans to address the deteriorating subway performance including its declining subway car reliability. In July 2017 MTA Chairman Joseph Lhota released the Subway Action Plan (SAP), a $1.8 billion program to reverse declining performance and stabilize the system, which includes increased investments in car inspection and preventive maintenance. In May 2018 NYCT President Andy Byford announced Fast Forward, an ambitious plan to modernize the transit system, which includes the purchase of more than 3,600 new subway cars and retrofitting of 1,200 existing cars to be compatible with a new signal system. If fully implemented over the next decade, this plan would restore proven car maintenance policies and replace all cars operating past their useful life.

The current critical challenge is to implement these plans during the decade-long time frame. The estimated cost relating to subway cars is about $9 billion, and the sources of most of this funding have not yet been identified. As the MTA develops future capital plans, subway cars will be compete against state of good repair work, normal replacement, and network expansion projects like the second phase of the Second Avenue Subway and East Side Access for priority; however, failure to prioritize subway car investments will place added pressure on the fleet’s maintenance and squander hard-fought gains in reliability.

BACKGROUND

The NYCT subway car fleet consists of 6,482 cars of 14 different models identified by the letter “R” followed by a number, for example, R142, that corresponds to the final digits in a contract number under which the cars were purchased.1 Cars are divided into two incompatible subfleets—A Division cars operate on the numbered train lines and B Division cars operate on the lettered lines.2 Each car is made up of systems that help a train move, stop, communicate, open and close its doors, and keep customers safe and comfortable. Prior to 2000 cars were expected to have a useful life of 35 years and were planned for replacement after that period; cars purchased more recently are expected to have useful life of 40 years, and this standard is now applied to the entire fleet. 3 Today the fleet includes some cars more than 50 years old and others currently being delivered from the manufacturer. More than 5,200 NYCT employees inspect, maintain and repair cars.4

Car performance is measured by the mean distance between car component failures (MDBF) that require a car to be removed from service. As cars and their systems age they generally fail more often, but sufficient inspection and maintenance can keep older cars operating at or above an agency MDBF goal of 150,000 miles. (See Table 1.)
Advent of the Modern MTA Capital Program

By the early 1980s the subway car fleet had suffered from decades of neglect and deferred maintenance. In 1981 MDBF reached an all-time low of 6,640 miles. (See Figure 1.) On a typical day NYCT abandoned more than 300 trains and was forced to keep more than one-quarter of all cars in reserve to replace broken down trains.5

Under these circumstances MTA Chairman Richard Ravitch identified the resources needed to bring the system to a state of good repair, lobbied the Legislature for support, and initiated the first modern five-year capital program. This initial five-year plan and a subsequent five-year plan—spanning the years 1982 to 1991—invested more than $3.9 billion in bringing the subway car fleet to a state of good repair.6 The three pillars of this program were (a) new subway cars to replace unreliable, older cars; (b) major midlife overhauls of remaining cars; and (c) a new system of preventive maintenance with scheduled inspections and rehabilitations to keep new and restored cars operating at a high level.

The first two five-year capital programs committed $1.9 billion to purchase 1,775 replacement cars for the fleet's least reliable vehicles. These purchases replaced cars built between 1948 and 1960. The new cars performed better than their predecessors, with MDBFs ranging between 34,600

<table>
<thead>
<tr>
<th>Car Model</th>
<th>Manufacturer</th>
<th>Division</th>
<th>Line(s)</th>
<th>Count</th>
<th>Age</th>
<th>Mean Distance Between Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>R32</td>
<td>Budd</td>
<td>B</td>
<td>A,C,J,Z</td>
<td>222</td>
<td>53</td>
<td>34,391</td>
</tr>
<tr>
<td>R42</td>
<td>St. Louis Car</td>
<td>B</td>
<td>J,M,Z</td>
<td>50</td>
<td>48</td>
<td>41,192</td>
</tr>
<tr>
<td>R46</td>
<td>Pullman-Standard</td>
<td>B</td>
<td>A,C,F,R,S</td>
<td>752</td>
<td>42</td>
<td>73,212</td>
</tr>
<tr>
<td>R62</td>
<td>Kawasaki</td>
<td>A</td>
<td>1.3</td>
<td>315</td>
<td>34</td>
<td>189,218</td>
</tr>
<tr>
<td>R62A</td>
<td>Bombardier</td>
<td>A</td>
<td>1.6,7,S</td>
<td>824</td>
<td>33</td>
<td>101,963</td>
</tr>
<tr>
<td>R68</td>
<td>Westinghouse-Amrail</td>
<td>B</td>
<td>B,D,G,N,W,S</td>
<td>425</td>
<td>31</td>
<td>106,133</td>
</tr>
<tr>
<td>R68A</td>
<td>Kawasaki</td>
<td>B</td>
<td>A,B</td>
<td>200</td>
<td>29</td>
<td>96,584</td>
</tr>
<tr>
<td>R142</td>
<td>Bombardier</td>
<td>A</td>
<td>2.4,5</td>
<td>1,030</td>
<td>18</td>
<td>163,012</td>
</tr>
<tr>
<td>R142A</td>
<td>Kawasaki</td>
<td>A</td>
<td>4.6</td>
<td>220</td>
<td>18</td>
<td>55,988</td>
</tr>
<tr>
<td>R143</td>
<td>Kawasaki</td>
<td>B</td>
<td>L</td>
<td>212</td>
<td>16</td>
<td>89,418</td>
</tr>
<tr>
<td>R160</td>
<td>Alstom / Kawasaki</td>
<td>B</td>
<td>C,E,F,J,L,M,N,Q,Z</td>
<td>1,662</td>
<td>12</td>
<td>241,866</td>
</tr>
<tr>
<td>R179</td>
<td>Bombardier</td>
<td>B</td>
<td>J,Z</td>
<td>64</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>R188</td>
<td>Kawasaki</td>
<td>A</td>
<td>7</td>
<td>126</td>
<td>6</td>
<td>444,913</td>
</tr>
<tr>
<td>R188-Conversion*</td>
<td>Kawasaki</td>
<td>A</td>
<td>7</td>
<td>380</td>
<td>18</td>
<td>165,167</td>
</tr>
</tbody>
</table>

Total | 6,482 | 24.1 | 121,220

Note: Age calculated using earliest manufacture date of car model.

Sources: Metropolitan Transportation Authority, New York City Transit Committee, February 2018 (February 20, 2018), Subway Mean Distance Between Failure - REVISED, p. 39; and Federal Transit Administration, National Transit Database, “Revenue Vehicle Inventory” (annual editions 1997 to 2016).

Table 1: New York City Transit, Mean Distance Between Failures for Subway Cars by Model, 2017

NA = Data not available.

*R188-Conversion cars are those R142As that have been retrofitted to operate using Communications-Based Train Control.
The first two capital programs also committed $2 billion to overhaul more than 4,100 subway cars. This work included component reconstruction, system upgrades, noise mitigation, car door mechanism replacements, and installation of air conditioning. Performance improved significantly as MDBF more than doubled for these cars, meeting or exceeding the reliability of the new cars.

With the replacement or overhaul of more than 5,800 cars the fleet reached a state of good repair in 1993. To maintain this state of good repair NYCT introduced a proactive maintenance strategy known as the Scheduled Maintenance System (SMS) composed of three elements: inspection, cleaning, and systematic and planned system replacements or rehabilitations. After cataloguing dozens of car parts and calculating their typical lifespan, NYCT began implementing pre-failure maintenance to avert the need for expensive overhauls. The process allowed NYCT to remove redundant parts and link cars into larger permanent sets, reducing the number of points of failure in a train.

From 1981 to 2011 MDBF increased from less than 7,000 miles to more than 172,000 miles, peaking at 178,085 miles in 2005. Not only did customers experience improved reliability but subway capacity also increased with growing MDBF. A younger, more reliable fleet reduced the number of breakdowns and allowed NYCT to keep fewer cars in reserve and to operate a larger share of its fleet during peak hours. By 2011 only 17 percent of the fleet remained in reserve during peak service, the equivalent of adding approximately 50 trains to the system over levels in the 1980s.
FALLING BEHIND STATE OF GOOD REPAIR

Fiscal pressures from the 2008 recession led the MTA to adopt policies that caused the subway fleet to fall short of a state of good repair. The agency limited the number of new car purchases and curtailed proactive maintenance. Subway car reliability declined from 2011 to 2016 as MDBF declined 35 percent and regressed to levels below the desired standard of 150,000 miles. (Refer to Figure 1.)

Reduced Subway Car Replacements

From 1982 to 2009 NYCT committed an average of $2 billion in current dollars to subway car purchases per five-year capital program. For each of these programs, car commitments were in excess of five-year needs published as part of the corresponding needs assessment.\(^\text{12}\) (See Table 2.)

The two subsequent capital programs—2010-2014 and 2015-2019—include $1 billion and $1.5 billion in subway car commitments, less than the previous five-program averages and significantly less than the corresponding needs assessments. Moreover, the inability to approve these capital programs in a timely manner resulted in a slower replacement of cars.

The 2008 recession erased a significant share of tax and other operating revenue that impacted the 2010-2014 capital program, which was initially funded only for the first two years.\(^\text{13}\) In 2012 the MTA fully-funded the five-year program, but this program reduced subway car commitments from $1.3 billion to $1 billion. This funding supported approximately 400 cars—less than half the 1,000 cars needed for normal replacement—and committed more than $6 billion to network expansions including East Side Access and the first phase of the Second Avenue Subway.\(^\text{14}\)

<table>
<thead>
<tr>
<th>Capital Plan Period</th>
<th>Five-year Need</th>
<th>Actual Commitments</th>
<th>New Subway Cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982-1986</td>
<td>1,957</td>
<td>2,436</td>
<td>1,595</td>
</tr>
<tr>
<td>1987-1991</td>
<td>1,248</td>
<td>1,450</td>
<td>200</td>
</tr>
<tr>
<td>1995-1999*</td>
<td>1,300</td>
<td>1,957</td>
<td>840</td>
</tr>
<tr>
<td>2000-2004</td>
<td>1,942</td>
<td>1,992</td>
<td>1,210</td>
</tr>
<tr>
<td>2005-2009</td>
<td>2,096</td>
<td>2,179</td>
<td>1,025</td>
</tr>
<tr>
<td>2010-2014</td>
<td>3,037</td>
<td>1,025</td>
<td>403</td>
</tr>
<tr>
<td>2015-2019</td>
<td>2,717</td>
<td>1,482</td>
<td>460</td>
</tr>
</tbody>
</table>

* - In 1995 MTA Chairman Virgil Conway altered the five-year sequence of the capital program to its current format. Though a needs assessment was not compiled ahead of the 1995-1999 capital program, a needs assessment compiled prior to the 1992 to 1996 program that was subsumed included $1.3 billion in car needs.

Source: Metropolitan Transportation Authority, Capital Program (various amendments to the five-year programs).
The needs assessment for the 2015-2019 capital program indicated a $2.7 billion subway car need, including an unspecified number of replacement cars not funded in the 2010-2014 program and 168 new cars for the Second Avenue Subway.\(^{15}\) The 2015-2019 capital program was approved late, in May 2016, and included $2.9 billion for 940 replacement cars.\(^{16}\) A May 2017 amendment reduced subway car commitments to $1.7 billion, 64 percent of the five-year need, and delayed half of the planned car order to the following capital program to accommodate other priorities.\(^{17}\) This five-year program included more than $7.6 billion in network expansions, including the initiation of two new commuter railroad projects—one to build new stations in the Bronx and bring Metro-North trains into Penn Station and another to add a third track to the Main Line of the Long Island Rail Road.

Other factors have contributed to problems in car replacement. Structural problems in the R44 car model led to premature replacement in 2010 which delayed the replacement of older cars slated for retirement. Delivery of R188 cars was delayed approximately six months after Superstorm Sandy damaged a Far Rockaway test track in 2012, and delivery of R179 cars has been delayed more than two years due to manufacturer defects found during testing. Even after replacement R179 cars arrive, the L train shutdown will require NYCT to continue operating its oldest cars to increase service on adjacent subway lines.\(^{18}\)

The lack of normal replacement and delays in car delivery have aged the fleet. If subway car procurements replaced cars on a uniform schedule according to a 40-year useful life, the agency would need approximately 125 new cars per year. From 2011 to 2017 NYCT received only 140 new cars, or approximately 23 per year.\(^{19}\) As a result the average age of the fleet increased from 17.9 years to 22.5 years, and the share of cars operating for more than 40 years increased from 4 percent to 16 percent.

**Changes to Car Inspection and Maintenance**

At the end of 2017 NYCT’s car equipment division employed approximately 4,400 workers, of which nearly 4,000 supervisory and hourly employees inspect, maintain, and clean subway cars. Approximately half of these employees inspected cars and performed incidental maintenance and emergency repairs, a little more than one-quarter of the employees were dedicated to scheduled car maintenance, 11 percent performed car cleaning activities at train shops and yards, and 13 percent did all other tasks.\(^{20}\) From 2002 to 2017 these positions decreased slightly from 4,105 to 3,994. (See Figure 2.)

Some of the variation in car equipment employees results from changes in scheduled maintenance staff requirements. These fluctuate from year to year based on the historical timing of car purchases and subsequent SMS requirements. For example, scheduled maintenance positions decreased from 607 in 2002 to 495 in 2004 before growing to 833 by 2010; as of 2017 SMS-related positions increased to 1,125. Post-2008 savings measures, intended to enhance productivity, extended
rehabilitation cycles from 6- and 12-year periods to 7- and 14-year periods by 2010. As a result approximately 150 fewer cars were rehabilitated annually.\textsuperscript{21} SMS-related headcount increased through 2015 despite the longer maintenance cycles.

All other car equipment positions decreased 19 percent between 2002 and 2016. To generate savings following the 2008 recession, NYCT extended inspection cycles for all but its two oldest car models from 11,000 miles or 71 days to 12,000 miles or 78 days.\textsuperscript{22} This decision was premised on analyses that showed the cycle change would have no impact on car reliability.

Though changes to inspection and maintenance cycles were considered efficiencies and productivity improvements, the reductions in car equipment positions coincided with a decline in performance. MDBF reached a second peak of 172,700 miles in 2011 but fell to 112,208 miles in 2016. (Refer to Figure 1.) The decline affected all car models to varying degrees with the exception of the R62s.\textsuperscript{23} (See Table 3.) MDBF of the two oldest car models—R32 and R42—decreased 46 percent and 21 percent, respectively; however, these cars accounted for only 4 percent of the fleet. R160s, newly delivered as of 2010, saw the greatest decrease in MDBF from nearly 668,000 miles to approximately 250,000 miles, a 62 percent decline, after their first few years of service. Even after significant declines these cars continue to exceed the agency’s MDBF goal. R68As, R142s, R142As, and R143s also experienced reliability declines greater than the fleet average over this period. Replacing the 277 R32s and R42s—just 4 percent of the fleet—with cars performing at the MDBF goal of 150,000 miles would have increased fleet MDBF by an estimated 10,000 miles, or 9 percent. New cars performing at the same level as new R188s would have increased fleet MDBF by 11 percent.\textsuperscript{24}
GETTING BACK ON TRACK

Beginning in spring 2017 MTA leaders gave greater attention to improving subway performance including car reliability. A six-point plan introduced in May, later subsumed by the SAP, deployed additional resources to car inspection and maintenance and to accelerate the procurement of new cars. In January 2018 NYCT ordered 460 new subway cars, R211s, under a procurement contract that could purchase up to 1,537 new cars by 2027. The Fast Forward proposal released in May 2018 includes long-term acceleration of subway car procurement, adding more than 3,600 new cars and retrofitting 1,200 cars over the next 10 years. If the latest proposals are implemented, the subway fleet would be restored to a state of good repair in about a decade, but funding for the proposal remains uncertain.

Car Inspection and Maintenance

In May 2017 the MTA announced it would perform a “top-to-bottom revamp” of its subway car maintenance procedures as part of a six-point plan to improve system reliability. The revamp increased car inspections and proactively replaced equipment on regular schedules prior to failure. These changes applied initially to the Eighth Avenue line over a six-month period. Building on
these changes, the SAP included system-wide proposals to expand SMS capacity—from 950 to 1,100 cars annually—and the addition of a repair and maintenance shift to keep shops operating around the clock. The SAP also called for 20 prepositioned emergency response teams to make repairs at the site of a breakdown, though only 10 have been deployed.27

The SAP’s car equipment operating expense is $25 million in 2018 and grows to $65 million annually beginning in 2019. These costs fund approximately 280 car equipment positions that will bring SMS cycles from 7 and 14 years back to 6 and 12 years.28 The MTA also expects to reduce the number of cars held in reserve and increase cars available for peak service by 228 cars, or 4 percent.29 Since July 2017, when the first of these initiatives launched, car reliability has improved slightly but still remains below the agency’s goal. The MDBF 12-month moving average increased 3.5 percent from 115,843 miles to 119,949 miles, as of May 2018.30

Subway Car Replacements

The January 2018 award of the R211 contract includes a $1.4 billion order for 460 new subway cars expected to arrive between April 2021 and July 2023. NYCT may exercise two options which would have to be funded as part of the future 2020-2024 capital program to increase the total order of new cars to 1,537. Delivery of all R211s would conclude by the end of 2026.31

A key element in the 2018 Fast Forward plan is accelerating installation of new signaling technology: bringing Communications-Based Train Control (CBTC) to more than 10 lines over the next 10 years affecting approximately 85 percent of daily ridership. Currently only one line, the L, has CBTC, and installation is in progress on a second, the 7 line. To serve these resignaled subway lines, NYCT will need more CBTC-compatible subway cars, and Fast Forward proposes the purchase of more than 3,600 cars and conversion of another 1,200 existing cars to make this possible. (One Genius Transit Award-winning idea was to shorten the useful life of a subway car to allow for accelerated replacement and introduction of new systems such as CBTC-compatibility.31 See Textbox.) New and modified cars are essential to the resignaling initiative, and their arrival will also help bring the fleet to a state of good repair.33

Genius Transit Challenge

In May 2017 Governor Cuomo commenced the MTA Genius Transit Challenge, a competition seeking proposals to solve the subway’s capacity constraints and diminished reliability. Three of the winning proposals for subway car improvements were: use of longer trains and platforming at alternating stations; new diagnostic systems that would provide real-time analytics about the performance and condition of car components; and a shorter lifespan car. Although the latter two proposals may include creative improvements to maintenance and car procurement that should be a part of the NYCT’s ongoing efforts, these technologies should not be viewed as a substitute for tried-and-tested approaches.
REVIVING THE FLEET: BILLIONS OF DOLLARS NEEDED AND MORE THAN A DECADE AWAY

Though the R211 contract could replace nearly a quarter of the subway car fleet, it alone is not enough to replace all cars nearing or surpassing the end of their useful life. By 2027 new R211s will have replaced the oldest B division cars, but the 1,139 A division cars procured as part of the first capital program will be between 40 and 44 years old. Implementing Fast Forward would rectify the situation, but would require an additional $5.5 billion and more than a decade to achieve.

Table 4 shows the cost of the existing R211 purchase schedule and of the car purchases and retrofits proposed in Fast Forward. The 2015-2019 capital program supports the base order of 460 R211s to arrive by 2023 at an average cost per car of $2.7 million. Options of 640 cars and 437 cars would be funded by the 2020-2024 capital program and arrive by 2027. These cars are expected to have a lower per car cost of $2.1 million. Full implementation of the R211 contract would cost nearly $3.5 billion.

Fast Forward spans a 10-year period beginning in 2018 that does not correspond to the MTA’s five-year capital plan periods and has not yet been aligned with these future investment plans. Fast Forward calls for 3,650 new subway cars and the retrofit of 1,200 existing cars. Of the 3,650 new cars, it is reasonable to assume that 1,537 are from full implementation of the R211 contract options. This leaves 2,113 cars to be purchased under new contracts. At an average cost of $2.3 million, this would require nearly $4.8 billion, bringing the combined cost of R211s and the additional cars to nearly $8.3 billion.

Table 4: New York City Transit Subway Car Planned Orders and Illustrative Fast Forward Orders

<table>
<thead>
<tr>
<th>R211 Car Order</th>
<th>2015-2019 Capital Program</th>
<th>2020-2024 Capital Program</th>
<th>Cost per Car</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base*</td>
<td>460 cars</td>
<td></td>
<td>$2.7</td>
<td>$1,242</td>
</tr>
<tr>
<td>Option 1</td>
<td></td>
<td>640 cars</td>
<td>$2.1</td>
<td>$1,327</td>
</tr>
<tr>
<td>Option 2</td>
<td></td>
<td>437 cars</td>
<td>$2.1</td>
<td>$914</td>
</tr>
<tr>
<td>R211 total*</td>
<td>460 cars</td>
<td>1,077 cars</td>
<td>$2.3</td>
<td>$3,483</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fast Forward less R211 Car Order</th>
<th>First Five Years</th>
<th>Second Five Years</th>
<th>Estimated Cost per Car</th>
<th>Estimated Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Forward (add. new cars)**</td>
<td>190 cars</td>
<td>1,923 cars</td>
<td>$2.3</td>
<td>$4,789</td>
</tr>
<tr>
<td>Fast Forward (modified cars)</td>
<td></td>
<td>1,200 cars</td>
<td>$0.6</td>
<td>$710</td>
</tr>
<tr>
<td>Fast Forward total**</td>
<td>190 cars</td>
<td>3,123 cars</td>
<td>NAP</td>
<td>$5,499</td>
</tr>
</tbody>
</table>

* - Does not include 75 Staten Island Railway Cars
** - Assumes R211s part of Fast Forward new car orders

At the same time NYCT would need to enter into a contract to retrofit 1,200 existing cars for CBTC service. Assuming car conversions could be achieved at the same price as NYCT’s previous conversions, the cost would be about $710 million. Together with new car purchases, the total procurement would be about $9 billion. Of this total only $1.2 billion is authorized in the MTA’s current capital plan, leaving close to $8 billion to be financed in future capital plans.\textsuperscript{36}

Initial estimates of the entire \textit{Fast Forward} program costs are greater than $40 billion, of which subway cars will be just one competing priority.\textsuperscript{37} The MTA must also consider its other regular state of good repair and normal replacement programs at all of its agencies, as well as expansions such as the second phase of the Second Avenue Subway, East Side Access, Long Island Rail Road Main Line Third Track, and Penn Station Access. Despite the competition from other popular initiatives, MTA leaders should be prepared to make significant commitments to subway cars in the 2020-2024 capital program if its expects to return car reliability to its previous highpoint.

\section*{CONCLUSION}

Despite more than $12 billion invested in subway cars since 1981, reliability has not been an uninterrupted march of progress. MDBF records set in 2005 were the result of a laser focus on maintaining the fleet in a state of good repair through a combination of scheduled maintenance and regular replacement. Extended inspection and maintenance cycles and delays to the fleet’s normal replacement cycle after the 2008 economic squeeze ushered in a period of decline in reliability.

Delivery of delayed subway cars and implementation of the SAP will help arrest this decline; if on time, delivery of the R211 cars will replace the next group of B division cars nearing the end of their 40-year useful life. \textit{Fast Forward}, if implemented as proposed, will make drastic changes to the composition of the car fleet, leaving it younger and better equipped to operate alongside a modernized signal system. But full and timely implementation of \textit{Fast Forward} is not a certainty; it must be funded in future capital plans and administered effectively to achieve anticipated results. To make the proposal a reality, MTA leadership should increase significantly its commitment to subway cars in the 2020-2024 capital program.
Some car models have letters after the number signifying a different manufacturer of a similar car design. For example, the R142 and R142A were procured at the same time, splitting an order of cars between two different manufacturers. See: Metropolitan Transportation Authority, Capital Program Oversight Committee Meeting (January 22, 2018), p. 37, http://web.mta.info/mta/news/books/pdf/180122_1400_CPOC.pdf.

Though all trains run on the same gauge, A Division cars are narrower than B Division cars, and thus operating a car on its opposite division is not allowed. Numbered lines have narrower tunnel segments, tighter curves, and tighter platform clearances than lettered lines; B Division cars would not fit on numbered lines and A Division cars would have large gaps between the platform and train on lettered lines. Additionally safety train stop mechanisms between divisions are located on opposite sides of the track and train in each division.

Capital needs assessments developed prior to 2000 state subway cars had useful lives no longer than 35 years. The 2009 capital needs assessment stated all subway cars have a useful life of 40 years; however, this document does not include a rationale for the change in useful life. At that time, more than one-third of the fleet included cars manufactured with useful lives of 35 years or less. See: Metropolitan Transportation Authority, Update of the MTA Staff Report on Capital Revitalization 1984-1993, (April 16, 1984), Twenty-Year Capital Needs Assessment, 1987-2006 (November 1986), MTA Capital Needs and Opportunities, 1992-2011 (May 25, 1990), Capital Needs Assessment, 2000-2019 (1999), and Twenty-Year Capital Needs Assessment, 2010-2029 (August 2009).


Use of single cars and multicar sets is a balance between the flexibility that single cars may offer versus the added maintenance cost of each car having a redundant set of systems. In 1978 NYCT purchased single cars instead of paired cars after management consultants recommended that, owing to the poor reliability of the fleet, cars out of service would increase 3 percent because unaffected pairs would remain out of service while their companion car received work. Today with improved fleet reliability, NYCT uses five-car sets, which are more cost-effective. SMS also included other benefits including easier material planning and reduced inventories; more predictable scheduling of maintenance hours; decreased operating expenses from components operating closer to peak efficiency; and greater opportunity to standardize components with regularly scheduled change-outs. See: Gene Sansone, Director of Maintenance Support, Car Equipment Department, New York City Transit Authority, “Implementing a Scheduled Maintenance System for the NYCTA Railcar Fleet” (paper presented at the American Public Transportation Association Rapid Transit Conference, Vancouver, BC, June 5, 1990).

Assumes ratio of vehicles operated during maximum service to vehicles available during 1981 of 0.75. Also assumes all trains are 10-car sets. See: Federal Transit Administration, National Transit Database (February 21, 2018), TS2.1: Service Data and Operating Expenses Time-Series by Mode.

The MTA's 20-year needs assessment developed ahead of the 1992-1996 capital program included $1.3 billion in five-year needs, but the MTA only committed $79 million to this program. However, the MTA changed its five-year capital program schedule and resubmitted a five-year program spanning 1995 to 1999. Though no needs assessment was developed for this capital program, the MTA committed $2.1 billion to subway cars, 171 percent of the five-year need for the 1992-1996 period.


Additional cars in the needs assessment were for the Flushing Line, which was being extended to Hudson Yards and outfitted with Communications-Based Train Control to allow trains to run closer together. The 2010-2014 capital program was initially approved in June 2010 but was only funded in the first two years. In December 2011 the MTA approved an amended 2010-2014 capital program worth $24.3 billion with full funding. See: The Council of the City of New York Committee on Transportation, Hearing on the Fiscal 2014 Preliminary Budget and the Fiscal 2013 Preliminary Mayor's Management Report, Metropolitan Transportation Authority (March 5, 2013), p. 5, http://council.
It also included $52 million for the development of an open-gangway prototype subway car.

In addition the delay to the capital program's approval and manufacturers' inability to deliver the first production cars before 2021 made procuring all cars as part of the 2015-2019 program extremely ambitious. See: Metropolitan Transportation Authority, *MTA Capital Program, 2015-2019* (as approved by the Capital Plan Review Board July 31, 2017), pp. 35 and 115, and *MTA Capital Program, 2015-2019* (as proposed to the MTA Board September 24, 2014), pp. 53 and 169.

Over the previous nine-year period NYCT received more than 1,900 new cars, or approximately 210 per year. See: Federal Transit Administration, *National Transit Database* (annual editions 2002 to 2016), “Revenue Vehicle Inventory,” www.transit.dot.gov/ntd/ntd-data.

Approximately 500 positions are responsible for terminal car cleaning, cleaning activities performed at the final station along a train's route; however, from 2011 to 2017 these positions were moved to Stations, and as such are not included in this analysis. See: Metropolitan Transportation Authority, New York City Transit, comments to Citizens Budget Commission staff (June 5, 2018).


R32 and R42 cars continued operating using a 11,000-mile or 71-day inspection cycle. See: Metropolitan Transportation Authority, New York City Transit, Division of Car Equipment, “Engineering Alert: Extend the Scheduled Maintenance Inspection (SMI) Cycle of Passenger Revenue Cars,” EA-08-12 Rev. B (December 9, 2010).

The increase in R62 MDBF over this period is largely owing to $30 million investment to replace the propulsion system and cam controllers on these cars. See: Metropolitan Transportation Authority, New York City Transit, email to Citizens Budget Commission staff (June 19, 2018).

Calculations assume miles traveled by R32s and R42s in 2016 were replaced by hypothetical cars that had MDBFs of 150,000 miles—the agency goal—and 476,693 miles—new R188 cars performance in 2016. See: Federal Transit Administration, *National Transit Database* (2016), “Revenue Vehicle
The plan intended to deliver all R179s by September 2018 and to accelerate delivery of R211 cars; however, full delivery of R179s is now scheduled for January 2019, and the R211 contract has not yet been awarded.


The July Financial Plan, once approved by the MTA Board, should reflect increased funding of $67.3 million annually and 354 positions. See: Metropolitan Transportation Authority, email to Citizens Budget Commission staff (July 17, 2017).


From December 2017 to May 2018 the 12-month moving average for MDBF has declined 1 percent. See: Metropolitan Transportation Authority, New York City Transit Committee, (monthly editions, 2018), Subway Mean Distance Between Failure, http://web.mta.info/mta/news/books/.


When purchased, these cars were expected to have a 35-year useful life. Though many of these cars are performing exceptionally—2017 MDBF of R62s was 189,218 miles, above the agency’s goal of 150,000 miles—pressing them into service past their useful life will likely lead to lower reliability and entail additional maintenance costs.

[36] Though *Fast Forward* purchases could be spread over the 2020-2024 and 2025-2029 capital programs, previous experience suggests the time between signing a contract on a new car model and receiving the first production car is between three and four years.

Getting Back on Track
Replacing and Repairing Subway Cars Will Be Expensive and Take More Than a Decade