Impacts of Spare Ratio Rules on Vehicle Availability

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American Public Transportation Association

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Introduction

The American Public Transportation Association (APTA) initiated a study to address the evolving challenges associated with the Federal Transit Administration's (FTA) spare ratio requirements. These requirements, which set limits on the proportion of backup vehicles in public transit fleets, are becoming increasingly difficult for agencies to meet due to aging fleets, maintenance staff shortages, delays in obtaining parts, and the integration of new technology. The rise of zero-emission vehicles (ZEVs) adds another layer of complexity as agencies navigate the challenges of transitioning their fleets to this new propulsion technology.

FTA states, "The basis for determining a reasonable spare bus ratio takes local circumstances into account. The number of spare buses in the active fleet for recipients operating 50 or more fixed route revenue vehicles should not exceed **20 percent of the number of vehicles operated in maximum fixed route service**. FTA does not set a specific spare ratio for smaller operators but expects the number of spare buses to be reasonable, taking into account the number of vehicles and variety of vehicle types and sizes."

FTA's 20 percent spare ratio policy for buses aims to ensure public transit agencies have sufficient backup vehicles to maintain service continuity (e.g., during breakdowns or maintenance needs). This policy was designed to balance the need for reliability with cost efficiency in fleet management. However, FTA's spare ratio policy may need re-evaluation as the transit landscape evolves—especially with the increasing complexity of ZEV technology, shifts in ridership patterns, and an overall move toward all-day and frequent bus service.

This study consisted of multiple tasks to provide a comprehensive analysis of the current challenges of this policy. As part of this effort, a survey was administered to 154 transit agencies across the United States to understand the prevalence of vehicle availability issues, identify specific challenges in keeping vehicles in service, and uncover the root causes of these problems.

Vehicle availability challenges are widespread, significantly affecting operations, staff, and passengers. **More than 40 percent of agencies report encountering vehicle availability problems at least a few times per month.** These issues have far-reaching consequences, including **reduced service, insufficient replacement vehicles for breakdowns**, and **increased staff stress**. Key causes for vehicle availability problems include **aging fleets, shortage of qualified mechanics, and delays in sourcing replacement parts**. Parts shortages are not confined to specific types of fleets, with agencies reporting challenges both with parts for older traditional fuel vehicles and acquiring replacement parts for new ZEV fleets.

According to Transportation Research Board's *System-Specific Spare Bus Ratios Update in 2013*, factors like fleet size, maintenance practices, and operating conditions impact spare bus ratios for transit agencies. The report highlights challenges such as financial constraints, mixed fleets, special event services, extreme weather effects, outdated maintenance facilities, and the need for skilled workers to maintain new technologies.

Seventy-four percent of agencies suggested that changing the FTA's spare ratio policy would improve availability for fixed-route operations, and 54 percent suggested that increasing staff to support vehicle maintenance could also be beneficial. About one-half of agencies supported solutions such as expanding fleet sizes (51 percent), increasing funding for vehicle purchases (50 percent), and shortening procurement cycles (48 percent). **A significant majority, 84 percent, also advocated increasing the spare ratio limit to address these issues.**

Altogether, this research found that vehicle availability issues are a common challenge for transit agencies, impacting their ability to meet service demands. The following sections outline actionable recommendations for transit agencies and policymakers to mitigate these challenges.

Survey Findings

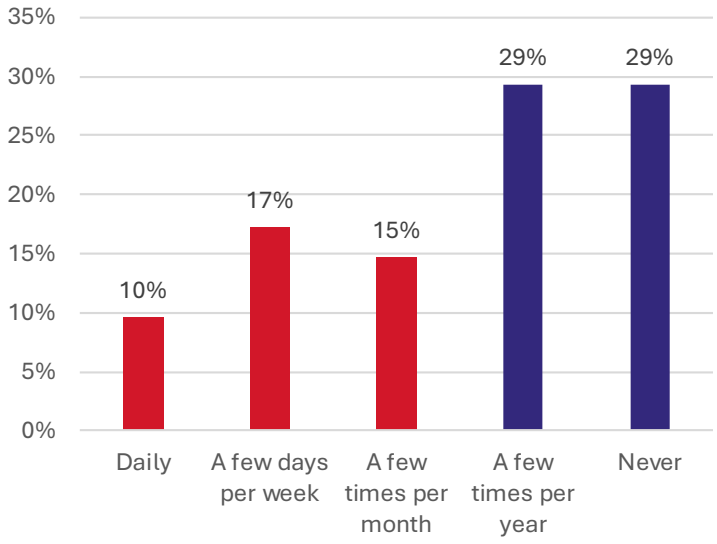
In September 2024, APTA conducted a survey of 154 public transit agencies across the U.S. to understand the prevalence of vehicle availability issues, identify specific challenges in keeping vehicles in service, and uncover the root causes of these problems. The survey provided a snapshot of the challenges agencies face with fleet sizes and availability, particularly in relation to ZEV adoption. The responses also shed light on the various strategies and approaches being used nationwide to tackle these challenges. To read a comprehensive survey summary, see the **Impacts of Spare Ratio Rules on Vehicle Availability: Survey Summary Report** on APTA's website.

The survey revealed that vehicle availability challenges are widespread, with many agencies frequently facing significant impacts to service reliability and operations. Agencies also expressed a strong desire for greater flexibility in fleet planning, particularly through adjustments to FTA's spare ratio policy to better accommodate diverse operational needs. Lastly, most respondents are incorporating ZEVs into their fleet, a transition that presents unique challenges.

Vehicle availability challenges are widespread.

Agencies nationwide have encountered many challenges regarding vehicle availability limitations, significantly impacting their ability to meet passenger demands and agency goals. Aging fleets, breakdowns, delayed parts, and mechanic availability, among other challenges, have placed a strain on agencies. As a result, agencies have been forced to balance their desire to expand and enhance services with the operational strain that is caused by vehicle availability. This section details challenges agencies face regarding vehicle availability, providing important insights from agencies on what the potential root causes of availability issues are and the ways they are impacting operations.

Figure 1: In the past year, how often have you not had sufficient operable (working) vehicles available to put into active service?



Vehicle availability challenges are a widespread issue across transit agencies, with significant impacts on operations, staff, and passengers. Approximately 40 percent of agencies report encountering vehicle availability problems at least a few times per month. **(Figure 1)**

The impacts of these issues are far-reaching, and increased staff stress, reduced service, and insufficient replacement vehicles for breakdowns stand out as major challenges (**Figure 2**). Key causes for vehicle availability issues include delays in obtaining replacement parts, aging fleets, and a shortage of mechanics. Difficulties in sourcing parts are not confined to specific types of fleets, with agencies reporting challenges both with parts for traditionally-fueled vehicles and acquiring replacement parts for new ZEV fleets (**Figure 3**).

Figure 2: What are the impacts of having insufficient available vehicles on your agency and its riders?

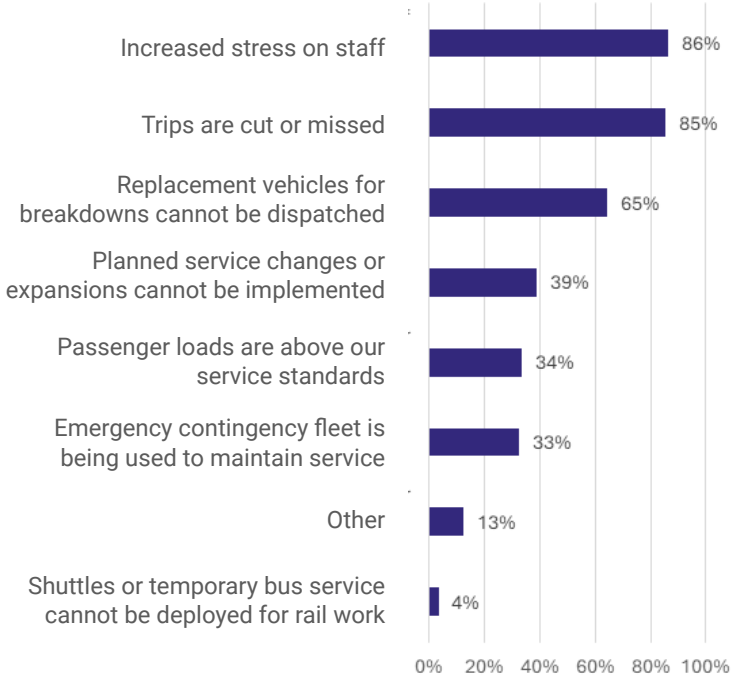
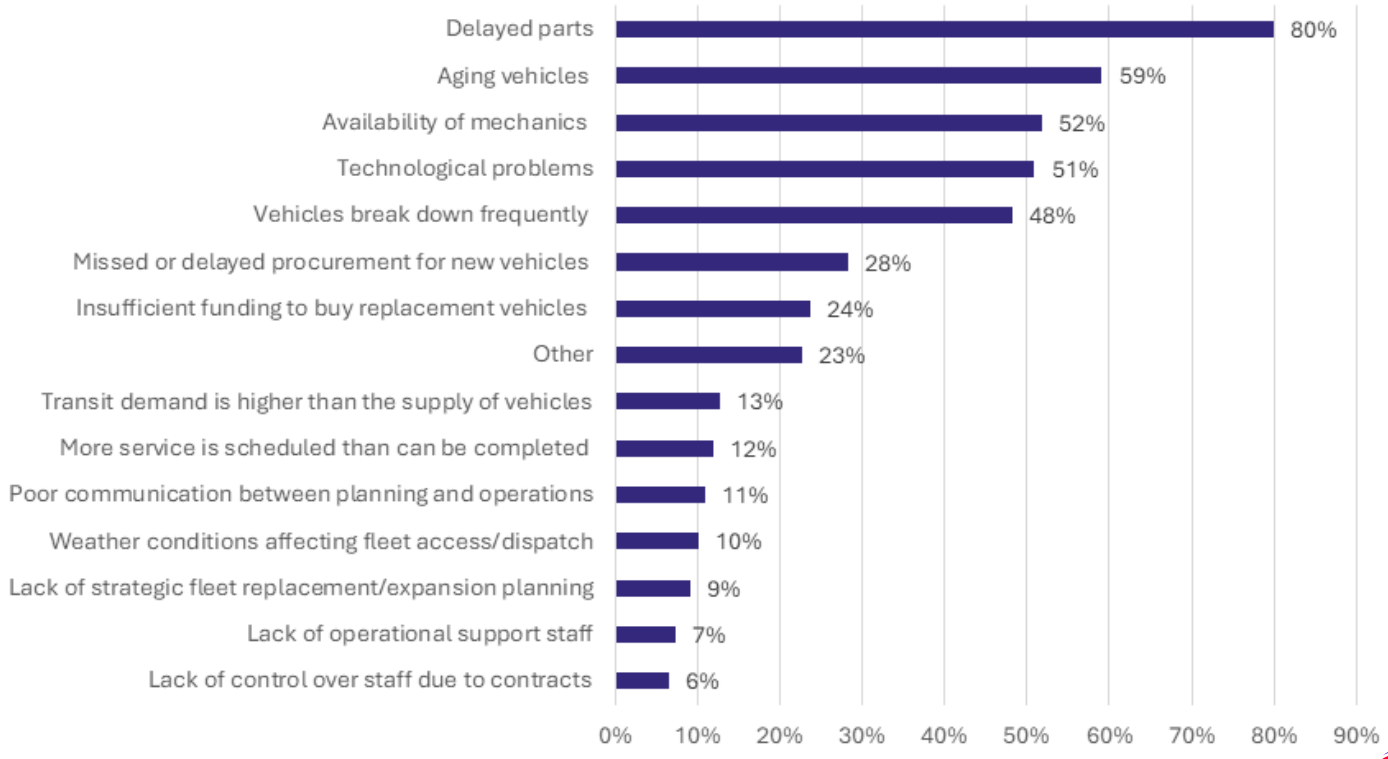


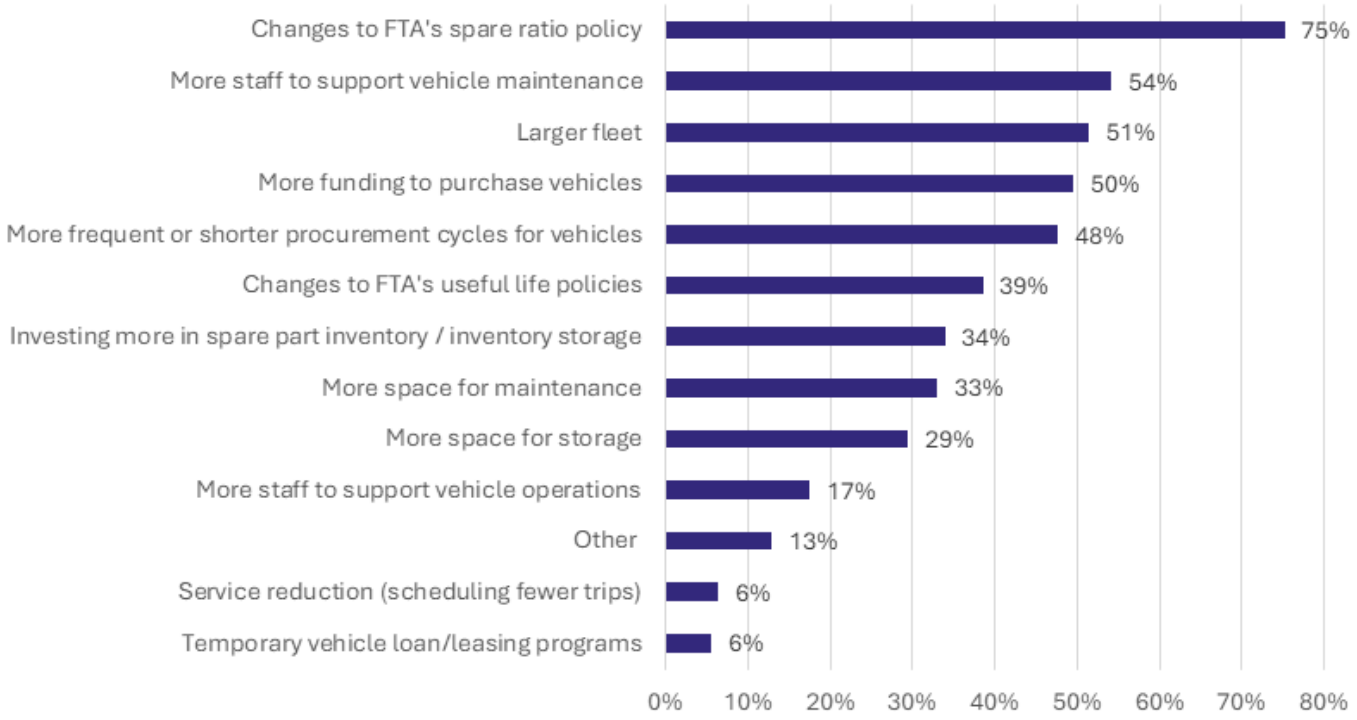
Figure 3: What do you believe is the source of your agency's vehicle availability challenges for fixed-route bus operations?



More flexibility is desired for fleet planning.

Many transit agencies believe that adjusting the spare ratio rule could help alleviate vehicle availability issues. Seventy-five percent of respondents feel that changing FTA's spare ratio policy would improve vehicle availability for fixed-route operations, while 54 percent suggest that increasing staff to support vehicle maintenance could also be beneficial (**Figure 4**). Other suggested solutions include expanding fleet sizes (51 percent), increasing funding for vehicle purchases (50 percent), and shortening procurement cycles (48 percent).

Figure 4: Which potential solutions below could help address your agency's challenges with vehicles available for fixed-route bus operations?



A significant majority of the respondents, 83 percent, advocated for raising the spare ratio limit to address those issues (**Figure 5**). Respondents also emphasized the need for more flexibility in the spare ratio policy, proposing that it should account for special events and consider historical data on fleet needs.

While many respondents support changes to the spare ratio limit, more than one-half (52 percent) still believe it should be calculated based on peak vehicle needs. Nevertheless, some respondents pointed out that "peak" service periods extend beyond just traditional AM and PM rush hours (**Figure 6**).

Figure 5: If there was a proposed change to the spare ratio percentage (20%), what would be your suggestion?

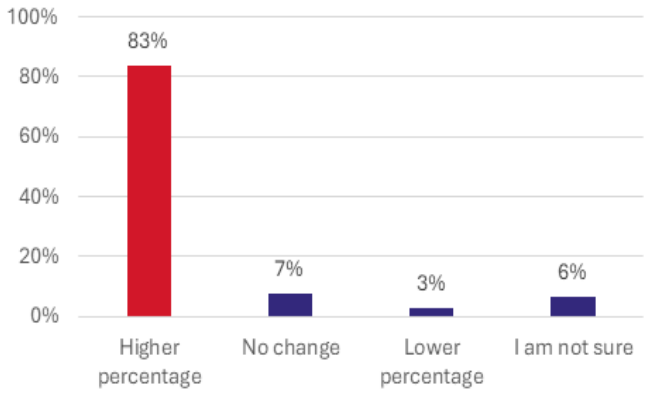
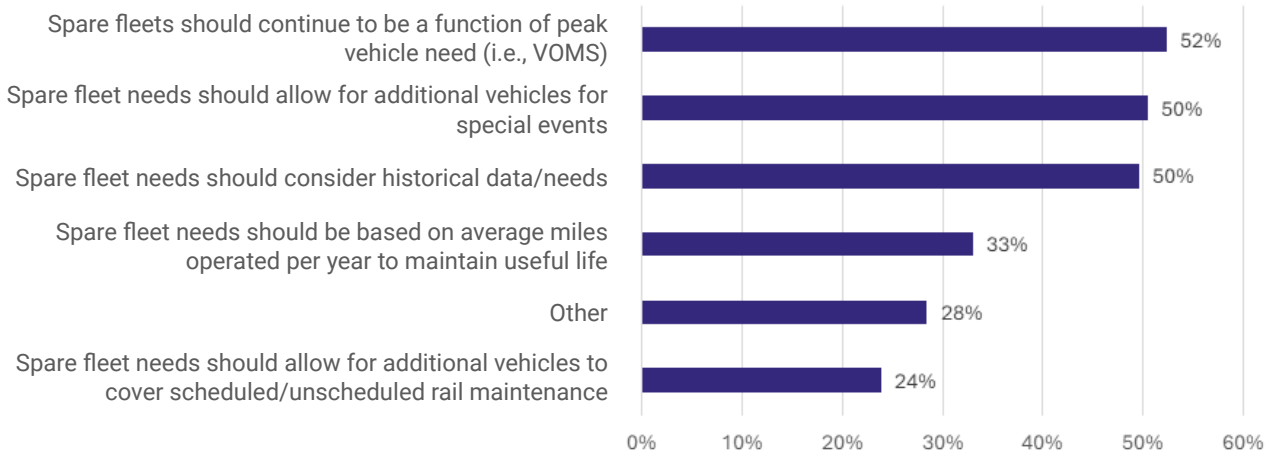


Figure 6: If there were alternative ways to account for peak vehicle needs, which of the following factors would you want to be part of FTA's spare ratio calculation?



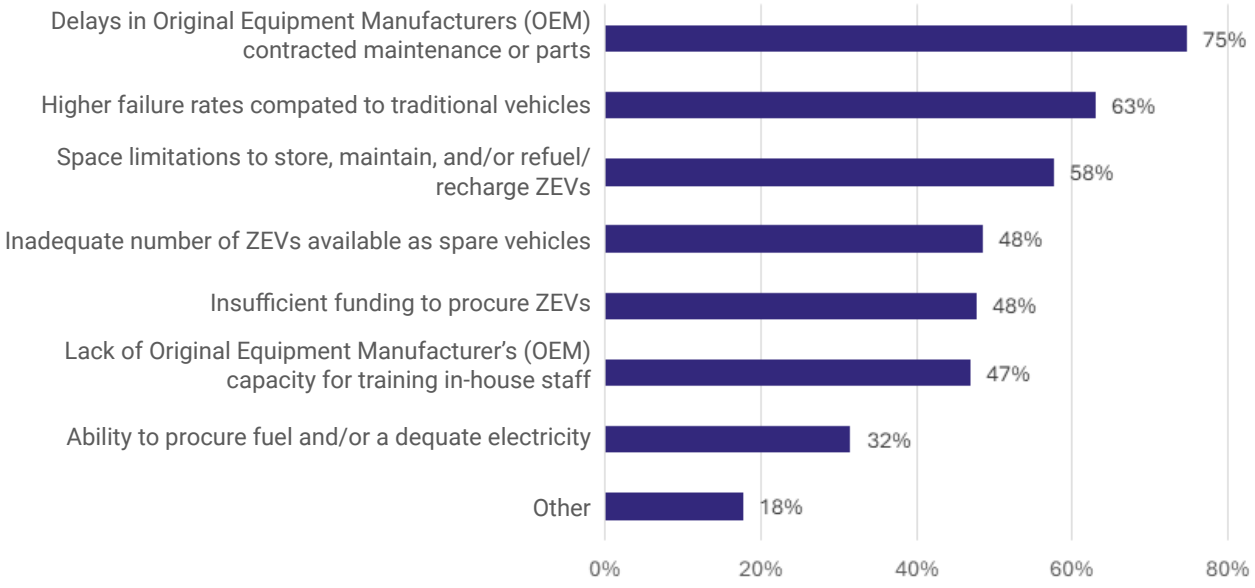
> On a daily basis we struggle to make service due to vehicle availability. There are a variety of factors that FTA does not take into consideration that is [sic] unique to each agency and impacts the real spare ratio number. Because of this there are negative impacts on our customers and operators. We can correlate operator and passenger incidents to the service delays, missed service, and overcrowding. We also have much needed improvements that can't be implemented due to concerns around vehicle availability."
>
> *-Survey respondent when asked to elaborate on their agency's vehicle availability challenges.*

> In a 24-hour period, almost 70 percent of the time we are operating at peak deployment (including on weekends). Ensuring vehicles are able to even do basic PMs [preventive maintenance] is truncated into six hours a day. Not to mention because of the amount of miles our vehicles travel, they require service sooner. In most cases, we're reaching useful life in miles within five to six years. Then include the 20 percent of vehicles that are out of service for any number of mechanical reasons related to accidents (including something as basic as a mirror strike) or weather-related incidents."
>
> *-Survey respondent when asked to elaborate on their agency's vehicle availability challenges.*

The transition to zero-emission vehicles is especially challenging.

Many public transit agencies are actively transitioning from conventional-fueled vehicles to ZEVs, and more than one-half of survey respondents reported that they have completed a transition plan and begun implementation. This shift underscores the need to update policies to accommodate the unique demands of ZEV operations. However, agencies are facing several ZEV-specific maintenance challenges, including uncertainties in the timing of contracted services from original equipment manufacturers (OEMs) and uncertainties in sourcing parts for in-house repairs (**Figure 7**). Additionally, the limited availability of training resources for agency staff further impacts their ability to conduct repairs independently, even if this capacity-building is part of the ZEV procurement contract. Agencies are still navigating the operational challenges posed by ZEVs, such as issues with vehicle range, seasonal performance variations, and other technological concerns.

Figure 7: What specific issues have you encountered (or anticipate encountering) in adhering to the spare ratio requirements with a ZEV fleet?

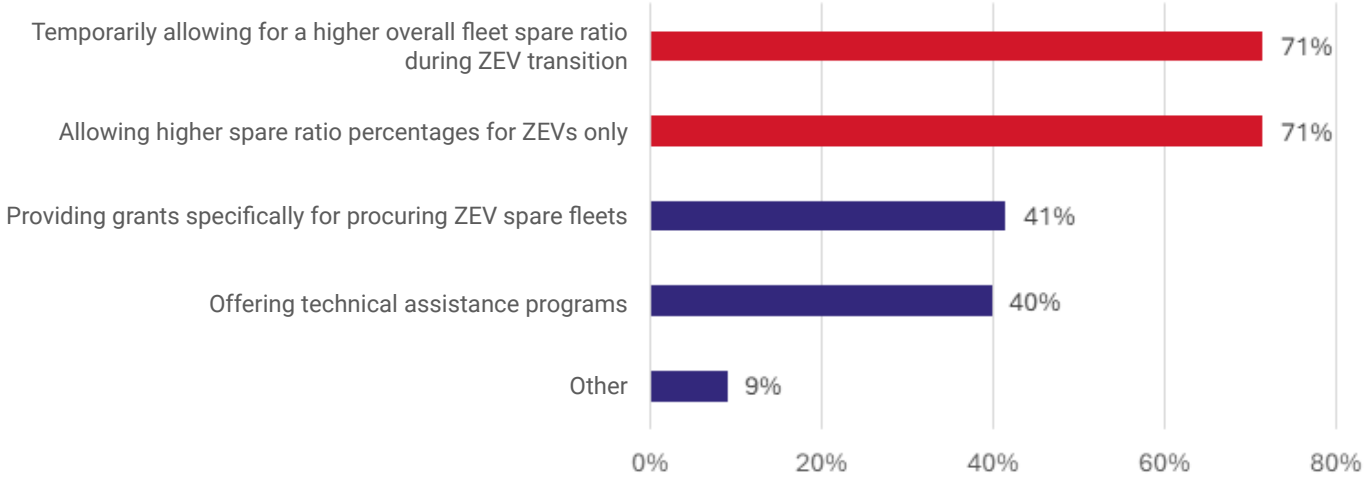


> "EV vehicles have been out of service more often compared with their CNG counterparts due to mechanical issues, alarms, technology issues, recalls, etc. Range has also been an issue in the winter, and we don't have very many routes we can feasibly deploy our first generation EVs on. Supply chain delays have resulted in buses being out of service longer or result in having to pay more for parts to expedite them, leading to higher costs."

-Survey respondent when asked to elaborate on their agency's vehicle availability challenges related to ZEV transitions.

In light of these challenges, many respondents (71 percent) expressed a desire to adjust the spare ratio percentages, specifically advocating for higher spare ratios for ZEVs and suggesting a temporary increase in the overall spare ratio during the ZEV transition period (**Figure 8**).

Figure 8: Based on your experience, how could the FTA's spare ratio rules be adjusted to better support transit agencies during the transition to ZEVs?



Agency Case Studies

Public transit agencies of all sizes are facing significant vehicle availability challenges due to staffing shortages, parts delays, aging vehicles, technology issues, and more, all while striving to a maximum 20 percent spare ratio. Smaller agencies are particularly impacted by limited spare vehicles, which lead to service disruptions and increased pressure on staff. Maintenance staffing shortages and difficulties retaining qualified mechanics exacerbate these issues, causing extended vehicle downtime.

The transition to ZEVs adds another layer of complexity. ZEVs often suffer from reliability issues, such as reduced range in extreme weather, system malfunctions, and maintenance challenges due to specialized parts and a shortage of trained technicians.
Many agencies are retaining older vehicles longer to form contingency fleets, but this comes with increased maintenance and storage costs. These older vehicles, while helpful in emergencies, also have reliability issues due to surpassing their useful life benchmarks.

To address these challenges, agencies are advocating for more flexible federal spare ratio policies and are implementing strategies like workforce development programs and improved fleet management. These efforts aim to balance service reliability with the demands of transitioning to newer, more sustainable technologies. To frame these challenges and potential solutions, six agencies shared their experiences with APTA, providing lessons for better fleet management and maintenance practices.

FTA provides the guidance on fleet spare ratios when transitioning to a new propulsion type through a frequently asked questions (FAQ) page: *"If a recipient replaces its rolling stock (buses/vans/similar vehicles) with rolling stock of a new propulsion type, then the spare ratio is calculated off the needs of the new fleet." However, during agency interviews, there was confusion on how to apply this guidance to individual agencies' fleet plans. Some believed it was stating no-change in the 20 percent spare limitation, while others interpreted it as a "carte blanche" to adopt as many new vehicles as needed during the transition period.*

CityBus

CityBus, the public transportation provider for the Greater Lafayette area in Indiana, serves the community by connecting downtown Lafayette with Purdue University. CityBus faces challenges typical of smaller transit agencies, with frequent vehicle availability issues, especially with maintenance staffing shortages, parts shortages, and adherence to FTA's spare ratio limits. CityBus's 47 vehicles in maximum service and fleet of 54 vehicles mean the agency is on the cusp of FTA's spare ratio compliance (grant recipients operating 50 or more fixed-route revenue vehicles). The small number of spare vehicles leaves the agency highly vulnerable to disruptions, as even routine maintenance or unexpected repairs can result in the full utilization of the spare fleet, leading to service delays or trip cancellations.

Another significant challenge for CityBus is attracting and retaining qualified maintenance staff. Limited pay increases for mechanics, coupled with nationwide parts shortages, have caused extended downtime for buses in need of repairs, further exacerbating vehicle availability problems. The situation has been compounded by staffing shortages among bus operators. While CityBus has increased hiring, the higher percentage of less experienced operators has had a corresponding increase in collisions (even minor ones) that leave buses out of service for extended periods, further straining fleet availability.

In response, CityBus has begun to retain older buses beyond their useful life to form a contingency fleet. While these older vehicles require more frequent repairs, they offer a critical buffer during peak demand or maintenance periods. The agency has also suggested changes to FTA's policies, including a more flexible spare ratio system that would allow smaller agencies like CityBus to maintain service without facing penalties. Such changes could provide much-needed support for transit agencies across the country facing similar challenges.

MetroTransit

MetroTransit, the primary public transportation provider for the Minneapolis-St. Paul region in Minnesota, is one of the largest agencies in the United States. It operates a fleet of 765 vehicles across various modes, including fixed-route buses, light rail, and heavy rail. However, like many northern transit agencies, Metro Transit faces unique challenges with the adoption of ZEVs because of harsh winter impacts.

Extreme cold significantly shortens the range of electric buses, forcing the agency to use more ZEV vehicles compared to internal combustion engine buses to cover routes. This increased need for ZEVs, coupled with the FTA's 20 percent spare ratio policy, often results in availability issues. MetroTransit also struggles to meet seasonal demands, such as additional bus service for the state fair, which draws nearly two million visitors over 11 days and requires 85 extra peak vehicles.

To address these issues, MetroTransit is developing a strategy to keep a stock of replacement electric bus batteries, ensuring that buses can be returned to service more quickly. On the policy side, MetroTransit advocates for greater flexibility in the FTA's spare ratio guidelines, particularly for ZEVs in cold climates. Higher spare ratios would give agencies like MetroTransit the flexibility to meet service demands while continuing to transition to more sustainable bus fleets.

RIPTA

The Rhode Island Public Transit Authority (RIPTA) is the state's provider of public transportation, operating a fleet of 230 buses for its fixed-route service. RIPTA is in the process of fully decarbonizing including the procurement of battery electric buses (BEBs) to reduce emissions and improve sustainability. However, as the agency transitions, it has faced challenges related to the long distances its buses travel and the complexities of operating zero-emission vehicles.

As the statewide operator, one of RIPTA's major issues is the heavy usage of its buses; sometimes reaching 200 miles per day on a single vehicle, accelerating wear and tear. In turn, this causes their vehicles to reach the end of their useful life up to two years earlier than expected. This increased turnover rate requires more capital replacements and strains the agency's resources. Unlike standard diesel or hybrid-electric buses, concerns over battery range limitations present a potential service risk. RIPTA's first 14 BEBs operate on their busiest and most frequent route, the R-Line, between Pawtucket and Providence. The failure of a single bus on this route directly impacts hundreds of riders and interrupts the 10-minute headway. Additionally, the agency encountered problems with the BEBs during the initial months of operation which resulted in significant downtime before they could be put back on the road. Utilizing its limited spare vehicles were required to avoid significant impacts on the R-Line, impacting RIPTA's ability to address service disruptions elsewhere in the network.

RIPTA, like other transit agencies, has also struggled with recruiting and retaining skilled mechanics, particularly those with the specialized training needed to work on ZEVs. The shortage of mechanics, exacerbated by the COVID-19 pandemic, is compounded by the fact that private-sector mechanical jobs often offer more competitive pay and benefits.

To address these issues, RIPTA suggests that FTA collaborate more closely with their regional offices to develop policies and guidance that can provide greater flexibility accounting for each specific agency's operations and service area. Regional offices may have a better understanding of the specific challenges agencies in their territory are facing such as long routes and cold winters which make battery electric operations more challenging with limited spare fleets. They also recommends that FTA provides clearer guidance on spare ratios as it relates to ZEVs so agencies can better improve their capital and fleet planning. Agencies, like RIPTA, would benefit from further support for planning, workforce development, and new vehicle technology adaptation with the ultimate intention of better leveraging existing resources and increasing the flexibility of spare fleets.

RTC

The Regional Transportation Commission of Southern Nevada (RTC) operates a mixed fleet of 415 vehicles, including traditional buses, CNG vehicles, BEBs, and hydrogen fuel cell electric buses. RTC serves the densely populated Las Vegas area, known for its extreme heat and high demand for public transportation, especially due to the influx of tourists attending special events like conventions and sporting events. The climate and special events create unique challenges in maintaining fleet availability, critical to meeting the city's operational needs.

One major challenge RTC faces is maintaining a sufficient spare vehicle ratio. Las Vegas has high peak demands for transit service throughout the day, with some routes operating 24 hours daily. Unlike other cities, there are no clear peak travel periods; RTC routes have long spans of operations and the same headways operating throughout the day. The frequent special events further complicate fleet management, as detours and increased ridership require additional buses, placing further strain on an already stretched fleet. This high demand and the extreme desert climate leads to rapid vehicle wear and tear, particularly affecting the high-mileage buses that operate in such harsh conditions. With temperatures reaching more than 140 degrees Fahrenheit on asphalt in summer, the heat accelerates the deterioration of batteries in electric buses, increasing maintenance needs and causing downtime, which reduces the fleet's availability.

RTC has implemented a robust preventive maintenance strategy to mitigate these issues, focusing on proactive inspections and maintenance, especially during the hot summer months. The agency regularly performs cooling system checks and addresses common wear-and-tear issues like battery and alternator failures exacerbated by the intense heat. Despite these efforts, the challenge of meeting the FTA's spare ratio requirement of 20 percent remains. This ratio is difficult to maintain given the high mileage demands of RTC's fleet, the frequent breakdowns, and the rapid depreciation of vehicle components. Although RTC has made strides in maintaining vehicle availability through preventive maintenance and regular performance analysis, these ongoing challenges highlight the need for a more flexible approach to fleet management and Federal guidelines to accommodate the unique demands of high-mileage, high-demand transit systems.

Santa Cruz

The Santa Cruz Metropolitan Transit District (MTD) operates a mixed fleet of 108 vehicles, including traditional diesel buses, BEBs, and hydrogen fuel cell electric buses. In a region of coastal California marked by rural terrain, varying climate conditions, and natural disaster risks like wildfires and earthquakes, the agency is grappling with frequent vehicle availability challenges, leading to service cuts, missed trips, increased pressure on staff, and a delay in the implementation of planned service changes and expansions.

The agency's fleet is aging, with many vehicles reaching the end of their useful life earlier than expected and often requiring more frequent preventive maintenance. This has strained the agency's resources and led to a shortage of operational vehicles. The transition to ZEVs, including battery-electric and hydrogen-powered buses, has added further complexity. These new technologies have introduced reliability issues, such as software malfunctions, charging problems, and fuel supply inconsistencies, particularly with hydrogen buses. These malfunctions result in extended downtime, increasing the need for spare vehicles to meet service demands. Adding to the challenge is the shortage of technicians trained to service these advanced vehicles, compounded by delays in parts and necessary software updates.

As the agency transitions to ZEVs, they have found that a 1:2 replacement ratio is more realistic than the expected 1:1 due to performance challenges such as software malfunctions, charging issues, and fuel supply inconsistencies. The more conservative approach helps maintain service levels while managing the increased breakdowns and maintenance needs of ZEVs. The agency also advocates for more flexible FTA spare ratio policies, allowing agencies to adjust based on local conditions and fuel types. Santa Cruz has expanded its workforce by hiring more mechanics in response to rising maintenance demands. The agency is also developing specialized training programs to better equip technicians with the skills needed for ZEV maintenance, reducing reliance on OEM technicians and improving operational efficiency.

Trinity Metro

Trinity Metro, serving the city of Fort Worth, Texas, operates a fleet of 142 vehicles, including commuter rail, bus, and microtransit services throughout the city and surrounding Tarrant County. While the agency faces typical challenges associated with medium-sized fleets, its location in a hot climate introduces additional complexities. The shift to ZEVs has brought unforeseen operational difficulties, including slower-than-expected replacement of CNG buses with ZEVs and issues with the range of electric buses on longer routes. Moreover, scorching summers place additional strain on ZEVs, as the HVAC systems used for cooling require more energy, further limiting vehicle range and necessitating the deployment of extra buses to meet service demands.

Trinity Metro's ZEV adoption has also led to maintenance challenges. These vehicles often require specialized parts, which are not always readily available, leading to extended downtime for repairs. Combined with a shortage of skilled labor, these factors have compounded the agency's difficulties in maintaining a reliable fleet. Trinity Metro staff have expressed concerns about the overall reliability of ZEV technology, noting that the limited number of manufacturers and the current limitations of the technology add to the strain on the system.

To address these challenges, Trinity Metro has implemented several solutions. The agency's 20 percent spare ratio has not been a major issue for its CNG fleet, but the transition to ZEVs has been a more significant concern. To mitigate fleet turnover and maintain service reliability, Trinity Metro employs an annual bus procurement strategy, along with a midlife repowering program and regular quality inspections. These efforts help keep the fleet in good condition and reduce vehicle availability issues. Additionally, Trinity Metro has partnered with local schools, colleges, and community organizations to develop a pipeline for hiring new mechanics, offering flexible internship opportunities to students. This initiative aims to ensure a steady supply of qualified technicians to meet the growing maintenance needs of the fleet.

Calculating VOMS

The FTA determines fleet needs based on the number of vehicles operated at maximum service (VOMS) plus an allocation for spare vehicles. As noted in FTA's Circular 5010-1E, the number of spare buses and/or vans in an agency's fixed-route fleet should not exceed 20 percent of their VOMS number. The circular states that VOMS "*is defined as the total number of revenue vehicles operated to meet the annual maximum service requirement. This is the revenue vehicle count during the peak week, day and hours maximum service is provided. It excludes atypical days and special events.*"

DEFINITIONS

Block: A group of round trips assigned to a single vehicle.

Cycle Time: The amount of time needed to complete a full round trip including the actual run time as well as any layover or recovery time added at each end.

Frequency: The rate at which a route is served by vehicles in one direction, usually expressed as time between arrivals.

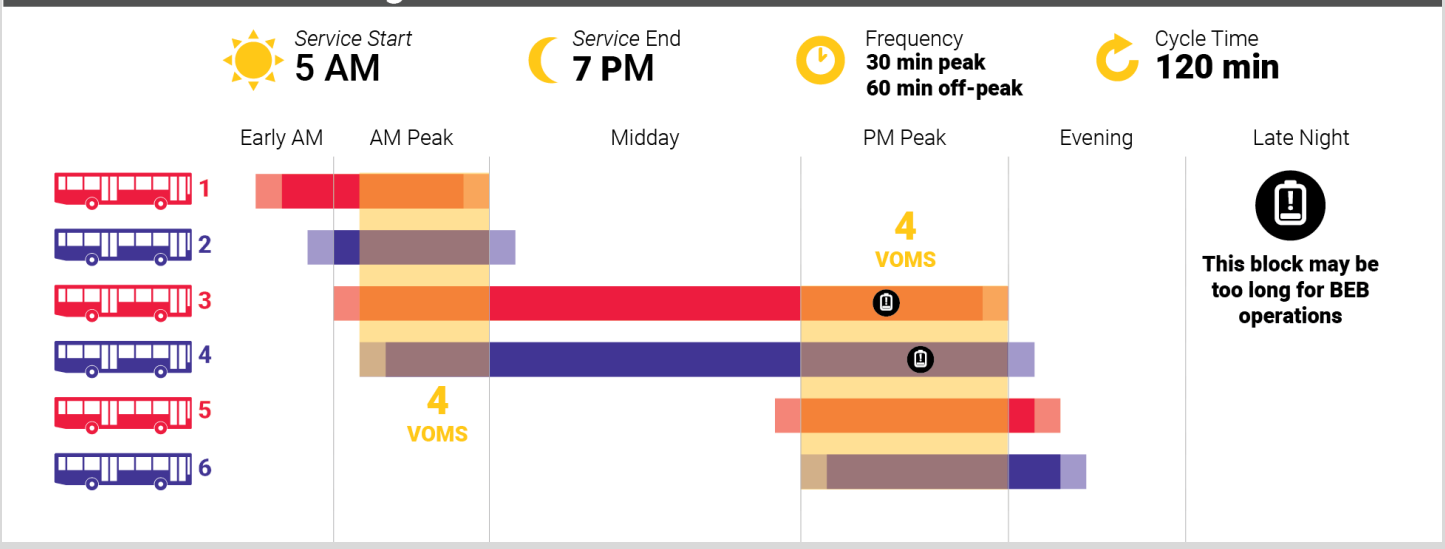
Span: The operating hours of a transit service for a given operating day.

Service Profile: The general characteristics of the level of service provided by a transit agency considering both span and frequency of operations.

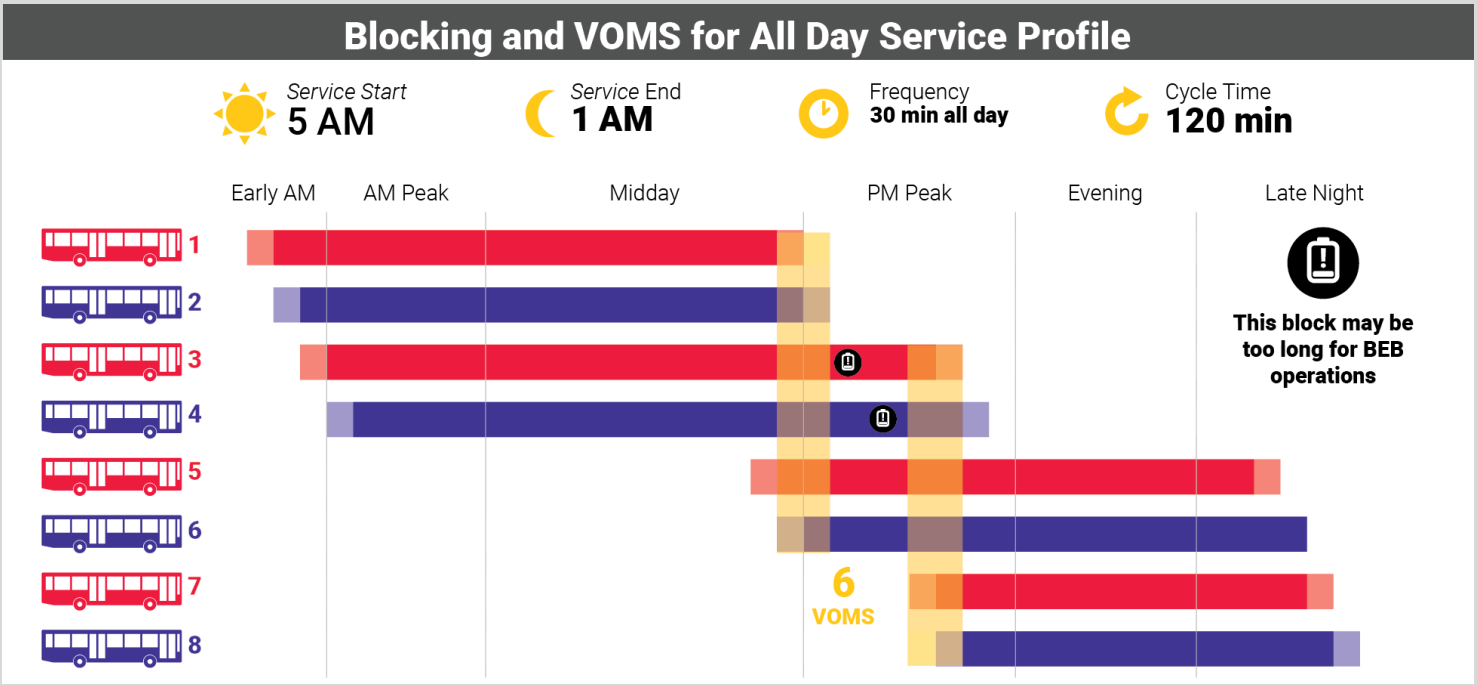
FTA identified the 20 percent spare threshold based on a transit agency survey conducted in the early 1990s, when many bus transit systems operated very peaked service, concentrating the bulk of their revenue miles and hours during traditional AM and PM weekday rush hours. However, transit agency operations have evolved significantly over the past 30 years. Modern transit operations have grown to include expanded operating spans with increasing demand for midday, late-night, and weekend services.

In the past, revenue service was concentrated heavily around the AM and PM peak travel times. This resulted in a profile where a subset of vehicles performed many short service blocks to bolster frequency in the peak travel periods. VOMS was easy to project based on the needed vehicles to meet peak frequencies by taking **cycle time** divided by **peak frequency** to estimate peak vehicle needs. The below graphic illustrates the blocking of vehicles for a route with a peak service profile. Note, however, that this service profile may result in blocking that is too long for BEB battery limitations.

Blocking and VOMS for Traditional Peak Service Profile



Transit agencies have shifted away from largely commuter-oriented service profiles with peak frequencies matching AM and PM rush hours toward a 24-hour operation with more consistent frequencies all day. Some may even operate at high frequencies through peak and off-peak periods. Given this change in operations, it is common for agencies to have two, and sometimes three, sets of block pullouts, operating continuously for eight or more hours. The result is a new VOMS window that often occurs in the afternoon as vehicles from the first wave come out of service and vehicles from the new wave enter to take their place. The below graphic demonstrates blocking for a route with a 30-minute all-day frequency and a span of operation from 5:00 to 1:00 a.m. The result is up to six vehicles are needed to provide the desired frequencies without gaps in revenue service. This differs from the calculation used to project VOMS, which is based on peak operating service windows. Again, it is important to note that even in this optimal blocking design, BEBs may not be able to be assigned to all blocks due to the operating length.



In addition to examining vehicle needs in the context of scheduling realities, transit agencies should consider the anticipated miles accrued on vehicles each year as they plan for fleet and fleet replacement. Long blocks with few buses may be efficient in terms of fleet size in the short term, but excessive mileage can lead to shorter bus lifespans requiring the agency. The FTA's useful life benchmarks (ULB), outlined in Circular 5010.1D, state that heavy-duty buses need at least 500,000 miles or to be at least 12 years old to be eligible to be replaced with FTA funds. For example, if an agency hopes to maximize the life span of their vehicles, then this formula could be used to calculate the limit of annual mileage per vehicle:

[ULB Miles for a vehicle] / [ULB Years of Service] = [Allowable Annual Miles per Vehicle]

For a standard heavy-duty bus, this formula equates to approximately 41,600 miles annually if the agency plans to replace the vehicle after 12 years.

All these factors must be considered when planning for a proper fleet size and spare needs. Calculating VOMS means more than just calculating the number of buses needed based on frequencies and cycle times. It also requires consideration of how blocking and non-revenue travel affect vehicle need and how total mileage impacts agencies' fleet lifecycle plans.

ZEV Fleet Challenges

The transition to ZEVs, particularly BEBs, represents a crucial step in decarbonizing public transit. ZEVs offer environmental and public health benefits by eliminating tailpipe emissions and reducing maintenance needs due to fewer moving parts. However, the shift from diesel to ZEVs presents challenges for transit agencies, including the need for specialized workforce skills, managing a new parts inventory, planning for new fuel supply and its storage, and implementing new safety measures. In the case of BEB conversions, agencies must also address battery capacity limitations, manage long charging times, and build new infrastructure, such as charging stations. Although ZEVs have been around for some time, widespread adoption by transit agencies is still in the early stages, with many agencies working to adapt operations to new propulsion technology or manage fleets with multiple propulsion systems.

Technological hiccups are impacting vehicle availability. Many transit agencies reported that breakdowns and out-of-service status for ZEVs were greater than those for traditional diesel buses. While ZEVs are not inherently unreliable, adopting new technology can result in more uncertainty. As the ZEV industry grows and vehicles have been in production longer, manufacturers will continue to address flaws and failures. However, the reality of ZEV reliability presents a particular challenge for agencies providing transit service to their communities, and as such, the spare ratio rules can inhibit agencies from performing their primary function.

ZEVs are out of service longer than traditional vehicles. As seen through the survey responses and agency case studies, when ZEVs require maintenance, they tend to be out of service longer than traditional fuel vehicles. This is driven by two factors: **a lack of qualified technicians and mechanics to make repairs and long lead times in procuring replacement parts** for vehicles and supporting infrastructure. Extended periods of downtime for ZEVs further exacerbate vehicle availability issues.

One of the most obvious challenges with ZEV operations, in particular BEBs, is **range limitations**. Range limitations are compounded by external factors such as weather and terrain, introduce further operational challenges. **BEBs typically require recurrent and lengthy charging**, which can create gaps in service unless agencies deploy more buses or adjust routes. While hydrogen bus refueling is similar to refueling a diesel vehicle, BEBs require several hours to charge or at least 20 minutes using fast chargers. Careful planning is essential to prevent service disruptions and ensure charging schedules align with peak service hours. These constraints force agencies to adjust schedules, shorten routes, or deploy additional buses to cover gaps when BEBs require recharging.

Operational planning becomes more complex due to challenges. Transit agencies may need to expand their fleet to ensure sufficient coverage, which increases capital and operational costs. Maintenance schedules must be adjusted to ensure vehicles remain in good condition while meeting the increased demand for service. This level of adjustment underscores the necessity of integrated planning for fleet management, infrastructure, and operations.

Conclusions

This research identified several trends and challenges that significantly impact public transit agencies' ability to maintain vehicle availability and provide reliable transit service to their communities. Responses to a national survey, evidence from agency case studies, and analysis of operational data reveal several issues related to fleet planning and the impacts of FTA's spare ratio rules for both conventional-fueled vehicles and for ZEVs. The research also identified many best practices for improving fleet management and aligning FTA policy with the changing transit environment.

Workforce and training gaps. Our research highlighted an urgent concern regarding the ongoing shortage of skilled mechanics and technicians, exacerbated by increasing vehicle complexity and insufficient training initiatives. Regular staff development training and competitive compensation are necessary to attract and retain personnel. Addressing these gaps will effectively ensure agencies adapt to the needs of their fleet.

Aging fleets and procurement delays. Delays in delivery of new vehicles and replacement parts in combination with rapidly aging fleets create a significant operational and financial strain. Many agencies rely on contingency fleets to bridge these gaps, but older vehicles require more frequent repairs and increased maintenance resources. These challenges contribute to extended vehicle downtime and service disruptions.

Evolving service design. The traditional focus on peak-period service has shifted since the inception of FTA's spare ratio rules, and has further shifted since the COVID-19 pandemic; transit agencies are responding to changing travel behavior with all-day, and frequent service. This shift reflects new service profiles that prioritize consistent frequencies throughout the day, and robust service overnight and on weekends, rather than service concentrated service at peak rush hour periods. Traditional methods of calculating VOMS are now less applicable. To address these changes, alternative approaches to service design must be considered, including scheduling and blocking strategies that account for more consistent and evolving patterns of demand.

Challenges with ZEVs. Transitioning to ZEVs presents challenges for agencies maintaining their current fleet counts. Issues include reliance on specialized parts and infrastructure, limited battery range, and long charging times. These challenges can be amplified in extreme weather, further degrading the battery, leading to an additional strain on fleet availability. Supply chain issues and workforce gaps also have an exaggerated impact on ZEV fleets.

These findings emphasize the need for updated policies, new workforce procedures, and guidance that supports transit agencies in meeting these new and evolving operational demands.

Best Practices for Agencies & Fleet Planning

Ensuring an appropriate spare ratio is crucial for public transit agencies to deliver reliable service and adapt to operational challenges. Initially developed to promote efficiency, the spare ratio policy offered agencies valuable guidance to maintain a lean and efficient fleet in an era when transit management concepts were less formalized than they are today. However, the more than 30-year-old policy has become increasingly restrictive under current agency operations. Agencies nationwide face significant challenges in maintaining spare ratios under 20 percent. Best practices were developed following engagement with agencies that have developed creative solutions to adapt to workforce shortages, changing commute habits, and supply chain disruptions.

As many agencies transition to new propulsion technologies, ZEVs' unique operational and maintenance requirements present additional challenges. Proactively applying the following best practices can significantly alleviate existing vehicle availability issues and could be crucial for agencies preparing to implement new propulsion technology while maintaining consistent vehicle availability and appropriate spare ratios.

Examine annual mileage in addition to peak vehicle counts. Understanding the scheduling and blocking implications of your transit service profile can help ensure that buses are retained for the intended 12-year or 14-year lifespan. Certain service patterns, such as all-day service or long regional routes, can add many miles to odometers and increase vehicle wear and tear, potentially shortening their useful life. Monitoring annual mileage helps maintain consistent performance and ensures that vehicles meet service expectations throughout their lifecycle.

Implement annual or consistent bus purchases. Staggered procurement schedules help balance fleet age, minimize maintenance spikes, and spread capital investment over multiple years, promoting a sustainable vehicle replacement cycle. Transit agencies should also review the APTA Bus Manufacturing Task Force recommendations which include providing price adjustments to existing bus procurement contracts; advance payments and milestone payments; and vehicle price adjustments for future contracts to reflect price inflation/deflation.

Increase stock for spare parts. Supply chain issues have slowed the manufacture and delivery of vehicle parts nationwide. Maintaining an ample inventory of essential parts ensures timely repairs and minimizes downtime, supporting consistent service levels.

Enhance workforce development and increase hiring for mechanics and technicians. Agencies can support workforce development through the following strategies:

- **Leverage Existing Funding**: Leverage 0.5 percent of public transit formula funding and allocate up to five percent of zero-emission funding from Low or No Emission (Lo-No) Bus grants specifically for workforce development.
- **Community College Partnerships**: Collaborate with local educational institutions to create programs to establish a pipeline of trained technicians.
- **Apprenticeship and Mentor Programs**: Establish structured programs to train and retain skilled mechanics, ensuring continuity and expertise.
- **Evaluate Technician Pay**: Analyze local wages to assess how agency compensation aligns with the private sector, aiming to enhance competitiveness.

Fuel backup plans. Agencies should consider fuel supply backup solutions or secondary charging solutions to mitigate disruptions in the primary energy supply, ensuring continued operations during outages, shortages, or unforeseen events.

Plan for maintenance and technology uncertainties. Develop contingency protocols for issues related to unexpected vehicle failures or ZEV issues, such as charging infrastructure failures or software malfunctions, to maintain service reliability. FTA allows agencies to "retain buses/vans that have met their useful life in a contingency fleet without being included in the spare ratio calculation." Many agencies will use contingency fleets to supplement vehicle availability issues around special event seasons or emergencies and plan procurement cycles with contingency fleets in mind.

Consider the impacts of subfleets. Subfleets are groups of vehicles within a transit agency's fleet that are differentiated by operational, functional, or physical characteristics. For example, some agencies may use articulated vehicles or vehicles with specific branding to operate bus rapid transit routes. Before adopting subfleets, agencies should consider whether the differentiation in fleets is worth the investment or if a division in fleet types can create more vehicle availability issues. While an articulated bus may make sense for a high ridership route, distinct branding could potentially limit the number of vehicles an agency might be able to use for said route, ultimately impacting service. If agencies adopt subfleets dedicated to specific service offerings, they must ensure that spare ratios are adequate for each subfleet to minimize the effect on vehicle availability.

Regional Collaboration Initiatives. Agencies can look to peers in their region to provide support for vehicle availability challenges. Some strategies that could be adopted include:

- **Fleet sharing measures:** Agencies within a region can collaborate on fleet-sharing strategies to address specific situations that impact vehicle availability. Special events, emergencies, or infrastructure maintenance often require additional buses to meet temporary mobility demands. Agencies can effectively address regional vehicle needs by coordinating and pooling resources, ensuring mobility is maintained during critical periods.
- **Regional maintenance initiatives:** To address vehicle availability issues, agencies could develop regional facilities for general bus maintenance that can alleviate the stress of individual agency shops. This can be supplemented by engaging in regional training initiatives to increase the pool of maintenance staff.

Policy Considerations

In addition to agency-led efforts to improve fleet planning, policymakers can also do more to support transit agencies in maintaining fleets and ensuring enough vehicles are available to meet the mobility demands of our communities. Policymakers should consider **allowing for more flexibility** in spare vehicle counts. The current 20 percent spare ratio cap based on peak vehicles can be too restrictive, especially because it does not consider many operational constraints that differ between agencies based on service profiles. Service can vary vastly depending on a multitude of factors, such as spans of service, frequency of service, total size of service areas, and climate conditions. Since the spare ratio requirements were introduced in the early 1990s, travel patterns—especially since the COVID-19 pandemic—and rider expectations have changed significantly. More shiftwork, flexible work schedules, and demand for increased overnight, weekend, and frequent transit service means agencies are 24-7 operations. As more agencies experience all-day demand rather than traditional peak demand, the vehicle counts for peak service may not be an accurate proxy for maximum fleet need.

The following policy considerations were developed based on the experiences of transit agencies nationwide and the challenges they have faced while maintaining a 20 percent spare ratio based on peak service.

1 **Provide options for calculating fleet and spare needs.** Transit agencies vary widely in their operations, affecting how vehicles are used and maintained. Factoring in historical data and annual mileage when calculating spare needs could be a more tailored approach, especially as agencies adapt to new propulsion technologies that may not have proven long-term performance yet.

2 **Clarify language around Useful Life Benchmarks (ULBs) and provide clearer guidance to agencies about fleet planning.** FTA defines ULBs as a vehicle's expected operational lifespan, measured in years of age or miles traveled, with benchmarks varying by vehicle type. Although both years of service and mileage are valid measures for determining useful life, there is often a lack of clarity regarding their applicability. This confusion arises because FTA sometimes cites years of useful life without referencing mileage in certain resources, which can lead to uncertainty about whether both measures should be considered in fleet planning. To better support agencies with high mileage operations, FTA should provide more explicit guidance emphasizing that mileage can also be a key factor in assessing useful life. This would help these agencies plan more effectively for future bus procurements.

3 **Provide better guidance and support on fleet planning.** Although FTA's spare ratio policy was developed to incentivize agencies to keep fleets lean and efficient, there has been very little guidance and support for calculating fleet needs, especially since transit networks have evolved in the quantity and type of services provided. As agencies document their challenges, FTA should learn from agency experiences and use them as a starting point for developing solutions and presenting exemplary practices. Templates, tools, and technical support can help agencies create effective fleet plans that make the best use of new technology while staying compliant with regulations. This approach also applies to ZEVs, as they introduce new challenges in fleet planning, such as the need for charging infrastructure and dealing with range limits.

4 Support workforce development for technicians and mechanics. Engagement with agency staff revealed significant difficulties filling and retaining mechanics and technicians. Maintenance staff shortages have further exacerbated vehicle availability issues with the growing demand for midday service, as maintenance work was traditionally conducted during service lulls in the middle of the day. Many agencies have also expanded revenue service hours to account for third-shift workers and late-night trips, creating a greater need for mechanics during the evening, overnight, and weekend hours to complete preventive maintenance tasks when vehicles are not in use. Investing in technician training can expand the workforce pool for future mechanics and contribute to job creation. Encouraging partnerships between transit agencies, technical and vocational schools, and manufacturers can help create well-rounded training programs that can ultimately reduce downtime, improve safety, and make fleet management more efficient. This also applies to the transition to ZEVs, which require maintenance teams to have new skills. Investing in technician training programs will make sure maintenance staff are prepared for the specific needs of electric and hydrogen vehicles.

Adjusting spare ratio policies to provide flexibility during **ZEV transitions** is essential for maintaining reliable service. **Temporary waivers, extensions, or allowances for higher spare ratios**—supported by data on integration issues and corrective actions—can help agencies address these challenges. Local conditions, such as extreme heat or cold affecting battery performance, should also be considered in spare ratio calculations to ensure dependable operations across varying climates.

5 Clarify FTA's Frequently Asked Question (FAQ) response regarding new propulsion systems. There is widespread confusion regarding what FTA's FAQ means, with some agencies indicating that they believe there is no change to the spare ratio rule of 20 percent based on peak vehicles in operation, while others have interpreted this guidance as a "carte blanche" to adopt as many new vehicles as needed during the transition period. FTA's current FAQ language states:

"If a recipient replaces its rolling stock (buses/vans/similar vehicles) with rolling stock of a new propulsion type, then the spare ratio is calculated off the needs of the new fleet. For example, if an agency was operating 100 buses and needed 20 spares (120 buses total), and after transitioning to a new propulsion type the agency now requires 110 buses, the FTA would expect 22 spares for a total of 132 buses."

Additionally, new vehicle technologies like electric, hydrogen, and hybrids bring questions about how they fit into current spare ratio policies. FTA should clarify its FAQ responses to ensure agencies are aware of any flexibility granted during the transition period or if spare ratios should be maintained at 20 percent regardless of propulsion type.

6 Enhance support related to fuel supply and infrastructure. A reliable fuel supply is critical for ZEV adoption, whether that means consistent access to electricity or hydrogen. Policies should encourage partnerships with energy providers to secure a steady fuel supply and incentivize building infrastructure like hydrogen fueling stations and charging depots.