Seattle Department of Transportation

Memo

Date: November 9, 2022
To: Councilmember Pedersen and other members of the Seattle Transportation and Seattle Public Utilities Committee, City Clerk
From: Greg Spotts, Director, Seattle Department of Transportation
Subject: Response to SLI SDOT-009-A-002-2022 - Request that SDOT report on the impact of over-weight vehicles

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As part of the 2022 Budget, Council included the following Statement of Legislative Intent (SDOT-009-A-002-2022):

> *This Statement of Legislative Intent would request that the Seattle Department of Transportation (SDOT) provide a written report to the Transportation and Utilities Committee, or successor committee, assessing the impact of over-weight vehicles on Seattle's streets and bridges. For the purposes of this report, over- weight vehicles include all vehicles operating at heavier weight than authorized by state law because of (1) federal or state categorical exemptions, (2) permitted over-weight uses, and (3) non-compliant uses in violation of state law.*
> *At a minimum, the report should: (1) identify the types of over-weight vehicles operating in Seattle and the types of SDOT assets impacted (e.g., arterials, non-arterials, bridges, sidewalks, areaways); (2) estimate the impact and cost to repair the identified assets; (3) identify best practices and recommendations for reducing damage or minimizing Seattle's costs to repair assets; (4) assess the City's enforcement capacity of non-compliant uses; and (5) recommend federal or state legislative changes for consideration as part of the City's legislative agenda.*
> *The report should rely on transportation literature review, SDOT's engineering judgment, and available asset condition assessments and cost estimates. If additional studies or assessments are necessary to answer any of these questions, the report should provide a cost estimate for the necessary work."*

Response to SDOT-009-A-002-2022

SLI SDOT-009-A-002-2022 asks SDOT to assume "over-weight vehicles include all vehicles operating at heavier weight than authorized by state law because of (1) federal or state categorical exemptions, (2) permitted over-weight uses, and (3) non-compliant uses in violation of state law. RCW 46.44.041RCW 46.44.041 defines weight limits on Washington roads, including highways and local streets as W = 500((LN/N-1)+12N+36). W is the maximum weight in pounds (to the nearest 500 pounds) carried on any group of two (2) or more consecutive axles. L is the distance in feet between the extremes of any group of two (2) or more consecutive axles. N is the number of axles under consideration. Although there is some variability due to axle spacing, statewide vehicle weight limits can be summarized as follows:

Weight limit: 80,000 lbs gross or more, depending on number of axles and their spacings:

Single axle	20,000 lbs
Tandem axle	34,000 lbs
Tridem axle	42,000 lbs (with at least 8' of axle spacing)

Divisible Loads Exceeding 80,000 lbs	a vehicle may exceed 80,000 gross without a permit on state highways or on Interstate highways as long as all axle/group weights are legal and the vehicle is licensed for at least the amount of your gross weight.

Washington's axle weight standards are consistent with national standards that first emerged in 1956 – increased from 18,000 to 20,000 lbs axle weight in 1974 – and have applied to all states since Congress passed the Surface Transportation Assistance Act in 1982. These axle weight limits are also echoed in City code (see, SMC 11.60.370). In 1992, the Intermodal Surface Transportation Efficiency Act (ISTEA) temporarily exempted transit buses (but not interstate motor coaches and other types of non-transit bustes) from the 20,000 pounds single axle weight limit, preventing states from enforcing anything below 24,000 pounds per axle. Every federal transportation act since ISTEA extended this exemption until 2012, when the Moving Ahead for Progress in the 21st Century Act (MAP-21) permanently adopted the 24,000 lbs exemption for transit buses. Washington law does not specifically exempt transit buses from the axle weights listed above, effectively making the federal standard the default in this state for buses until/unless Congress repeals the exemption. (For the most recent comprehensive overview of axle weight limits at the federal and state level and background on transit exemptions, see "An Analysis of Transit Bus Axle Weight Issues Prepared for the American Public Transportation Association,"by MORR Transportation Consulting Ltd (November 2014.)

1) Types of overweight vehicles operating in Seattle and SDOT assets impacted

Permitted overweight commercial vehicles

Vehicles and loads that exceed the maximum legal height, weight, width, and/or length limits specified by state and City law must obtain a permit to operate within the City of Seattle. Vehicle operators can purchase one-time permits for a base cost ranging between $24 to $42 and annual permits for $290, not including tonnage fees (SMC 11.60). Tonnage fees are added to these base permit costs, ranging from $360 for below 12,000 lbs, up to $720 up to 80,000 lbs for any vehicles weighing more than the licensed permitted axle weight. An overweight permit is conditioned on the permit holder indemnifying the City against any damages due to the holders acts or omissions and according to terms and conditions imposed by SDOT, which may include using prescribed routes based on load size and weight and, in some cases, may also require the permittee to pay the cost for a City of Seattle Commercial Vehicle Enforcement Officer (CVEO) escort.

Heavy-Haul Permits

At the urging of the Port of Seattle and other maritime interests, the City Council passed a Heavy Haul Network permit program (SMC 11.61) in 2015 that takes advantage of state authority designed to foster movement of heavier shipping containers between port terminals and intermodal transfer yards. The Seattle ordinance allows for a $200 annual permit for drayage vehicles carrying "a sealed ocean-going container on a container chassis in route between the trans load facility and a designated marine terminal." Permit holders are only allowed to carry overweight loads (up to 43,000 lbs per tandem axle, 96,000 lbs gvw) on a designated Heavy Haul route (see map).

Transit buses

Most buses operated by King County Metro in Seattle are 2-axle 40-ft models with a maximum capacity ranging from roughly 60 to 90 passengers with a range of fully-loaded weights between about 30,000 and 44,000 pounds. However, Metro and Sound Transit operate many 60-ft articulated buses that run on 3 axles, carrying up to about 120 passengers with a fully-loaded weight range from about 56,000 to

65,000 pounds (MORR). All coaches used by Metro and other public transit agencies operating in Seattle have two tires on either middle and rear axle end but none of these vehicles use tandem axles, as utilized by most private coaches.

The rationale for exempting transit buses from the 20,000 lbs commercial vehicle axle weight limit is because of federal environmental and accessibility regulations enacted previous to ISTEA that require additional equipment, such as lower polluting fuel systems and wheelchair lifts, along with the federal mandate for minimum 12-year service life that effectively requires heavier weight components to withstand more wear and tear compared with similarly scaled commercial vehicles (MORR). Nearly all buses now purchased by Metro and other Puget Sound transit agencies include air conditioning units and Metro trolleybuses now all include batteries for temporary off-line operations, features which add additional axle weight. Metro has committed to replacing all diesel and diesel-hybrid buses with a zero emissions fleet by 2035. Metro has long operated trolley buses on the busiest former Seattle Transit routes equipped with overhead catenary wires and is now beginning to replace its diesel-electric hybrid coaches with battery-electric vehicles. King County Metro's 2023-24 budget and accompanying CIP marks a shift towards a higher proportion of 40' vehicles that will reduce the overall proportion of 60' articulated buses in its fleet through this transition as its seeks to provide more frequent all-day service in lieu of the more am/pm peak commuter service that it emphasized for much of its history (See, *King County Metro Transit Zero Emission Bus Fleet Transition Plan*, May 2022).

Garbage trucks

Although fully loaded garbage trucks can, along with articulated buses, be among the heaviest of vehicles by axle weight traveling on Seattle streets, there is no federal exemption for garbage trucks. However, according to Washington law, "…emergency vehicles, buses, trucks transporting perishable commodities, commodities necessary to the health and welfare of city residents, trucks providing services necessary to the health and welfare of city residents, and local deliveries are permitted to exceed the load restriction; provided, that the gross weight of said vehicle does not exceed the vehicle's legal weight rate designation as defined in RCW 46.16.111. Published specifications for trucks operated by the two companies with City franchises, Waste Management and Recology, are between 52,500 lbs gross full weight/37,500 lbs over the tandem drive axle for the trucks that provide most residential service and up to 62,000 lbs gross full weight/34,000 drive axle weight for trucks with dumpster lifts (extended axle spacing allows slightly heavier than the minimum state/federal axle weight limits). Therefore, a fully loaded garbage truck may be carrying significantly higher weights over the drive axle weight than on an articulated transit bus (see below). Like buses, garbage trucks are most often operating within federal and state weight limits and are not technically overweight. However, like buses, garbage truck operating movement (eg, frequent starting and stopping) can exacerbate wear and tear. While use of tandem drive axles on most garbage trucks operating in Seattle mitigates impacts, garbage trucks are more likely to run on non-arterial streets and alleys most likely to have insufficient pavement width to carry the heavy axle loads and cannot withstand the same wear and tear as most arterial streets made of concrete on which transit buses most frequently operate.

Other heavy vehicles

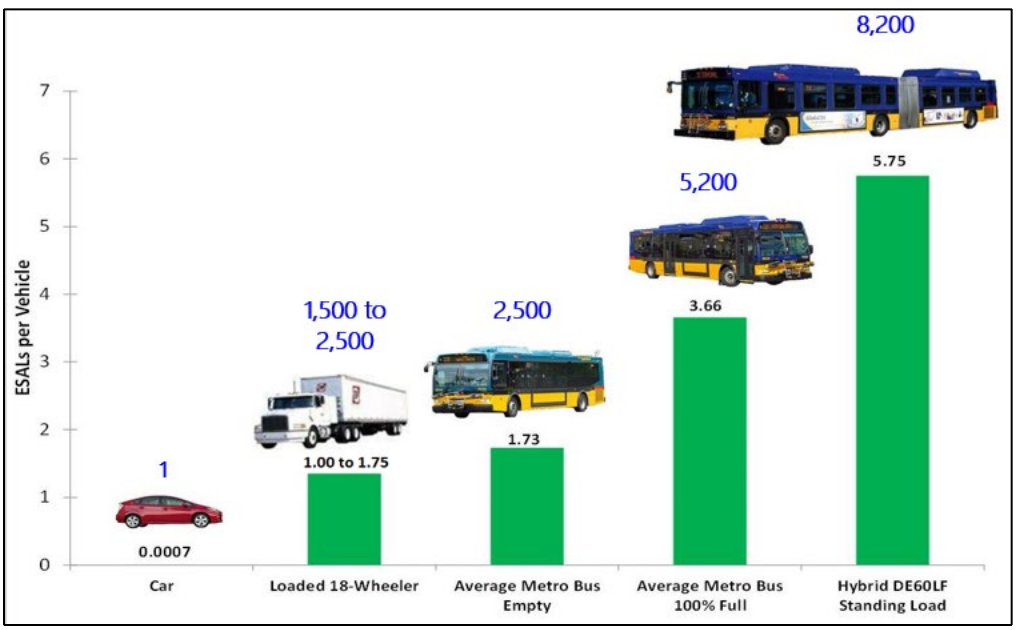
Other heavy vehicles operating on Seattle City streets include Vactor (drain and sewer cleaning) trucks owned or contracted by Seattle Public Utilities, fire trucks and private mobile cranes, all of which may be allowed to meet higher limits by provisions in state law (RCW 46.16.111 and RCW 46.44. RCW 46.44.190 for fire trucks). However, all the heaviest makes of these vehicle classes also utilize tandem axles to spread weight distribution and mitigate impacts on pavement and bridges.

2) Impacts and cost to repair

Pavement

The federal and state exemptions cited above, combined with a growing adoption of passenger comfort features like air conditioning, and environmental features, especially batteries for auxiliary and primary power, have resulted in increasingly heavier axle loads for transit buses, as well as sanitation and emergency vehicles. The relationship between the traffic loads imparted on the pavement and resulting structural damage is exponential, with increases in a vehicle's axle weight leading to much greater pavement damage. We also know that pavement deteriorates structurally through the mechanism of fatigue, damage caused by repetitive loading. So as bus volumes and axle weights have steadily increased, we have seen an increase in pavement deterioration across the city, straining our abilities to sustainably fund capital improvements and maintenance activities.

Buses and street infrastructure must function together as a system to maintain a high level of transit service. As, over the last 50 years, the City has moved toward a transportation system which emphasizes transit, our arterial streets are carrying loads well beyond what their original designs anticipated. These trends, along with our inability to allocate adequate resources to support maintaining a transportation system largely built out by private developers but with diminishing gas tax revenues to maintain it, and voter-approved levy funding only first approved in 2006, the City now has a backlog of over $1.4 billion in deferred arterial pavement investments, approximately $1.1 billion (as of 2018) of which consists of streets in very poor to failed condition in need of reconstruction to support current traffic volumes and loads. SDOT is in the process of updating and quantifying critical asset needs for pavement in the upcoming Transportation Asset Management Plan. This plan will be used to inform the development processes associated with the Future Transportation Funding Package.



Heavier vehicles have accelerated anticipated pavement deterioration on Seattle's streets because most of our streets were designed before the ISTEA exemption, for vehicles that met the 20,000 lb per axle restriction. An equivalent single axle load, or ESAL, is based on a reference axle load of 18,000-lb. for a single axle with dual tires, and conceptually describes the load equivalency and damage factors associated with different types of vehicles. The table above shows the different number of ESALs that different vehicles impart on our pavements and the ratio (in blue), or damage factor, of those vehicle types as compared to a single occupancy vehicle. Heavy vehicles dictate the structural design of roadway pavements because they cause the most damage. Simply put cars, light trucks, motorcycles, and bicycles do not cause significant pavement damage compared with these larger vehicles. As shown in the bar graph, the typical 18-wheel truck operating on a Washington state highway has a total ESAL factor in the range of 1.00 to 1.75, while the heaviest vehicle in Metro's current inventory, the relatively new 60' version of the New Flyer Battery Electric Bus, weighs in at 67,690lbs at 130%.capacity, which translates to a damage factor above 5.75.

To summarize, with new equipment like hybrid and battery electric driven-powertrains, buses have grown heavier over the last two decades, yet the number of axles remains at three, in large part because a single rear axle allows for a low-floor design that improves accessibility of buses. The result is that the average empty bus is more damaging than the typical truck on a state highway (see "Equivalent Single Axle Load," Dr Steve Muench, University of Washington School of Civil and Environmental Engineering, PavementInteractive.org).

Future considerations of impacts of buses and other heavy vehicles on SDOT assets

The 40' New Flyer electric bus that Metro is also considering is extraordinarily heavy with a rear axle at almost 29,000 lbs. If this 40' bus should be added to the fleet, it would be more damaging than its current fleet of 60' articulated hybrids. Compared with the Diesel-Hybrid 40' buses that now make up the majority of Metro's fleet, these new battery-electric vehicles could potentially be 60-90% more damaging per trip than the older buses – which translates to a corresponding (60-90%) decrease in remaining structural pavement life.

While SDOT Arterial Asphalt and Concrete (AAC) and Transit Plus Multimodal Corridor projects are factoring the realities of heavier and more frequent use of heavy transit vehicles, existing funding streams can only improve a few street segments each year. Our current investment levels in pavement reconstruction are insufficient to support a sustainable transportation system long term, resulting in declining pavement conditions across the network. Ideally, transit agencies and the bus manufacturing industry would take greater heed of the pavement issues that all cities with large bus systems are facing toward greater adoption of composites and other strategies to both improve efficiency and reduce pavement damage. However, the 12-year useful life threshold required for federally subsidized bus purchases along with the current cost of composites do not favor lighter bus fleets near term, especially given the imperative to electrify bus fleets. Additional axles to mitigate the per axle weight is another strategy for reducing pavement damage but such requirements do interfere with low-floor designs that maximize both passenger capacity and accessibility and have become popular with riders.

Bridges and other roadway structures

Most bridges within the City of Seattle that serve transit routes are designed to withstand the axle weights of buses and other heavier vehicles, including trucks. However, heavier vehicles certainly put more wear and tear on our bridges and can add to our overall maintenance costs, especially for bridges nearing or beyond their useful life where annual maintenance costs are rapidly accelerating. However, it is difficult to quantify the wear and tear specific to buses or heavier vehicles generally. Metro operates buses on one bridge, the Cowen Park bridge, which is currently under a weight restriction. While the Cowen Park Bridge recently saw a seismic upgrade, it is possible that further weight restrictions could be imposed that would prohibit Metro from operating any buses on this crossing.

3) Identify best practices and recommendations for reducing damage or minimizing Seattle's costs to repair assets

It is important to note that although transit buses are the one vehicle class that enjoys such a broad exemption from state and federal axle weight limits, and at crush occupancy, the actual axle weight load on a rear axle can be significantly higher than tested curb weight, a robust, high frequency public transit system is essential to the City of Seattle's economic and environmental growth and sustainability, as well as ensuring equitable access to opportunities and meeting a quality of life standard expected by residents, visitors and workers in any modern city. While buses running at high passenger occupancy are creating real damage to our streets, particularly older pavement that's already damaged or was not built to current standards for serving high frequency transit routes, buses are a critical component, maybe the most critical mode of travel, in our transportation system. Metro buses carry, as of mid-2022, 210,000 riders per average weekday countywide, the majority of which are traveling on City of Seattle streets (countywide average weekday ridership was 400,000 pre-pandemic; ridership continues to recover but with less concentration at peak hours than pre-pandemic). Even as new regional light rail lines enter service, buses continue to provide the connective tissue to the bones of the rail network, and sole source of coverage to the many Seattle neighborhoods without rail access. We have seen that continued operation of bus network through the Covid pandemic has been a critical lifeline for essential workers, the disabled and people without other mobility options. As a mature city without any space for new roadway capacity, robust transit service has been essential to accommodating the incredible economic, job and population growth Seattle has enjoyed over the past decade.

Transit service is critical to the city and region's strategy for reducing greenhouse gas emissions from the transportation sector, source for 55% of the City's emissions profile. According to Office of Sustainability & Environment's 2020 Greenhouse Gas Emissions Inventory, while Seattle's population from 2008-2018 grew by over 25% from the 594,000 in 2008 to around 745,000 in 2018, overall GHG emissions remained flat and per capita emissions declined by 21%. Total passenger Vehicle Miles Traveled (VMT) grew by about 11% but per capita VMT declined 11% over the same period. Keeping emissions relatively flat while substantially reducing roadway emissions and per capita VMT over a period of substantial population and job growth in Seattle would not have been possible without growing transit capacity and even higher growth in ridership. Transit also supports the denser residential and employment development over this same period that made possible the reductions in residential and building emissions reflected in the GHG inventory report.

The following table is derived from "An Analysis of Transit Bus Axle Weight Issues Prepared for the American Public Transportation Association," by MORR Transportation Consulting Ltd, November 2014. The report authors developed a comprehensive list of 23 options to address transit bus axle weight issues based on a literature review, survey, and interview findings, summarized across five categories, along with key outcomes and tradeoffs associated with each option:

1. Transit bus weight data
2. Transit bus design
3. Transit bus operations
4. Pavement design and engineering
5. Regulations and enforcement

The options were developed with the goal of achieving at least one of two main outcomes. First, there are opportunities to mitigate pavement deterioration caused by transit buses if axle weights can be lowered through bus design or operational changes, or pavements that can be designed to better withstand transit bus axle loads. These outcomes can occur without changing regulatory limits. Second, there are opportunities to revise weight regulations (e.g., by increasing limits or introducing exemptions) and the enforcement of these regulations to reduce the likelihood that transit bus axles will violate state standards.

Options by Category	Key outcomes and Tradeoffs
Category 1: Options Related to Transit Bus Weight	
1. Install weigh-in-motion devices at selected locations	• Does not directly mitigate pavement impacts • Does not address regulatory issues • Additional operational costs • Requires appropriate analysis capability
2. Combine transit schedules, bus inventory, ridership, and GPS data	• Does not directly mitigate pavement impacts • Does not address regulatory issues • Additional operational costs • Requires appropriate analysis capability • On-board equipment adds weight
3. Install on-board weight sensors	• Does not directly mitigate pavement impacts • Does not address regulatory issues • Additional operational costs • Requires appropriate analysis capability • On-board equipment adds weight
Category 2: Options Related to Transit Bus Design	
1. Increase steer axle weight capacity	• Mitigates pavement deterioration • Addresses regulatory issues • May increase curb weight • Increases manufacturing and procurement costs • Worsens vehicle handling
2. Provide tandem steer axles	• Mitigates pavement deterioration • Addresses regulatory issues • Increases curb weight • Increases manufacturing and procurement costs • Increases maintenance costs • Decreases fuel efficiency • Reduces passenger capacity • May diminish bus maneuverability
3. Provide tandem drive axles	• Mitigates pavement deterioration • Addresses regulatory issues • Increases curb weight • Increases manufacturing and procurement costs • Increases maintenance costs • Decreases fuel efficiency • Reduces passenger capacity • May diminish bus maneuverability

4. Use wide-base single tires	• Mitigation of pavement deterioration uncertain • May address regulatory issues • Decreases curb weight • Increases fuel efficiency
5. Manufacture transit buses with alternative materials	• Mitigates pavement deterioration • Addresses regulatory issues • Decreases curb weight • Increases manufacturing and procurement costs • Increases maintenance costs
6. Apply additive manufacturing methods	• Mitigates pavement deterioration • Addresses regulatory issues • Decreases curb weight • Increases manufacturing and procurement costs
7. Provide lower performance transit bus components	• Mitigates pavement deterioration • Addresses regulatory issues • Decreases curb weight • Imposes logistical challenges • Increases manufacturing and procurement costs
8. Reduce auxiliary features on transit buses	• Mitigates pavement deterioration • Addresses regulatory issues • Decreases operating weight • Degrades service provision
Category 3: Options related to transit bus operations	
1. Operate more low capacity buses	• Mitigation of pavement deterioration uncertain • May address regulatory issues • May necessitate more buses and drivers to meet demand • May degrade service provision • Increases transit bus emissions • Increases transit agency costs • Increases transit bus pavement impact per passenger
2. Restrict the number of passengers on existing transit buses	• Mitigation of pavement deterioration uncertain • May address regulatory issues • May necessitate more buses and drivers to meet demand • May degrade service provision • Increases transit agency costs • Increases transit bus pavement impact per passenger

3. Increase bus frequency during peak periods	• Mitigation of pavement deterioration uncertain • May address regulatory issues • May necessitate more buses and drivers to meet demand • May degrade service provision • Increases transit agency costs • Increases transit bus pavement impact per passenger
4. Restrict transit buses from certain routes	• Mitigates pavement deterioration on certain routes • May address regulatory issues • May degrade service provision
5. Match transit bus models to passenger demand	• Mitigates pavement deterioration • May addresses regulatory issues • Introduces logistical and management challenges • Increases transit agency costs
Category 4: Options related to pavement design and engineering	
1. Design and implement pavements to better withstand transit bus axle loads	• Mitigates pavement deterioration • Does not address regulatory issues • Requires revisions to design and construction specifications • Requires development of programs to monitor and manage pavement assets • Increases pavement construction and maintenance costs
2. Adjust pavement design loads to more accurately reflect transit bus axle weights	• Mitigates pavement deterioration • Does not address regulatory issues • Requires appropriate data collection and analysis capability
Category 5: Options related to transit bus weight regulations and enforcement	
1. Maintain current regulatory environment (status quo)	• Does not mitigate pavement impacts • Perpetuates current regulatory environment • No incremental costs
2. Decrease axle weight limits to match limits for other CMVs	• Mitigates pavement deterioration • Does not address regulatory issues • Increases operating costs • Decreases compliance without rigorous enforcement
3. Increase or eliminate axle weight	• Does not mitigate pavement deterioration • Addresses regulatory issues

	• Reduces incentives to pursue manufacturing alternatives that decrease curb weight • Raises concerns about special allowances for transit industry
4. Require annual permits	• Does not mitigate pavement deterioration • Addresses regulatory issues • Reduces incentives to pursue manufacturing alternatives that decrease curb weight • Raises concerns about special allowances for transit industry
5. Improve enforcement practices	• Mitigates pavement deterioration • Does not address underlying cause of regulatory issues • May increase operational delays and costs • Additional equipment operational costs

4) City's enforcement capacity

The City of Seattle's Commercial Vehicle Enforcement Officers (CVEO) efforts related to heavy vehicles are focused on enforcing the weight limits imposed by state law, which meet the federal standard and are echoed in the Seattle Municipal Code. The City's four Commercial Vehicle Enforcement Officers, which operate under SDOT's Transportation Operations Division, enforce a variety of commercial vehicle issues ranging from overweight loads and unmaintained vehicle safety systems to illegal semi-trailer parking, unpermitted haul routes or hauling oversized loads without a permit. The CVEOs are also responsible for escorting permitted oversize loads on designated routes, typically during overnight hours to minimize interaction with general purpose traffic and for inspecting commercial vehicles associated with collisions within the city.

There are three primary challenges associated with the City's enforcement of illegal over-weight loads:

1. Fines associated with citations for overweight loads are levied against the individual truck driver as the person ultimately responsible for their vehicle. This is particularly an issue for drayage drivers moving containers between Port terminals and intermodal yards. These drayage drivers transport pre-loaded trailers and a refusal to accept a load can have significant financial impacts for them as individuals. A significant change in City code would be required to make the party loading the trailer share legal/financial responsibility for these overweight loads.
2. With four CVEOs spread across the city and sharing time between enforcement and escorting permitted loads, weight enforcement activity is necessarily an infrequent activity rather than an every-day occurrence.
3. Costs for escorted loads often exceed the cost of a citation for an unpermitted oversized load, potentially resulting in an increase in unpermitted loads.

5) Recommended state or federal legislative changes

The City may be able to utilize its lobbying power in Olympia and, potentially more importantly its public utility franchise powers, to push for stronger weight limits on garbage trucks and some other classes of heavy vehicles that operate on City streets and are less likely to implicate Commerce Code or other federal prohibitions. The City may be able to leverage its own purchasing power, more so in concert with other local and state governments in Washington, Oregon and California, to improve the market for more climate-friendly and lower weight equipment purchased or leaseed by the City, such as vactor trucks and fire trucks. However, the City has little power on its own to limit the weight of transit vehicles on city streets. Transit buses traveling on Seattle streets are purchased by Metro, Sound Transit and Community Transit. Even if there was no federal weight exemption for transit vehicles, bus manufacturing is a limited market with normal market forces further distorted by increasingly robust Buy America requirements, leaving a limited marketplace for transit agencies that might desire to purchase lighter vehicles. Furthermore, City elected officials and most Seattle transit riders, overwhelmingly support the federal accessibility and environmental requirements, along with rider comfort features like air conditioning, that are responsible for many of the weight gains on buses over the past few decades. But these weighty features cumulatively still have less to do with bus axle weights than the 12-year durability requirement for the federal funding involved in most transit bus purchases. Electrification of buses, a critical component of state and regional greenhouse gas strategies, which also eliminate localized air quality impacts and the noise that can sometimes provoke opposition to siting bus stops and layover zones is another disincentive to reducing bus axle weights. In other words, it may not be feasible, politically or in terms of vehicle engineering, to repeal the now permanent weight limit exemption for transit buses in federal law for the foreseeable future, especially with the coming transition to all-electric fleets.

A more feasible approach to reducing bus weights may require the federal government to impose a combination of financial incentives and regulations that move the industry toward utilizing carbon fiber and lighter alloys into durable vehicle frames, bodies and components, along with manufacturing techniques that reduce structural weights as well as lighter batteries. Composites, like carbon fiber, can be every bit as durable as steel at a much lower weight ratio, but they're still considerably more expensive than steel and most transit agency maintenance facilities are not well equipped for composite repair. However, the federal government could subsidize development lighter weight bus frames and drive trains, subsidize agency purchases of lighter weight buses just as the Obama administration helped incentivize the development of Battery Electric bus (BEV) purchases by, first, mid-sized transit agencies, leading to broader availability and adoption of BEV buses by transit agencies large and small across the US. Such incentives and demonstration could ultimately allow a reduction of the 24,000 lb axle weight limit down to 22,000 or even the 20,000 standard that applies to trucks that can also be met with rear and center dual axles.

Another approach is the one taken by California, essentially requiring the state's transit agencies to help encourage manufacturers into providing lower axle weight buses over time. In the mid-2010s, the California Legislature passed a series of bills that effectively prohibit, as of 2022, transit agencies in that state from procuring articulated or zero-emission buses with a *curb weight* on any one axle exceeding 22,000 pounds unless that axle is supported by 4 tires (ie., two wheels on either end of the axle) (See, 2015's AB 1250) . "Curb weight" is defined as the total weight of the vehicle including all equipment and fuel but not including a driver or passengers. Most buses do include four tires on the axles supporting the most weight. So this standard is met by virtually all buses on the US market. Basing axle weight restrictions on curb weight rather than passenger weights and allowing agencies to ignore the axle weight limit by only requiring four wheels instead of more effectively requiring dual axles are loopholes that essentially acknowledge even a large state like California's limited power to overcome the federal axle weight exemption. At the same time, AB 1250 is encouraging California's many transit agencies to make axle weight a more central element in their procurement standards, thereby incentivizing the manufacture of the heaviest new buses, New Flyer, to find some weight-saving strategies to better compete with California-based Gillig and Proterra. Proterra, which only manufactures BEVs produces the vehicles with, by far, the lowest rear axle weight, however neither Proterra nor Gillig make 60' articulated buses, leaving that market entirely to New Flyer for the time being. Yet, even New Flyer, the primary manufacturer of buses purchased by King County Metro and Sound Transit, announces in the marketing materials for the newest version of its popular Hybrid-Electric models: "Weighs 8% less than previous models achieved through structure optimization and lighter weight supplier components, leading to improved efficiency and lower operating costs."

In spite of the California law, many of the techniques available to the consumer auto industry, such as making drivetrains and bodies from composites or lighter alloys and plastics designed to absorb shock by crumpling are in direct opposition to the federal 12-year minimum durability requirements on which the federal grants that cover a large share of vehicle purchases among agencies in the US. While the Washington legislature could join California in trying to lower bus weights through procurement standards and the City of Seattle can certainly work through organizations like National League of Cities and NACTO, and with the American Public Transportation Association, partner transit agencies, state DOTs and Transportation Research Board, to encourage Congress and manufacturers to reduce allowable axle weights, such efforts pale in comparison with the fiscal incentives and federal requirements to maximize vehicle service life. Nearer term it may be more feasible for the City and other local governments to seek added federal funding to accelerate reconstruction of pavement on high frequency transit routes to meet the reality of heavier buses that have dominated the US market since at least the 1980s and which seem destined to continue to dominate the market through the transition to fully electrified vehicle fleets.

King County Metro leadership is very much aware of these issues and shares the City's concerns, evidenced by the fact that King County, through its Road Services Division, which until recently was combined with Metro in the King County Department of Transportation, is itself responsible for 1500 miles of roads and 185 bridges with proportionally fewer resources for maintaining this infrastructure than the City of Seattle. Given the County and City's shared interests in maintaining and restoring pavement sufficient to carry buses and other heavy vehicles, Metro leadership has expressed a strong interest in partnering with Seattle and other King County cities to develop strategies to address these issues through finding new opportunities to seek joint funding for pavement reconstruction projects; encouraging more research and policy development through NACTO, APTA and other industry organizations, and by jointly pursuing efforts with manufacturers that could reverse the trend over the last few decades toward heavier and heavier transit coaches.

KC Metro Transit Seattle Fleet Capacity and Weight Characteristics			
	Capacity (seated/total)	**Curb weight, empty with no passengers (lbs)**	**Gross Vehicle Weight at full declared capacity (lbs)**
New Flyer Excelsior XDE40 HEV	42/83	28,580 (est rear axle weight = 19,720)	40,720
New Flyer Excelsior XDE60 HEV	47/128	42,790 (est rear axle weight = 20,750)	61,750
New Flyer Excelsior XT40 Trolley	36/72	32,878 (est rear axle weight = 21,371)	33,968
New Flyer Excelsior XT60 Trolley	48/128	46,932 (est rear axle weight = 22,759)	57,720
Gillig Low Floor 40 HEV	32/73	31,390 (est rear axle weight = 20,170)	42,380
Proterra Catalyst 40	31/78	34,760 (est rear axle weight = 20,800)	43,640
New Flyer Excelsior XE40 Charge - BEV	41/82	34,040 (est rear axle weight = 22,320)	44,400

New Flyer Excelsior XE60 Charge - BEV	53/124	51,100 (est rear axle weight = 22,710)	69,800

Source: Penn State Pennsylvania Transportation Institute (Altoona) Bus Testing Center https://www.altoonabustest.psu.edu/bus-list.aspx. Please note that stated weights are based on representative vehicles submitted for testing by manufacturer. Specifications, including seating layouts, interior trim, air conditioning and other rider features, even drivetrain equipment vary with every procurement. Coaches listed above are most recent examples of models tested. Trolleybuses are not tested at Altoona; stated weights for the New Flyer XT models are based on procurement documents and estimates derived from those documents.