

A photograph of a busy city street in Philadelphia, likely Center City. The street is filled with cars and a SEPTA bus. Buildings line the street, including one with a 'WELLS FARGO' sign and another with a 'Citizens Bank' sign. American flags are hanging from a building. The scene is captured during the day, with some buildings reflecting the sun. A green semi-transparent banner is overlaid on the top half of the image, containing the title and subtitle. A dark blue banner is at the bottom of the image.

# 2019 MASITE Annual Conference

Limiting our Potential:  
How Center City Congestion Impacts all Philadelphians

**ESI** ECONSULT  
SOLUTIONS INC.

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# Introduction and Overview

## Introduction

In recent years, Center City Philadelphia has grown in its attractiveness and activity, and with it has seen an increase in the number of pedestrians, transit riders, bikers, and drivers of all types that share its narrow street grid. At the same time, the emergence of ride sharing and online shopping has put new kinds of demands on the grid. The resulting traffic congestion impacts the lives of residents throughout the city, costing them valuable time and limiting their ability to reliably access employment opportunities and amenities.

While congestion is in part a signal of success, if not managed properly it reduces the attractiveness of downtown Philadelphia as a business location, limiting job growth and opportunities for Philadelphia neighborhood residents and undermining a key competitive advantage of the city. Further, delays impact buses to a greater extent than cars, deepening existing equity challenges and setting into motion a vicious cycle by incentivizing riders with sufficient means to find alternatives, compromising the future competitiveness of the bus system while adding even more traffic to the roads.

## Scope of Report

This report does not evaluate potential causes or offer tactical recommendations for mitigating congestion, or address issues related to speed and safety, but rather seeks to quantify the economic and social losses that congestion engenders. The scale and scope of these impacts demonstrate that there is much to gain from addressing this issue.

## Direct and Downstream Impacts

Economic losses quantified in this report are incident on a range of groups, ultimately impacting all Philadelphians:

- *Direct Impacts* describe time value and transportation cost losses to drivers, to bus riders, and to SEPTA
- *Downstream Impacts* describe losses to the city's economy, its tax base, and its transportation network

# Key Findings: Impacts on all Philadelphians

## Direct Impacts



**9.7 million**  
annual hours of time delay  
for bus and car passengers



**\$152 million**  
annual time value and transportation costs  
to bus and car passengers



**\$21 million**  
additional SEPTA bus operating costs and  
downstream revenue losses annually

## Downstream Impacts



**15,700**  
potential jobs forgone  
**\$1.08 billion**  
potential earnings foregone



**\$58 million**  
foregone City and School District tax revenue



**Negative Feedback Loop**  
Congestion → Declining bus service quality  
→ Bus ridership loss → More cars on roads  
→ Further congestion → ...



# Time Delays from Congestion

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# Measuring Congestion Delays: Approach

## Study Area

This analysis uses a narrow definition of the downtown area spanning Vine Street to South Street, Delaware River to Schuylkill River, covering 2.3 square miles. Highways within this area are excluded from the analysis.

## Defining Congestion

Congestion delays for both cars and buses are measured relative to “free flow” travel time. Free flow times are pegged to the fastest observed hour of the day, and smoothed across road segments based on the full dataset. Congestion delays for each road segment are calculated as:

[Observed Time] – [Free Flow Time]

## Who is Impacted?

While Center City represents the measurement area for travel delays, congestion losses fall on residents from all corners of Philadelphia as they access the employment opportunities and amenities located downtown.

Quantifiable economic costs from congestion delays are borne by a variety of actors, including drivers, bus riders and employers. They also impact the financial profile of SEPTA and the tax base of the City, impacting all Philadelphians.

These losses ultimately diminish the welfare and economic strength of Philadelphia and its residents.

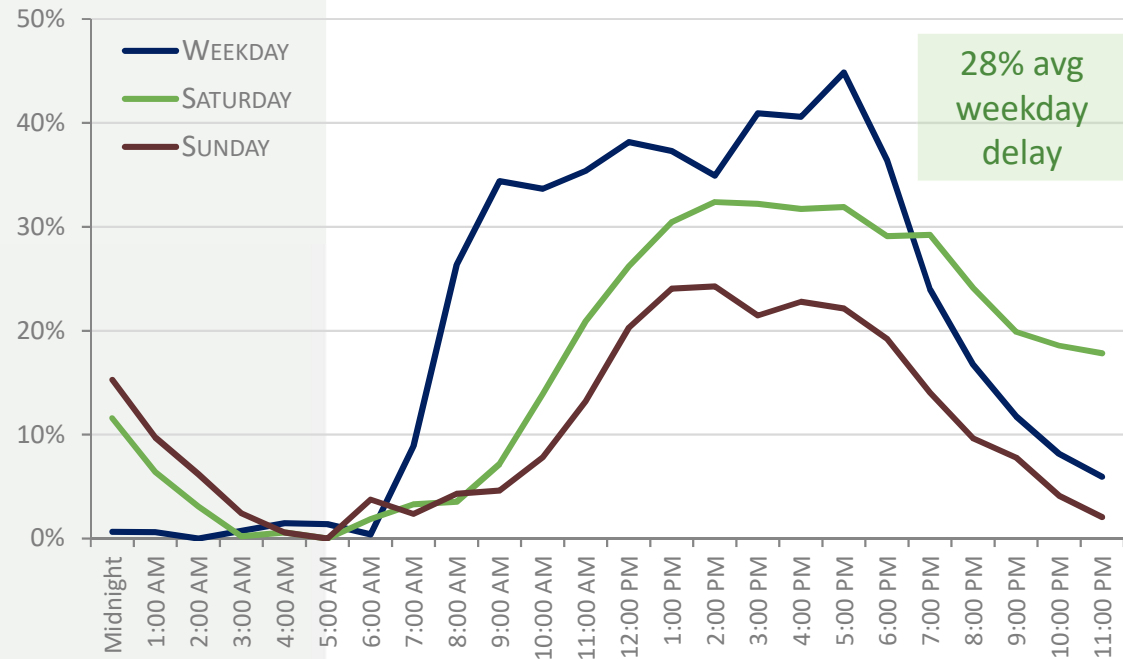
# Car Congestion Delays by Hour

Increases in car travel times relative to free flow are calculated using PennDOT and DVRPC data on traffic volumes and INRIX data on travel times by time of day.

Significant delays are evident on weekdays (shown at right in blue) from 8 AM to 7 PM. Notably, while congestion delays peak during the PM rush hour, travel time increases at mid-day are equal to those during the AM rush hour. Weekday travel time increases average 28% over the course of the day.

Weekend delays are less severe than weekdays and occur later in the day, including on Saturday nights (shown at right in green).

AVERAGE CAR TRAVEL TIME INCREASE FROM DOWNTOWN CONGESTION (%)



# Weekday Car Congestion Delays by Location

The most severe travel time delays relative to free flow (shown in red at right) cluster around City Hall, Rittenhouse Square and on bridges connecting University City to Center City.

The time and spatial distribution of time losses highlights the breadth of their impact. Delays are experienced by commuters but also potential customers of Center City businesses, by residents of neighborhoods throughout the city as well as visitors. Travel delays discourage activity from all of these impacted groups.

AVERAGE CAR TRAVEL TIME INCREASE BY ROAD SEGMENT (%)



## Aggregate Car Congestion Delays

The 440,000 daily vehicles on Center City streets experience average delays of 28% on weekdays, and somewhat less on weekends, relative to free flow.

Aggregated across all road segments and times of day, this results in 5.8 million hours of vehicle delay per year. Using an average of 1.4 passengers per vehicle (the figure used by the federal Department of Transportation in evaluating transportation impacts), these delays result in 8.0 million hours of lost passenger time per year. This equates to 11 hours of annual delay per weekday passenger.



**440,000**  
daily vehicles on  
Center City surface roads



**28%**  
increase in weekday travel time  
in Center City vs. free flow  
**21% Sat increase 14% Sun increase**



**5.8 million**  
annual hours of car delay  
**8.0 million**  
annual hours of lost passenger time

**11 hours of annual weekday delay  
per car passenger**

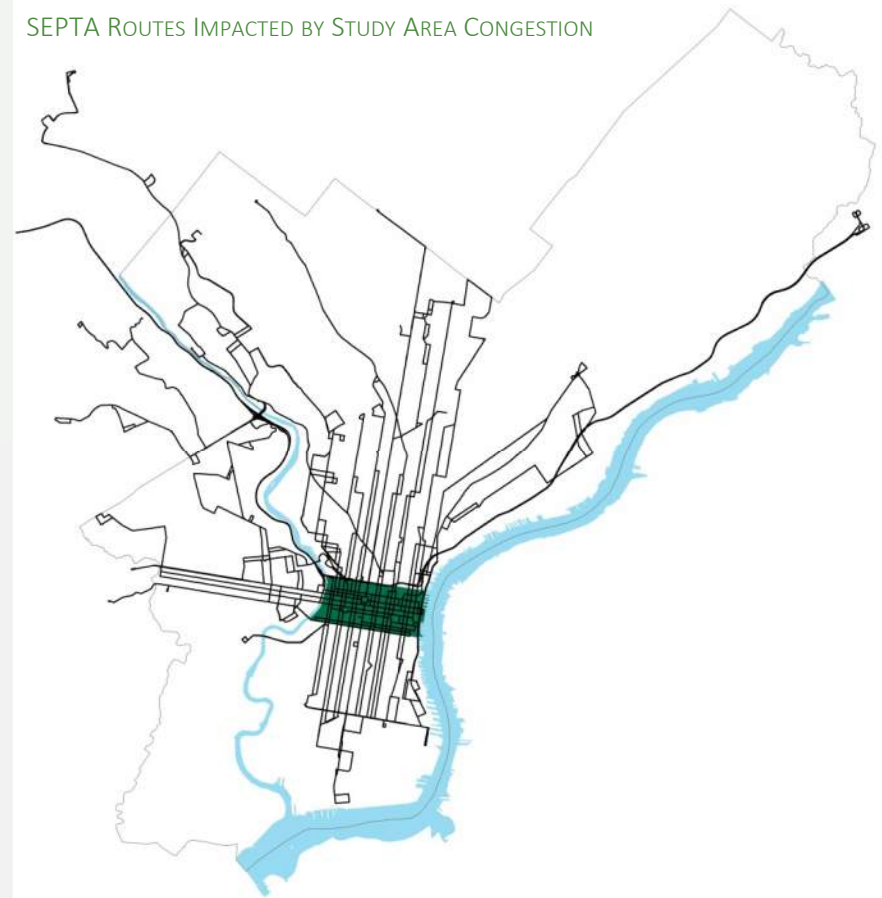
## Bus Congestion Delays

31 different bus routes with more than 4,200 total trips pass through the study area each weekday. These routes (mapped at right) cover all sections of the city, with only a small portion of passengers originating in the downtown area.

Riders from all corners of the city rely on bus service to connect them to employment opportunities, amenities, educational and health services, and other destinations. For many riders, alternative travel modes may be cost prohibitive, particularly for travel to Center City that would require paying to park a private vehicle.

Bus delays in Center City therefore impact the quality of life for residents across Philadelphia.

SEPTA ROUTES IMPACTED BY STUDY AREA CONGESTION



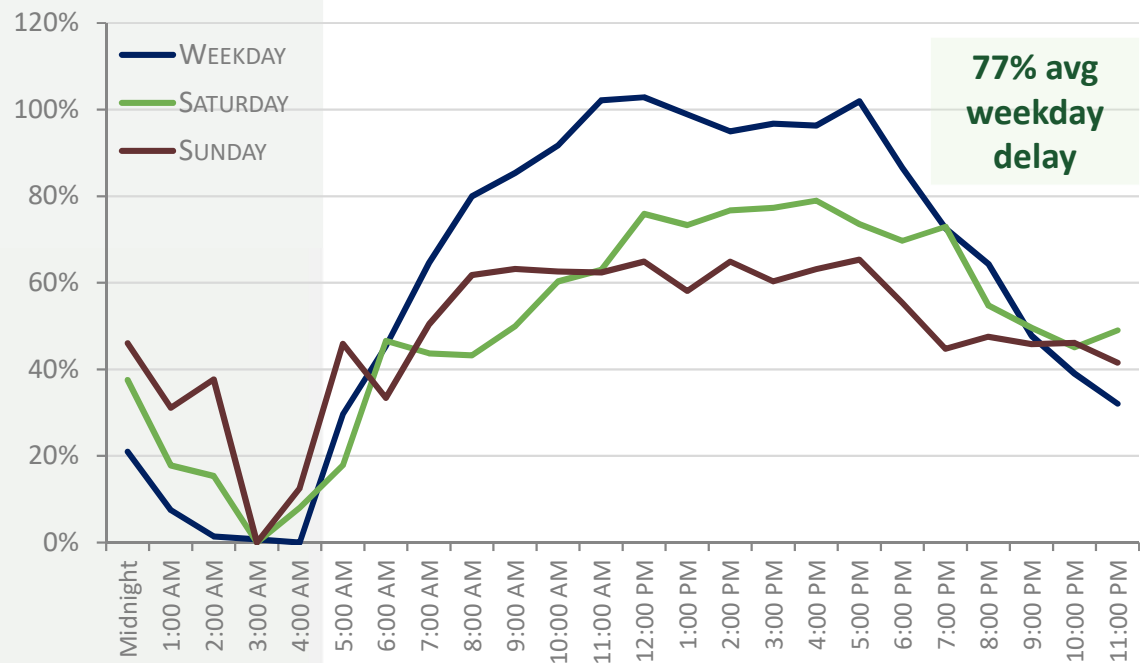
# Bus Congestion Delays by Hour

Increases in bus travel times relative to free flow are calculated using data from SEPTA's Automated Passenger Counters (APC), accounting for time spent at passenger stops.

Weekday delays (shown in blue) are most severe from 9 AM to 5 PM, and like car delays remain elevated through the middle of the day. Percentage delays relative to free flow are much higher for buses than cars, averaging 77% on weekdays, reflecting the greater difficulty for buses navigating through congested conditions.

Weekend delays are less severe than weekdays, though still well above the levels observed for cars.

AVERAGE BUS TRAVEL TIME INCREASE FROM DOWNTOWN CONGESTION (%)



**77% avg  
weekday  
delay**

## Aggregate Bus Congestion Delays

The thousands of daily bus trips through Center City experience average delays of 77% on weekdays, and somewhat less on weekends, relative to free flow. Aggregated across all road segments and times of day, this results in 149,000 hours of vehicle delay per year.

These vehicle delays are magnified by the significant volume of passengers carried on each bus. Accounting for vehicle loads, which typically peak at times of higher congestion, bus riders experience a total of 1.7 million hours of delay per year. This equates to 31 hours of annual delay per weekday passenger.

Importantly, this calculation only includes time losses while passengers are aboard vehicles, and does not account for additional wait time at bus stations due to delays. The variability of congestion delays diminishes the reliability value of service. For example, commuters may need to allow additional time above and beyond even the average delay to ensure they are not late for work on days when delays are more severe. The costs of variability are not included in these figures.



**31**  
bus routes impacted  
**4,200**  
daily bus trips impacted



**77%**  
increase in weekday travel time  
in Center City vs. free flow  
**62%** Sat increase **55%** Sun increase



**149,000**  
annual hours of vehicle delay  
**1.7 million**  
annual hours of lost passenger time

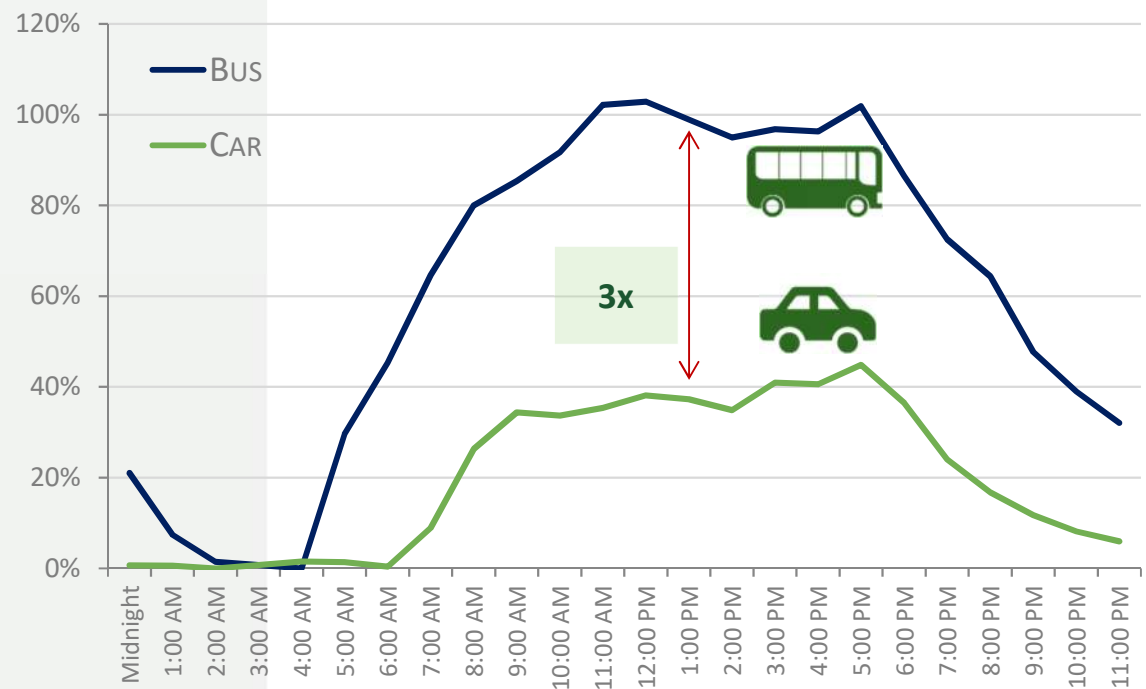
**31 hours of annual weekday delay  
per bus passenger**

## Relative Delays by Mode

Travel time increases for buses are substantially larger than cars across virtually all times of day and days of the week. Average weekday losses are roughly 3x higher for buses (77%) than cars (28%), and this ratio holds relatively consistent through the most traveled parts of the day.

As detailed in the following pages, this differential reduces the utility of public transit relative to private vehicles, which has implications for the modes that travelers choose. Further, it has important equity implications, since residents of greater means are better positioned to switch to more costly travel alternatives like private cars and ridesharing.

AVERAGE WEEKDAY INCREASE IN TRAVEL TIME DUE TO CONGESTION BY HOUR FOR BUSES AND CARS



## Commute Comparison: Tasker & Moyamensing to 17<sup>th</sup> & JFK

The differential in congestion impacts between buses and cars impacts the travel decisions that Philadelphians face each day. At free flow, bus trip times are typically somewhat longer than car times, but many residents are willing to trade a small time loss for the cost savings associated with transit. When buses suffer greater congestion delays than cars, the time differential between modes grows, leaving riders with a choice to suffer greater delays or switch to cars, increasing costs.

For example, the ride from Tasker & Moyamensing Ave in South Philadelphia to 17<sup>th</sup> & JFK Boulevard averages 16 minutes by bus (using Routes 29 and 17) and 14 minutes by car at free flow, a differential of 2 minutes. At AM peak, bus travel time increases to 34 minutes and car travel time to 21 minutes, growing the time differential between modes to 13 minutes.

COMMUTE TIME BY MODE FROM TASKER & MOYAMENSING TO 17<sup>TH</sup> & JFK (IN MINUTES - INCLUDES IN-VEHICLE TIME ONLY)

	Free Flow (3 AM)	Congested (9 AM)	Increase (%)
<b>Car Commute Time</b>	14	21	50%
<b>Bus Commute Time</b>	16	34	113%
<b>Mode Differential</b>	2	13	550%

**11 minute increase in time differential**

## Commute Comparison: 44<sup>th</sup> & Westminster to 15<sup>th</sup> & Walnut

Similarly, the ride from 44<sup>th</sup> & Westminster Ave in Mantua to 15<sup>th</sup> & Walnut averages 18 minutes by bus (using Routes 64 and 21) and 14 minutes by car, a differential of 4 minutes. At AM peak, bus travel time increases to 32 minutes and car travel time to 20 minutes, tripling the time differential between modes to 12 minutes.

Importantly, not only are bus delays longer than car delays as a percentage of travel time, but that percentage is applied to a larger base due to the faster free flow time for cars, leading to an outsized increase in the time differential between modes. In this example, the increase in bus commute time (78%) is roughly double the increase in car commute time (43%) on a percentage basis. However, this increase adds 14 minutes to bus commute time, more than double the 6 minutes added to car commute time. This leads to a 3x increase in the time differential between modes, from 4 minutes at free flow to 12 minutes with congestion.

COMMUTE TIME BY MODE FROM 44<sup>TH</sup> & WESTMINSTER TO 15<sup>TH</sup> & WALNUT (IN MINUTES - INCLUDES IN-VEHICLE TIME ONLY)

	Free Flow (3 AM)	Congested (9 AM)	Increase (%)
<b>Car Commute Time</b>	14	20	43%
<b>Bus Commute Time</b>	18	32	78%
<b>Mode Differential</b>	4	12	200%

**8 minute increase in time differential**

## Commute Comparison: 48<sup>th</sup> & Chestnut to City Hall

Finally, the ride from 48<sup>th</sup> & Chestnut Street in West Philadelphia to City Hall takes 14 minutes by bus (using Route 21) and 12 minutes by car at free flow, a differential of 2 minutes. At AM peak, bus travel time increases to 24 minutes and car travel time to 18 minutes, growing the differential to 6 minutes.

These bus travel time losses for neighborhood residents across the city add up day by day to the 1.7 million hours in congestion time losses for bus passengers. It also makes bus travel less competitive relative to cars and other alternatives, contributing to losses in SEPTA's bus ridership base.

COMMUTE TIME BY MODE FROM 48TH & CHESTNUT TO CITY HALL  
(IN MINUTES - INCLUDES IN-VEHICLE TIME ONLY)

	Free Flow (3 AM)	Congested (9 AM)	Increase (%)
<b>Car Commute Time</b>	12	18	50%
<b>Bus Commute Time</b>	14	24	70%
<b>Mode Differential</b>	2	6	200%

**4 minute increase in time differential**



# Direct Impacts from Congestion

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## Time Value and Transportation Cost to Drivers and Car Passengers

Time losses experienced by car and bus passengers can be translated into monetary terms. Based on a standard time value of \$14.80 per hour (the figure used by the federal Department of Transportation in evaluating transportation impacts), the 8 million person-hours of lost car time results in a time value loss of \$118 million per year. These losses apply not only to drivers but to private car, rideshare and taxi passengers who experience the same delays.

In addition, car time delays result in additional fuel usage emissions due to more stopping and starting and slower speeds over the same distance. Additional fuel costs to drivers are estimated at \$7.7 million per year. This calculation excludes additional related harms such as vehicle wear and tear and environmental costs from greater emissions.

CONGESTION  
IMPACT



UNIT  
COST



ANNUAL  
LOSS

Time Value Loss

**8.0 million**  
hours of lost  
passenger time

**\$14.80**  
time value per hour

**\$118.2 million**  
annual time value loss

Transportation Costs

**2.7 million**  
additional gallons of  
gasoline (0.48 per hour)

**\$2.83**  
fuel cost per gallon

**\$7.7 million**  
annual fuel cost

Combined: \$125.9 million annual cost

## Time Value Cost to Bus Riders

Lost time for bus passengers can be monetized using the time value standards applied to car passenger time. At \$14.80 per hour, the 1.7 million hours of passenger time yield a time value loss of \$26 million per year.

These losses are borne by riders from a variety of neighborhoods throughout the city as they access the downtown area. Importantly, buses do not have the ability to take an alternate route to avoid congested areas, meaning that riders could only avoid these losses by choosing an alternate mode or avoiding the trip.

As noted earlier, this calculation includes time loss aboard vehicles only, and does not include any additional value loss from the diminished reliability of service. While these reliability losses are not calculated, they have a significant impact on the daily experience of riders, and can serve as a deterrent to using public transit.

CONGESTION  
IMPACT



UNIT  
COST



ANNUAL  
LOSS

Time Value Loss

**1.7 million**  
hours of lost passenger time

**\$14.80**  
time value per hour

**\$25.8 million**  
annual time value loss

# SEPTA Operating Costs

Bus delays also increase operating costs for SEPTA, causing vehicles and drivers to be on the road for more hours and necessitating more vehicles in service at peak times. According to SEPTA's annual service plan, the average hour of bus operations costs \$64, meaning that the 149,000 additional annual hours relative to free flow result in \$9.5 million in additional operating costs.

Additional peak vehicles required relative to free flow are estimated based on time increases by route at the PM peak [with fractional results dropped such that only the potential removal of a full vehicle at peak time is counted]. The use of 30 additional peak vehicles at an allocated overhead cost of \$197,200 yields an annual overhead cost of \$5.9 million. Combined, congestion losses cause SEPTA to spend an additional \$15.4 million in the process of delivering slower and less reliable service to its riders.

CONGESTION  
IMPACT



UNIT  
COST



ANNUAL  
LOSS

Bus Hourly Cost

**149,000**  
additional annual  
hours of operation

**\$64**  
operating cost per hour

**\$9.5 million**  
annual operating cost

Bus Overhead Cost

**30**  
additional peak  
vehicles required

**\$197,200**  
overhead per peak vehicle

**\$5.9 million**  
annual overhead cost

**Combined: \$15.4 million annual cost**



# Downstream Impacts from Congestion

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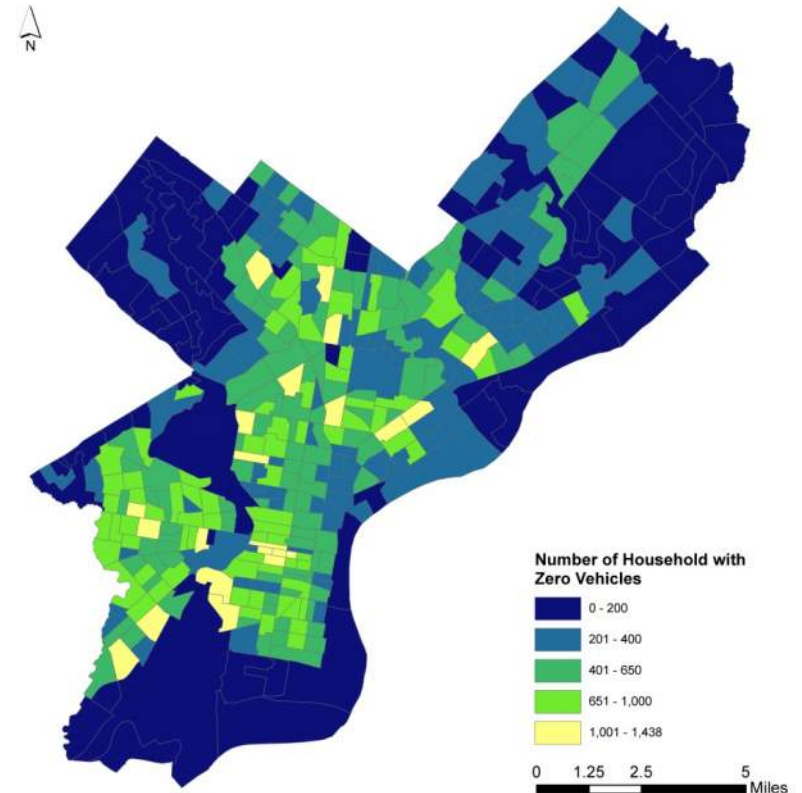


## Equity Implications

Increases in the time differential between bus and car trips leave bus riders with the difficult choice to bear greater delays or switch to more costly modes. The relative willingness of riders to pay more to save time is in part a function of their means, meaning that higher income residents are better positioned to switch, leaving lower income residents to bear the brunt of the time losses. Drivers are also better positioned to take alternate routes to avoid congested areas, where buses follow fixed routes regardless of traffic conditions.

One in three households in Philadelphia do not have access to a private vehicle. While some residents forgo a car by choice, others do so by necessity. The cost of transportation alternatives like ridesharing does not make it a realistic commute option for many Philadelphians who rely on transit service.

PHILADELPHIA HOUSEHOLDS WITHOUT VEHICLE ACCESS



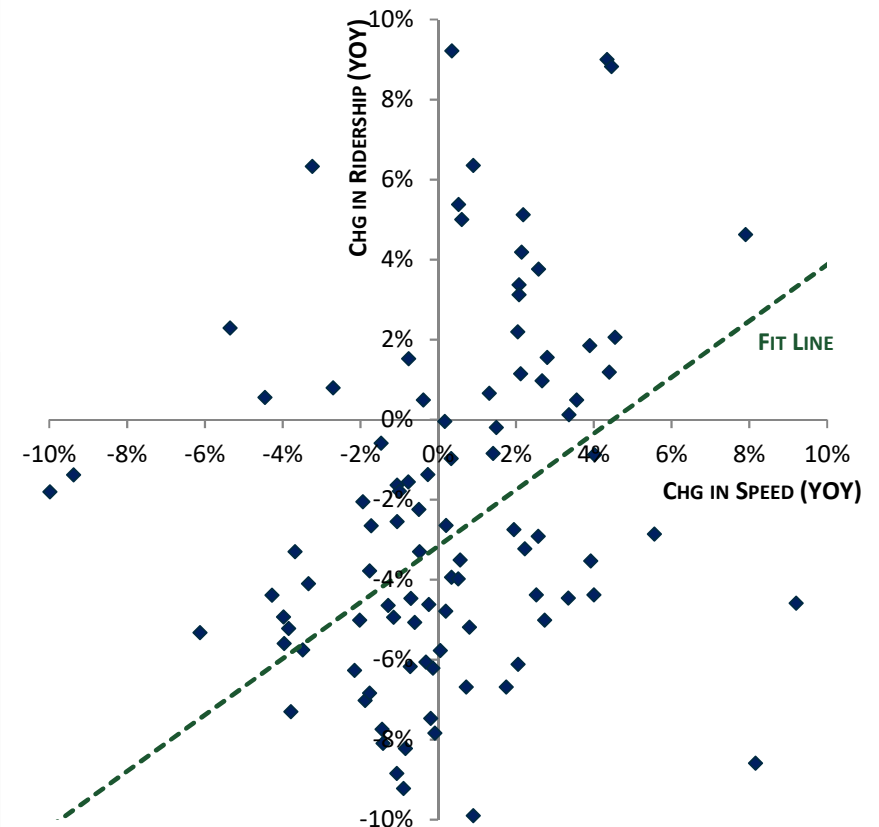
## Impact on Bus Ridership

While bus ridership has declined over this period on non-Center City routes (consistent with national trends), percentage ridership losses on routes that pass through Center City are twice as large.

A statistical analysis of annual changes in trip time and ridership for Center City routes between 2012-2017 (shown at right) shows that time losses are strongly associated with ridership losses for these routes when controlling for overall ridership trends. Said another way, routes that have suffered greater congestion losses over this time period show greater declines in ridership.

This analysis supports the conclusions of basic behavioral modeling: given a decline in service quality, some portion of bus riders will find an alternative mode of travel.

CORRELATION BETWEEN CHANGE IN SPEED AND RIDERSHIP FOR CENTER CITY BUS ROUTES, 2012-2017 (YOY CHG BY ROUTE)



## Bus Ridership Loss

A regression analysis of the relationship between bus speed and ridership is used to estimate the losses in bus ridership attributable to congestion. Congestion delays are estimated to result in 4.7 million lost trips annually, which at an average fare of \$1.22 results in a loss of \$5.8 million in revenue for SEPTA.

More broadly, riders who switch to other modes endure losses as well (likely in the form of increased transportation costs), since the bus represents their preferred mode absent congestion delays. These losses can be significant for residents and their households.

Further, these shifts produce negative externalities for all residents by putting more cars on the road, generating more congestion. Based on commute share data, it is estimated that this shift would add 8,000 car trips to the streets of Center City each weekday.



**4.7 million**  
annual bus ridership decrease



**\$1.22**  
average fare (unlinked trips)



**\$5.8 million**  
annual SEPTA revenue loss



**8,000**  
additional Center City car trips  
each weekday

## Feedback Loop: Further Congestion

Shifts in ridership from buses to cars caused by congestion are self-reinforcing, since they put more cars on the road, which creates further congestion. This in turn degrades relative bus service quality even further, causing more riders to switch to private vehicles, and deepening the negative feedback loop.

These losses erode the economies of scale for bus operations, threatening the future competitiveness of the bus network. Accordingly, it threatens the positive externalities that public transit provides as a means to deliver high volumes of passengers to a dense area efficiently.

Importantly, this self-reinforcing cycle can also work in a positive direction if congestion is mitigated. Increases in bus speeds would attract greater ridership, reducing the number of cars on the road and yielding further reductions in congestion.



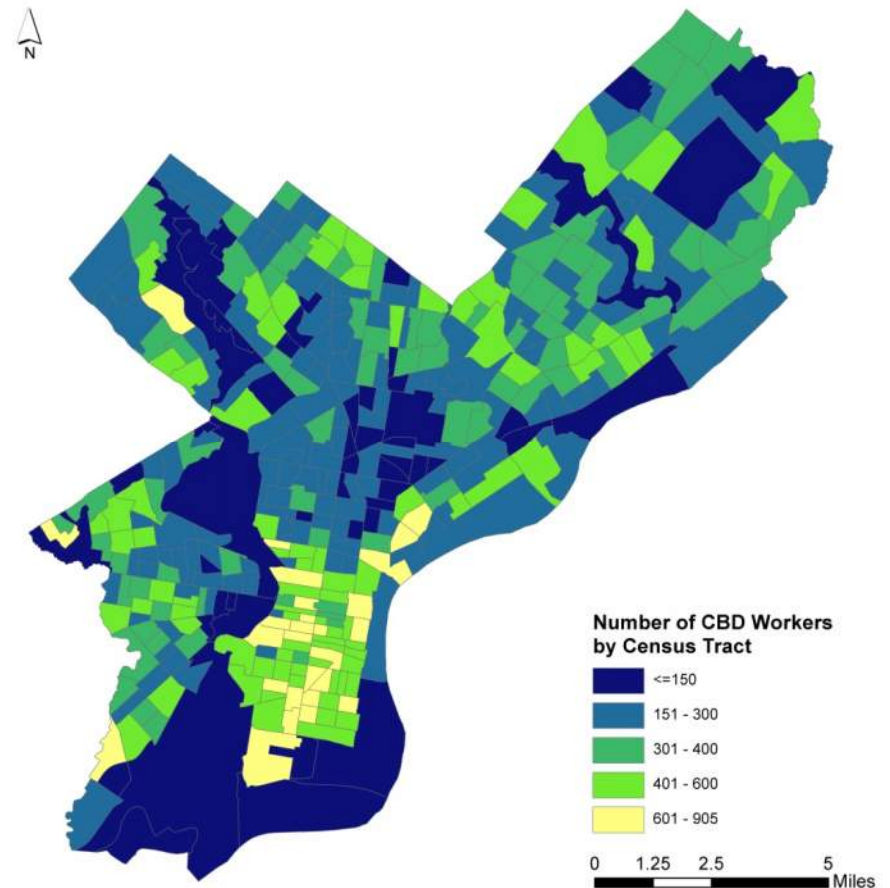
## Impact on Neighborhood Residents

Center City is the largest employment node in the state, and is crucial to the economy of the entire city and region. The vast majority of center city jobs are held by workers residing outside of downtown.

Center City workers, and in particular those who rely on bus service, are scattered across Philadelphia's neighborhoods. Many of the opportunities in Center City are accessible to workers at a range of skill levels, with more than half of the jobs falling outside of the office and education sectors and in industries like hospitality and retail.

In addition, nearly half of Center City workers live outside the city. These commuters are a net positive to the city's tax base, generating significant revenues while consuming a only a fraction of city services.

DISTRIBUTION OF CENTER CITY WORKERS THROUGH PHILADELPHIA



## Economic Competitiveness

Philadelphia has been the engine of economic and population growth for the region and state in recent years. Left unchecked, downtown congestion will reduce the attractiveness of the city as a place to do business. This in turn will serve as limiter for development and associated job growth in the future.

This unmet potential means fewer job opportunities for residents living throughout the city. It also reduces the city's tax base, foregoing revenue that could be returned to residents or used to provide more services.



## Unmet Job Growth Potential

Time value losses to workers and other travelers ultimately accrue to Center City businesses, reducing their customer base and increasing their costs to attract workers. This reduction in attractiveness dampens commercial demand, making future growth and development less likely. It also threatens the competitive advantage in density of amenities and activity that have driven the city's growth in recent years.

Economic modeling of increased business costs and foregone agglomeration effects suggests that congestion losses reduce potential downtown employment growth by 15,700 jobs. This equates to more than \$1 billion in foregone wages related to these jobs. The loss in direct earnings also reduces spillover impacts that would circulate through the local economy as household spending.



**15,700**  
potential jobs foregone



**\$1.08 billion**  
potential earnings foregone

**Job gains would be equivalent to adding  
4 new Comcast towers**

## City Revenue Losses

Congestion losses function in some sense like a tax, discouraging activity in the impacted area. But it's worse than a tax—private losses to not have any offsetting public benefit in revenue. In fact the city and school district miss out on revenue from the foregone employment and business activity.

Economic modeling of employment, business and property value impacts suggests that foregone activity results in \$58 million annually in lost potential tax revenue to the city and school district. This equates to about \$100 per household across Philadelphia, which could be returned to residents at the same level of public services or used to provide additional services, but instead is lost entirely.



**\$58 million**  
foregone city  
and school  
district tax  
revenue

**\$39 million**  
wage tax

**\$9 million**  
BIRT tax

**\$10 million**  
property tax

**\$100 for every household in Philadelphia**

## Limiting our Potential: Summary

**9.7 million**  
annual hours of time delay  
for bus and car passengers



**4.7 million**  
annual bus trips lost



**15,700** potential jobs foregone  
**\$1.08 billion** potential earnings foregone



**\$58 million**  
foregone City and School District  
tax revenue



**13 hours of annual weekday delay per bus or car passenger**

**8,000 additional car trips each weekday, generating further congestion**

**Job gains would be equivalent to adding 4 new Comcast towers**

**\$100 for every household in Philadelphia**