# Sustainable Transportation Infrastructure

(STS Topic)

A Thesis Prospectus

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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# I. Introduction

Every year the average number of vehicle miles traveled (VMT) and vehicle hours of delay (VHD) is rising. The average number of cars per household is also increasing from 1.86 vehicles in 2009 to 1.88 vehicles in 2017. These steadily increasing metrics contribute to the rise in congestion, accidents, and degradation of the environment. Multi-modal transportation is also rising, albeit at a somewhat stagnant pace.

The term congestion refers to travel conditions where the current speed is less than 90% of the free-flow speed (speed limit). A recent study by the Texas A&M Transportation Institute found that the average American spends 54 hours a year in congestion. This finding seems somewhat expected, but one should keep in mind that this is an average over a mostly rural country. When broken down by city, they found that New York, Washington DC, and San Francisco commuters all spend between 92-103 hours per year in traffic. These are tangible impacts on the environment, economy, and people.

The costs of congestion are increasing as well, in 2016 the cost of extra time and fuel amounted to $157 billion, in 2017 that number rose to $166 billion. In 2017 8.8 billion hours of extra travel time occurred due to congestion, and this resulted in 3.3 billion gallons of wasted fuel. For the average commuter, these numbers result in $1300 in lost time, and 21 gallons of fuel wasted per year.

Route reliability is decreasing. Historically a commuter would expect rush hour times as the only congestion periods, but about 33% of the total delay is now midday and overnight. Congestion rates increasing are not bound to urban areas; during Texas A&M's study, they found communities of all sizes are experiencing significant growth trends.

These trends have now passed the previous congestion records in the years leading up to the Great Recession from 2007 to 2009. Assuming the country does not go through another recession, the steadily rising rates suggest that our current transportation infrastructure is not sustainable. By 2025 all the metrics listed above are projected to increase by 10-20%.

I want to make the argument that if a solution to congestion does not contain multi-modal aspects, then it is not a real solution. Insights will be given by first exploring how congestion became a problem, then diving into realistic, data-driven solutions.

## II. How Did We Get Here?

In 1956, President Dwight D. Eisenhower signed the Federal-Aid Highway Act, allocating twenty-six billion dollars to fund 41,000 miles of highway expansion. Originally Eisenhower envisioned this as necessary means to connect rural America with urban without having to gut through city centers. However, once signed, the highway engineers were in control.

The resulting expansion decimated entire neighborhoods, predominantly lower-income and black communities — Brown v. The Board of Education had passed two years earlier, and engineers saw this as an opportunity to physically force segregation.

Dividing neighborhoods in this way often neglected the entire point of a highway; to get a person from point A to B in as little time as possible. The roads curved around affluent areas, creating bottlenecks. Major American cities can still see the class divide between highways. An egregious example is interstate I-10 in west Houston, a massive, 26 lanes wide interstate that has Spring Branch, a predominantly immigrant community to the North, and Memorial, one of the most affluent neighborhoods in the country, to the south.

No longer restricted to urban living, wealthy residents began moving to the suburbs in a mass exodus commonly referred to as 'White Flight' throughout the '60s and '70s. As metropolitan areas grew, traffic became worse. In the years after white flight, city planners and engineers started working on ways to fight traffic.

A glaring solution would have been to expand public transportation out to the suburbs, but suburban residents blocked these efforts. The word nimby "not-in-my-back-yard" became popular in the 1980s, about those who block infrastructure developments.

Nimbyism was predominant in blocking public transportation efforts all over the country. Nimbyism is a reactionary, fear-based mechanism rooted within the deeply engrained racism throughout America that persists today. Wealthy, suburban residents were not willing to allow the inner-city access to their community. To this day, public transportation expansion continues to get voted down. For decades the solution to fighting congestion has been to add lanes to the highway.

## III. If You Build It, They Will Come

There are two fundamental laws of congestion. The first is the fundamental law of highway congestion, which claims the elasticity of a given highway's vehicle miles traveled (VMT) to added highway lane miles is approximately one. In layman's terms, it will not relieve congestion. This phenomenon is known as induced demand. In economics, induced demand shows that if the supply of a good increases, more of

that good is consumed. Studies show that adding highway miles increases the number of commuters on that highway, and congestion stays relatively constant.

Multiple factors explain how induced demand happens. Adding lanes to highways creates more efficient trucking corridors. A growing number of factory jobs sent overseas leaves workers looking to opportunities in urban areas. The United States population grows at a rate of around 0.6% per year.

Critics of the fundamental law of highway congestion claim that due to these contributing factors, induced demand should not be a concern to policymakers. Special interest groups make exuberant claims - the American Road and Transportation Builders Association quote, "adding highway capacity is key to helping to reduce traffic congestion." The American Public Transit Association states that without investment, highways will become too congested and no longer work. Data does not support these definitive claims.

Congestion is a complex problem that is not universal. Investment in nonintrusive traffic operations, advanced technologies, better land development, congestion pricing, autonomous vehicles, park and rides, and construction - where necessary - all play a vital role in keeping traffic flowing, but the best way to do this is getting cars off the road.

## IV. Comparison To The European Model

Public transportation is not the only solution, but it is one of the most important. The number of commuter rail riders has remained relatively stagnant for the past 20 years. Countless factors explain this, absurdly high-ticket prices to account for the routes they lose money on, slow trains, and convenience seems to be the common complaints.

Taking the train from Richmond, VA to NYC will cost anywhere from $100-$300; the trip takes 7 hours, which averages to 47 miles per hour, and only two trains leave Richmond a day. A comparable route in Europe would be Paris to Amsterdam, which will cost around $40; the trip takes 3-4 hours, which averages to 90 miles per hour, and trains depart every 2 hours.

Every wealthy nation in the world has invested in high-speed rail, including the United States, albeit at a much slower pace. Amtrak recently received $1.8 billion in subsidies, in comparison to $19 billion Germany received in 2014. An argument was going to presented that Amtrak deserves exponentially higher funding; upon research, I realized that Amtrak requested the federal government take 141 million back.

Amtrak's business plan states their goal is to be the preferred mode of intercity transport, and double ridership by 2040. The goal is respectable, but one could argue that it's an attainable goal much sooner than that. Throughout the urban corridors (east coast and west coast) rail expansion projects comparable to the Highway Act

would benefit congestion, commuters, and freight. This doesn't necessarily mean it needs to be a nationwide high-speed rail network. This idea is great to consider, but unlikely any time soon. What this is referring to are separate high-speed rail networks throughout the Northeast corridor, hitting all of the main cities (Boston, New York, Philadelphia, Baltimore, Washington DC) and then connecting to the growing southeast economic powerhouses (Richmond, the Research Triangle in NC, Charlotte, down to Atlanta.)

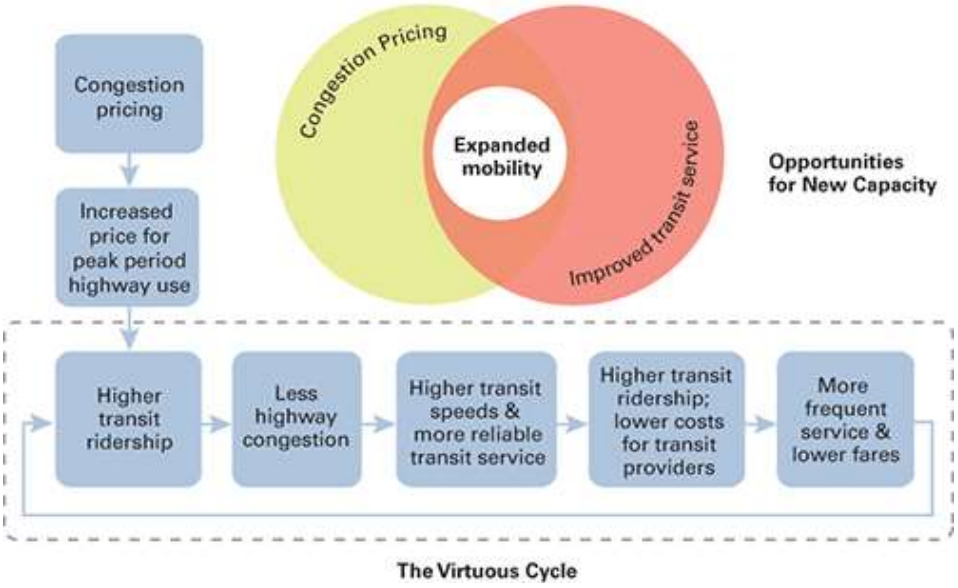
Implementing rail/subways through inner cities can be a daunting project if there is no existing rail infrastructure. For this reason, there have been successful projects involving bus-only lanes that are showing promise. In 2018, Richmond, VA opened the PULSE system. The PULSE is a bus that operates in the same fashion as a typical subway would. It goes up and down the main thoroughfare through Richmond, and each stop is serviced every 10 minutes. Downtown business centers like MCV, the Government Center, and Shockoe Bottom are all serviced. Since the PULSE's rapid transit implementation, Richmond's transit ridership has increased by 17%, while national transit ridership has decreased by 2%.

There is currently a southeastern high-speed rail project that has been approved, but we're years away from seeing it come to fruition, and it took years to be approved. Many jurisdictions fought over proposed routes, and there were problems with funding.

A project to this scale would need to have multiple sources of income being generated in order to be successful. The most promising options to generate income while also reducing congestion on the highways are presented below.

## V. Congestion Pricing

Congestion pricing is a zone-based tolling meant to lower congestion and pollution by dynamically charging by demand. It can be viewed within the same scope of other demand-based pricing such as; airline travel during the holidays, skipping lines at a theme park, and uber prices surging after an event. The benefit of congestion pricing is the extra tax dollars can be used to fund public transportation. The theory is that when there is regular stop and go traffic and congestion prices are implemented, then fewer people are driving. This results in more walk, carpool, biking, and less delay on the road. When you add in the transportation alternatives that it can help fund and consider the benefit of cleaner air in the city, then one can see how this is a crucial implementation for sustainable transportation systems. The following diagram from the Federal Highway Administration visually lays out the benefits of congestion pricing.




The four main types of congestion pricing are variably priced lanes, also known as HOT lanes, variable tolls for an entire roadway (regular toll road), the cordon pricing strategy, and area-wide charges. HOT lanes dynamically toll drivers with prices spiking during peak hours. HOT lanes have been successful in Northern Virginia. I-95, I-395, and I-495 all have HOT lanes that go down the middle of the highway. The HOT lanes have succeeded in reducing congestion, but this implementation comes with some drawbacks.

The downside to variably priced lanes is that people will naturally be inclined to find ways around it, this includes simply taking the general-purpose lanes, waiting for prices to drop and then driving (this causes abnormal and unpredictable traffic patterns), or taking arterial routes that are not connected to the highway. In my research, An Econometric Analysis of the Northern Virginia I-495 Express Lanes, I found that these patterns can have an adverse effect on the value of reliability, and value of travel time. This isn't to say that I believe these programs to be unsuccessful, it's simply stating there are areas of improvement to be considered.

The first improvement for future HOT lanes is that they should be publicly funded, the reason for this is so that the profits can go towards the public benefit. Most of the HOT lanes in Northern Virginia are owned by Transurban, an Australian company. Some of the toll money goes towards a community grant program, but the majority goes to Transurban. Congestion pricing will have optimal benefits when the revenue generated is used to fund mass transit initiatives and community projects. Paying $25 a toll can certainly reduce congestion but when that money is being sent to a company overseas, little benefit remains.

The second improvement is that the cordon strategy should be implemented in all major metropolitan areas. The cordon strategy doesn't restrict the tolling to a

certain roadway or lane, it cordons off a geographical area, and anyone driving in or out of this area during peak times will pay. The first US city to pass cordon pricing legislation was New York City this past April. The legislation states that the area of Manhattan south of Central Park will be a congestion pricing zone during the day. The plan begins in 2021 and with 880,000 people driving into Manhattan on a given day, an expected $15 billion will be generated for the Metropolitan Transportation Authority. This money will be used to improve subways, modernize aging rail infrastructure, and expand rail access in communities in Queens and Brooklyn that are lacking efficient subway systems.

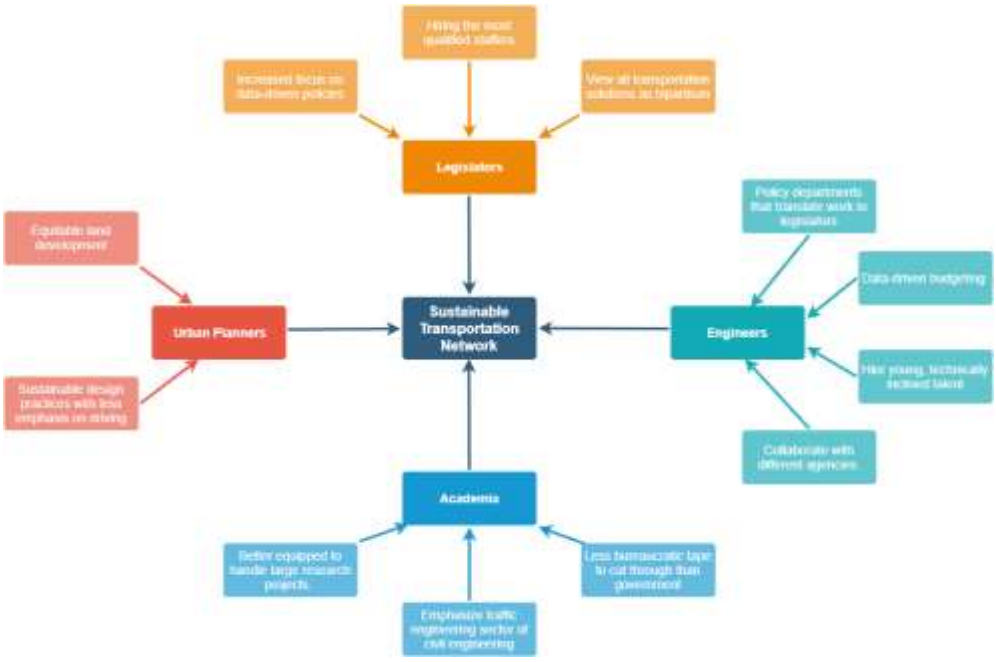
A common, and valid, argument against congestion pricing are concerns regarding equitability. New York has dealt with this by offering a tax write-off for anyone making less than $60,000. Implementing an equitable cordon strategy in Northern Virginia in business districts such as Tysons' Corner, Crystal City, Ballston, etc. would net billions in revenue that could be used to expand transit and increase the public well-being.

## VI. Actor-Network Theory

For a project of this size to be successful, multiple parties will need to harmoniously work together. Traffic engineers, legislators, and urban planners will all need to collaborate. Actor-Network Theory (ANT) is an STS framework that can be used when describing a heterogeneous group of actors that form a network with a common goal in mind. ANT views each actor with equal importance, and if one actor fails to mesh with the network, the network crashes.

There are working networks within cities, states, and regions, but there has yet to be a national network. Since ANT requires every actor's participation, any time politics play a role, ANT can be a challenge to maintain. The secretary of transportation is a cabinet position appointed by the president, and while transportation is often viewed as a bipartisan issue, many of the issues described have been partisan. For example, the cordon pricing strategy being implemented in New York took 10 years to finally pass. The legislation was first drafted when Michael Bloomberg was mayor and the plan was continually voted down by republicans. The turning point wasn't until 2018 when democrats took control of the New York state senate.

An improved network would consist of traffic engineers practicing sustainable design practices and consulting with urban planners to ensure equitable solutions. Solutions will then be proposed to legislators who are not motivated by any outside factors and are able to see scientific, data-driven studies and make unbiased decisions based on the findings, regardless of which political party they belong to. The following diagram shows the normative network, with information on how each actor can contribute.




There have been some lofty ideas proposed within this paper but going from the current ANT network to the improved network would be the most challenging, and unfortunately, this is once again due to politics. Given the current state of affairs, it can be difficult to imagine bipartisan legislation passing on a federal level. Thankfully this is less of an issue on the state level, Ralph Northam (VA-D) and Larry Hogan (MD-R) recently announced plans to collaborate on an improvement of the American Legion Bridge on the Virginia, Maryland state border.

In order to achieve this on a federal level, sustainable transportation efforts will need to be sold to republicans as not only as good for the environment, but good for the economy as well. This can be done by local and state governments implementing successful solutions to congestion that can be used as examples on a federal level, and by making the amount of money wasted sitting in traffic a well-known metric.

## VII. Conclusion

Congestion is a multi-variate, complex issue that deserves data-driven solutions in order to create sustainable transportation infrastructure throughout the nation. Interstates are nearing capacity and are unable to support the projected VMT rates over the next decade. In order to be prepared for the future, sustainable transportation initiatives are needed now.

These initiatives include a federal high-speed rail expansion on the major coastal corridors, data science projects done within cities to determine the optimal form of public transportation improvement, and pricing strategies that fund public

well-being projects and force roadway consumers to financially consider their carbon footprint.

A starting point will be studies that determine the efficiency, and value of public health, that similar strategies have produced in Europe. If simulation results show that areas of the US will have alike benefits, then transportation and academia personnel need to ensure their legislative bodies see the results and act on them. Creating a network of traffic engineers, legislators, urban planners, and academics all working together to reduce congestion will set the US up for future success and sustainable infrastructure.

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