THE NEXT STEP FOR E.V.s

Abstract

The next step for E.V.s is a grade-separated, high-speed, automated roadway that uses solar energy to power the electric vehicles as they travel. Preliminary studies have shown that a public-private partnership could build and fund a low-cost travel service using autonomous electric vehicles. The travel service is for both in-town and city-to-city travel and would provide private virus-free door-to-door service. The small-footprint automated roadway could be built over railroad rights of way to connect cities. Stations would control access to the high-speed roadway. The travel service is for both passengers and freight. This paper proposes the creation of a Solar Powered National Transportation Service – SPNTS.

Key Words: E.V.; SOLAR; MASS TRANSIT; AUTONOMOUS; GREEN

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1. Introduction

We propose a green alternative transportation service that addresses climate change, reduces paralytic traffic congestion, is far more efficient, and provides **sustainable** and safer travel. A revolutionary, continent-wide electric transportation system based on autonomous electric vehicles should be the next step. These vehicles access an elevated three-lane toll road, which powers and controls the vehicles as they travel. This revolutionary weatherproof, solar-powered covered system is designed for all users, including ADA passengers, and freight. It will outperform today's cars, trains, and even short-haul flights, with low-cost, high-speed (140 mph)(225.3 kph) nonstop transport from entry-station to exit-station. The proposal creates **mass transit** with **private vehicles, significantly reducing the chance of exposure to infectious diseases.**

1.1 Mass Transit History

For thousands of years, mass transportation has depended on collecting many people together, who then boarded a vessel. When all were on board, weather permitting, it sailed off to a common destination. Even though ships have changed and creature comforts vastly improved over the millennia, mass transit's primary function has not significantly changed. People still gather together en masse to board a train, subway, bus, or plane to travel to some common destination. Weather permitting and often with intermediate stops.

1.2 Door to Door Mass Transit

Our proposal offers a new blueprint for door-to-door mass transportation. Purpose-built software and hardware would allow private vehicles to platoon, travel along the roadway in single file at a designated distance from one another and at high speed while under the vehicle control system's guidance. Our approach's significant difference is that everyone can have an independent start and endpoint. And can travel at any time frame of choice to any destination, independent of other travelers. When an E.V. enters the roadway, it will join a platoon of vehicles and travel together en masse to save energy.

1.3 Next Step for E.V.s

The next step is to build a nationwide, grade-separated, high-speed roadway just for E.V.s. The dedicated road powers and controls the electric vehicles as they travel with an additional step of using solar energy to power the E.V.s. We propose building an automated roadway infrastructure for E.V.s that can power the cars as they travel. Take one step more and put a roof of solar panels over the guideway/roadway. A National Transportation Service – NTS that is solar-powered, weatherproof, high-speed, and automated could offer many advantages over current travel modes.

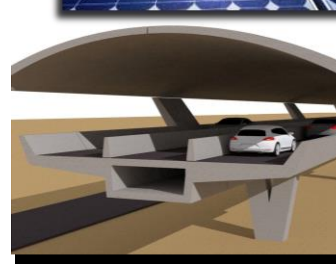
2. Electric Vehicles and Climate Change

"According to the Inventory of U.S. Greenhouse Gas **Emissions** and Sinks 1990–2018 (the national inventory that the U.S. prepares annually under the United Nations Framework Convention on Climate Change), **transportation** accounted for the largest portion (28%)

of **total** U.S. GHG **emissions** in 2018. "Utility power generation is second at 27%." [i] Just converting to electric vehicles may not reduce CO_2 emissions. The power to charge the electric car batteries comes from the local electric utility, which will emit CO_2 and other gas when generating electricity. Several studies have tried to estimate how much CO_2 is saved by using electric cars when the CO_2 emitted by the power company is included. The issue is complex, and estimates range from no savings to maybe 30%. The energy used to manufacture the E.V. car and its battery pack further reduces lifetime emissions savings. In the proposed mass transit system, the E.V.'s battery pack can be made much smaller as the vehicles will get most of the power from the roadway as they travel, and most of that power will come from solar energy. Just converting to electric vehicles will not save us from climate change; however, it could if the next step is taken. [ii]

3. The Proposed Next Step

3.1 The proposed transport service has several component features-



- A National network of elevated toll roads
- Accessed via stations or terminals
- High-speed travel (140 mph)(225.3 kph)
- Weatherproof - roof covered by solar panels
- Powered by solar - 5.7 megawatts per mile
- Created by a Public-Private Partnership
- Funded mainly through small investors
- For all-electric vehicle types
- Designed for passengers and freight
- Elevated 5 to 10 meters and only 11.3 meters wide
- Capacity equivalent to a 20-lane expressway
- An eventual replacement for the interstate highway system

Eventually, an NTS network of guideways/roadways would be constructed with private funds, and millions of private investors would have a significant retirement supplement. A 20,000-mile weatherproof guideway system all across the country would offer door-to-door travel faster and for far less money than flights of up to 700 miles or less. 70% of domestic flights are 500 miles or less and would not be needed.

3.2 Features of the Electric Vehicles

- All electric
- Self-driving/autonomous
- Produced by current electric vehicle manufactures
    - With adaptations for power rail tracking and power pickup
- Powered by the roadway
    - May have lower-cost battery packs (40-mile range)
- Controlled by the roadway
- Manually or autonomously driven at street level on battery power for door-to-door service
- Electric cars, vans, crossovers, SUVs, lite trucks, heavy trucks, travel vans, and motorhomes

The NTS electric vehicles would be manufactured by current electric car makers according to the specification and adaptations required to use the NTS toll-road. Fleet owners / manufactures could offer any body-style, comfort level, any entertainment features, Wi-Fi, that they wish. It is expected that several classes of service would be offered Economy, Premium Economy, Business, and First Class.

3.4 Features of the Stations

- Vehicle parking
- Control of vehicles exiting and entering the roadway
- Access points every 4 miles(6.4 km) along the route in urban areas
- In-station retail stores and fast food
- Restrooms
- Automated fast-food and package delivery drive-through dispensing chutes
- Vehicle automation checks and travel worthiness inspections
  every time a vehicle enters the station
- Vehicle cleaning and U.V. light sterilization when not in use between trips

Stations provide access to and from the NTS toll road network and passenger services, such as fast food, convenience stores, and automated package delivery from ATM-like dispensers. Dispensing packages provide a delivery solution for online orders.

There are three types of stations:

1. Entrance/exit station
2. Combination entrance/exit station and interchange for change of direction
3. Heavy freight truck terminal or Fulfillment Center for heavy vehicles, such as 18-wheelers, container freight, and large motor homes.

3.5 Heavy Freight Terminals

NTS is one system for all transportation. Both passengers and freight would use the same roadway. However, the 18-wheel trucks would have dedicated terminals for access and, generally, would not use the passenger stations. If necessary, the very large trucks can exit at passenger stations but cannot enter the NTS roadway from these stations. The heavy trucks would require a longer entrance ramp and must enter the system from the truck terminals. Freight vehicles can be as heavy as 80,000 pounds; maximum vehicle width: 102 inches. Maximum vehicle height: 14 feet. Single unit maximum length: 45 feet. These are current national interstate highway standards for maximum vehicle size and weight.

Entrance/Exit stations are strategically placed along the route, and in urban areas are placed approximately every 4 miles. Heavy Freight Terminals will be placed as needed along the NTS route.

3.5.1 Heavy Freight Features and Savings Example

Fulfillment Center –

- Fast, secure, low-cost shipment

Heavy Freight Terminal Example

- Driverless Terminal to Terminal
- NTS Electrical cost / mile $0.261 **
- AVG Fuel cost / mile $0.609 [iii]
- LA to Chicago – 2,015 Miles
  - 72.76% less travel time (Non-Stop)
    - NTS travel time 16.12 Hours
    - Current Average drive Time 59.2 Hours
  - 57.1% less fuel cost

** Platoon average vehicle number 6 vehicles

4.0 The Next Step Fees

The NTS automated door-to-door travel service could provide a low cost travel of 50.6 cents per mile. The fee would pay for the vehicle rental, the energy used, and the roadway toll. Electric vehicles should be less expensive to make and less costly to maintain. According to AAA, the average cost to own and drive a car is about 59 cents a mile. The fuel cost per mile is about 11.62 cents per mile.[iv] An electric car's energy costs range from 3 to 5 cents per mile. Depending on how much you are charged for electricity and how you drive. Electric cars could save 6.62 cents per mile or more. G.M. said by 2035; they will only make all-electric cars and trucks. Many vehicle manufacturers have followed. Electric cars are far less complicated. "The drivetrain in an ICE vehicle contains 2,000+ moving parts typically, whereas the drivetrain in an E.V. contains around 20. " [v] We propose moving to a transportation service with a fee of 51 cents per mile for the NTS car. The current IRS rate is 56 cents per mile, [vi] and the AAA estimate is 59 cents per mile, [vii] making a rate of 51 cents per mile less expensive.

4.1 Fee Components

The $0.506 fee has 4 components

1. Toll Road fee of $0.200 per mile
2. Vehicle rental fee of $0.159 per mile
3. Solar energy fee of $0.092 per mile
4. Energy savings bonus of $0.055 per mile

4.1.1 Toll Road Fee

$0.20 is based on construction costs, including stations, expected ridership, expected retail and fast food space rental in the stations, and a reasonable payback time. One usage estimate is 30% percent of existing traffic. In the congested areas of the country, a ridership of 30% of existing road traffic will provide a net revenue payback of 11 to 12 years. At 60% of current traffic, payback is 6.8 years. With a payback of fewer than 20 years, the fee seems correct.

4.1.2 Vehicle Rental Fee

The $0.159 per mile vehicle fee is for vehicle purchase cost, maintenance, and a life of 3 years. The Estimated vehicle cost is $38,000, a life of 400,000 miles, and a 68% profit for the vehicle provider. Based on the same volume of trips as above, vehicle payback is 1.1 years based on usage time of 50% and the number of vehicles required for the traffic load. This fee and payback estimate is the average for a $38,000 2 to 6 passenger electric vehicle. The vehicle rental fee will vary based on vehicle size, features, and type.

4.1.3 Solar Energy Fee

The solar energy fee is based on solar panel installation cost and a $0.240 per kilowatt-hour fee. With the estimated traffic volume as above, the solar energy provider's payback is 2 years at 30% of the current traffic. The business entity that provides solar energy also pays for and manages the utility power. It is expected that NTS stations will be the utility customer.

4.1.4 Energy Savings Bonus Fee

This fee is an education fund fee and consists of the difference in cost between fuel per mile and electricity cost per mile. As stated above, electric cars could save $0.0662 per mile. This money could become an education fund and is paid to schools per student. NTS, with a 47,000-mile network replacing the interstate highway system, the fund would receive revenues of over $220 billion per year. That amounts to over **$40,000 per K-12 student per year**! Based on public elementary and secondary enrollment projected to be **51.1 million** by 2029. [viii] School taxes could be reduced or possibly eliminated with this new source of funding.

5. Customer Needs

The expectations and requirements for potential customers vary based on their category. Each customer segment has a specific bottom-line expectation from NTS.

5.1 Customers Categorization

1. Long-distance travelers 80 miles or more
    a. Business travel
    b. Personal travel (visiting friends and family)
    c. Recreational travel (vacation)
2. Short distance travelers 10 to 80 miles (35 minutes)
    a. Travel to work
    b. School
    c. Shopping
    d. Entertainment (sports, concerts, shows, movies, dinner)
    e. Recreational (sightseeing/dinner travel)

5.1.1 Customer Needs for Long-distance travelers 80 miles or more

5.1.2 Business Travel

The first and foremost requirement is reliability and punctuality. Business travelers are often traveling for time-critical work, and any delays are a significant hindrance. Therefore, reliability of the mode of transport is essential so that they can be at the required place at the right time. They would also prefer if there is an Internet connection on board so that they can work while traveling. If it is an overnight trip, the transport should be comfortable enough to sleep so that they can be well-rested for the meetings or appointments the following day.

5.1.2 Visiting Friends & Family and Vacations

Customers visiting family and friends tend to do so during the major holiday seasons or weekends, and the top requirement on their list is not to get stuck in traffic or at airports. Also, ticket prices for public transport get very expensive during this period due to increased demand. The base requirement of the customers in this segment is a quick and fair price for travel. They do not want to get stuck in traffic jams or spend hours at airports due to long waiting lines and delayed or canceled flights. They also expect the prices to be genuine. The ones traveling for vacations want to enjoy every moment with their loved ones and prefer a hassle-free journey.

5.2 Short distance travelers 10 to 80 miles (35 minutes)

5.2.1 Commuters

Commuting customers could be a large consumer base for NTS. Short distance trips ranging from 10 to 80 miles will be quite short, but a high customer volume and frequency are expected. The commuters require reliable and fast rides through the daily commute, without any delays since it might be one of the main reasons they would use NTS to avoid the traffic on current streets and highways. Vehicles need to be available on an on-demand basis so that those customers can get on the system right away. Commuters would also prefer Internet connections on board to work or enjoy entertainment during the commute.

5.2.2 Shopping, Entertainment & Recreation

This customer group is like the commuters. They would like to bypass and avoid the rush hour traffic and have a fast and relaxed ride to their destination. Besides the requirement of reliability, shoppers may also require storage spaces to put their belongings.

5.2.4 Travel Profile

1. Families
    a. Entertainment
    b. Vacation
    c. Shopping
2. Working People (age 18 to 65)
    a. People who drive to work
    b. People who use public transportation each workday
3. Seniors 65+
    a. Ride buses to shopping, doctor appointments, or entertainment
    b. Drive personal car
    c. Walk or bicycle
    d. Take taxis
4. Disabled or Disadvantaged
    a. Ride buses to shop, doctor appointments, or entertainment

5.3 Freight - Customer Needs

5.3.1 Cross Country Heavy Freight

Similarly, the electric, driver-less vehicles used in the NTS freight system are much faster, more secure, and highly economical. Being nonstop, it reduces travel time by 72.76% and cuts fuel cost by 57.1%. A journey that takes approximately 60 hours currently can be completed in just about 16 hours using NTS. Long-haul freight would use automated truck cabs to pull existing freight trailers across the country on NTS built above or next to existing railroad tracks. Conventional or electric truck cabs would deliver these trailers to their destination from regional freight terminals.

5.3.2 Freight Benefits

Freight is essential for livelihood and businesses to thrive. Typically, freight vehicles are bulky and incredibly heavy, which means they move slowly and cost a lot of fuel and time to reach their destination. Currently, drivers must adhere to drive time limitations for safety and comply with DOT rules and logbook entries, increasing the delivery time. When it comes to NTS, the benefits of freight transportation are incredible. It is not only a lot cheaper to transport goods in an all-electric freight vehicle, but it takes 72.76 percent less time to reach its destination as compared to traditional delivery routes. The main reason for such efficiency is the autonomous nonstop driving of the freight vehicle. It also cost 57 percent less in fuel cost. To put this into perspective, let's compare it with a Los Angeles to Chicago freight transportation. The total distance is 2,015 miles. A typical freight vehicle would take approximately 59.3 hours to complete the journey, while the NTS travel time for the same trip would just 16.12 hours. The current average fuel cost is $0.609 / mile, while on NTS, it would only cost $0.261 / mile. [[3]]

Another significant benefit of freight transportation through NTS is the platoon movement strategy. Since NTS already plans to use platooning for all vehicles (including the passenger vehicles), it will save freight transportation a lot of money.

According to research by MIT, "Scientists have previously calculated that if several trucks were to drive just a few meters apart, one behind the other, those in the middles should experience less drag, saving fuel by as much as 20%, while the last truck should save 15% — or slightly less, due to air currents that drag behind. Assuming this and the lead truck gaining 10%, a five-truck convoy would save 17% on fuel compared to single trucks, eight would see an 18% gain, and at 15 trucks would efficiency reach 19%." In other words, there's a diminishing return after convoys of about ten trucks ." [[ix]]

5.3.2 Package Delivery Services

There are two types of delivery service. The first is in station pickup. Each station has package pickup queues or lanes where packages may be picked up through dispensing terminals. The process involves messaging service notifications that the recipient will be at a specific station on the delivery date. Upon making a travel reservation, the package service would be notified of the customer exit station, and the package would be delivered to that station for pickup. The second delivery service involves shipping packages through the network.

Package delivery could potentially be a significant customer group. Carries such as UPS and FedEx provide fast and reliable deliveries. Sometimes those two companies rely on other carriers to transport their packages across the country or even the world. Of course, they have their trucks and airplanes, but as mentioned earlier, those modes of transportation always rely on a schedule. NTS could transport packages on an on-demand basis. Another potential customer could be Amazon. Amazon introduced same-day delivery, and in some cities, it even guarantees delivery within a few hours. For Amazon, those speedy deliveries cost a lot of money. NTS could significantly lower that cost and still provide quick delivery.

According to a statement released by Sanford C. Bernstein, Amazon ships an average of 608 million packages each year, which equates to (an estimated) 1,600,000 packages a day. Amazon and other big carriers such as FedEx and UPS require strong logistics to deliver all the packages to the correct address and on time. When working with other firms (in this case, NTS), those freight customers require the same: an on-time delivery, no damage to the package, a correct delivery location, and low cost. NTS can provide all of that. This is the reason why freight customers might become a massive customer base.

The need for fast delivery options grows as online orders grow. Over the last couple of years, most retailers have started an e-commerce business where customers can buy the same (sometimes even more) products than the brick-and-mortar stores. This fast growth in online shoppers results in a higher number of packages being sent and delivered. This is great for UPS and FedEx and can result in a new mode of transportation that provides fast delivery. NTS could fill that need.
In the following, we have summarized a couple of examples of shipping costs that UPS and FedEx offer. Big customer usually pay less than that, but this is just a rough overview: [[x]]

<u>FedEx Priority Overnight or Standard Overnight</u>

1. Ship From 90090 Ship To 60603
2. Weight 10 lb. 0 oz.
3. Published Rate $120.51

<u>FedEx Smart post (2-7 days to deliver)</u>

1. Ship From 90090 Ship To 60603
2. Weight 10 lb. 0 oz.
3. Published Rate $18.74

<u>Amazon Delivery Options</u>

1. Weight 10 lbs.
2. Ship Date 05/04/2017
3. Average Published Rate $17.31 - $154.16

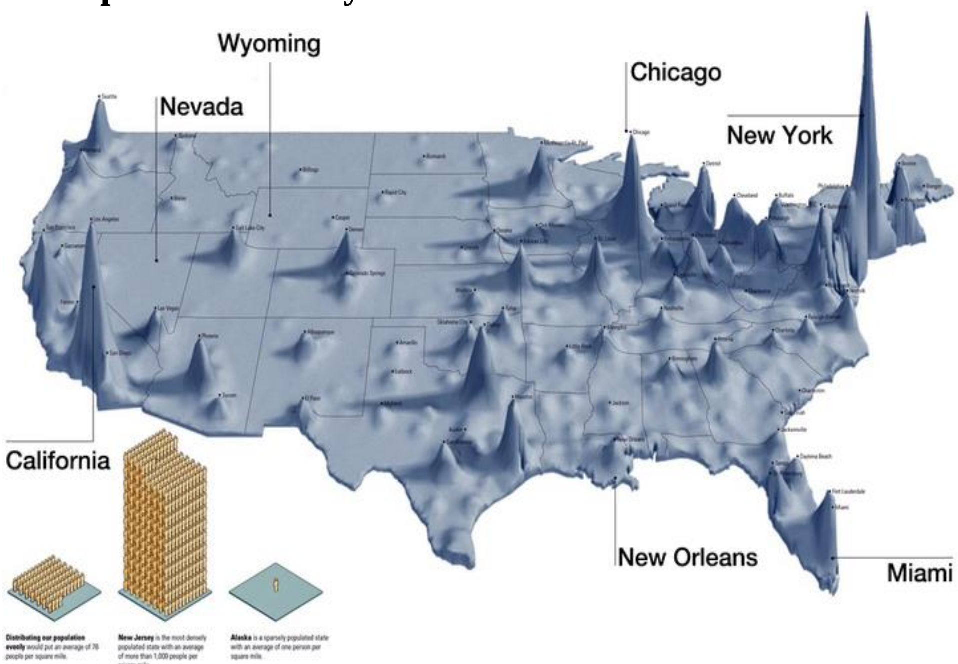
<u>Shipping options</u>

1. Overnight
2. Two-Day
3. Ground
4. International
5. Air
6. Remote Area
7. Saturday
8. Domestic
9. Ocean

6. Ridership Estimates

We looked at two ways to estimate ridership. The first was to look at population density in the areas served and traffic congestion.

6.1 Population Density



The U.S. Census Bureau website, an official website that provides government-related social-perspective data, states that "Los Angeles–San Diego" and "Boston–Washington, D.C.," corridors are among the most densely concentrated and highest populated areas in the country. A densely populated area would be a perfect location for an all Electric Mass-Transit service pilot project. [xi]

6.2 Congestion

In the U.S., drivers lost an average of 26 hours due to congestion in 2020, down from 99 hours last year, saving the country $51 billion or $980 per driver. New York (100 hours), Philadelphia (94 hours), and Chicago (86 hours) lost the most time to traffic congestion, despite a 28% to 40% drop in congestion from 2019. Washington, D.C. (29 hours) saw the most significant decrease globally in congestion, down 77% compared to last year. [xii]

Before Covid-19, INRIX reported that the most traffic-congested city in the U.S. is **Boston**; drivers lose 149 hours a year to congestion. Things aren't much better in **Chicago**, where commuters slogged through 145 hours of congestion each year. Which U.S. cities were the worst? According to the 2019 Global Traffic Scorecard, the 10 most congested American cities, and the number of annual hours lost to congestion (read: stuck in traffic), and the number of 35-hour workweeks lost were:

RANK	CITY	HOURS LOST	WEEKS LOST
1	Boston	149	4.3
2	Chicago	145	4.1
3	Philadelphia	142	4.1
4	New York City	140	4.0
5	Washington, D.C.	124	3.5
6	Los Angeles	103	2.9
7	San Francisco	97	2.8
8	Portland, Oregon	89	2.5
9	Baltimore	84	2.4
10	Atlanta	82	2.3

People are more likely to use the new National Transportation Service due to current highway traffic congestion. And over other slower and more expensive transportation modes. Adoption rates could be very high.

6.3 AADT

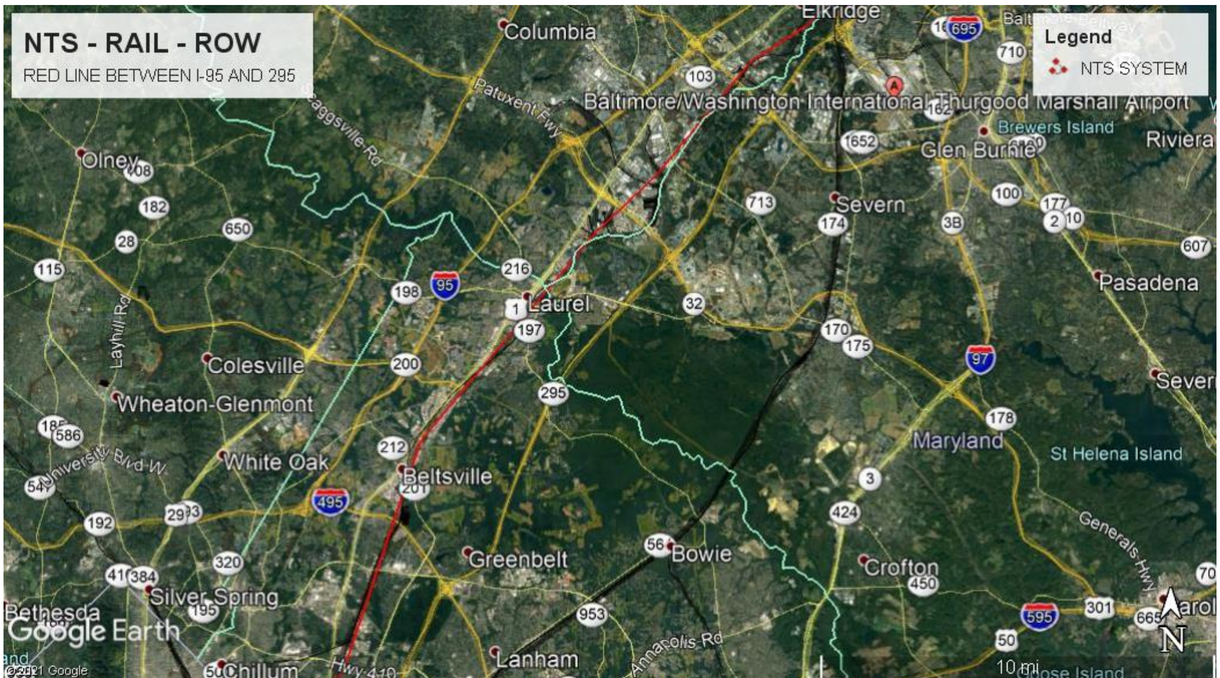
The second way was a look at the Average Annual Daily Traffic (AADT) of a specific current highway and estimated what percent of that traffic would use the new travel service in that area. [[xiii]]

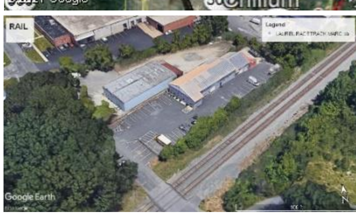
State	Urban Area	Route	AADT
California	Los Angeles-Long Beach-Santa Ana	I-405	374,000
California	Los Angeles-Long Beach-Santa Ana	60	337,000
California	Mission Viejo	I-5	334,000
Illinois	Chicago (IL-IN)	I-90	329,542
California	Los Angeles-Long Beach-Santa Ana	I-110	328,000
Florida	Miami	I-95	328,000
New Jersey	New York-Newark (NY-NJ-CT)	I-95	325,495
Texas	Houston	US-59	323,092
California	Los Angeles-Long Beach-Santa Ana	US-101	321,000
California	Los Angeles-Long Beach-Santa Ana	91	318,000
California	Los Angeles-Long Beach-Santa Ana	I-5	313,000
Texas	Houston	I-45	310,662
Texas	Dallas-Fort Worth-Arlington	US-75	304,620
California	Los Angeles-Long Beach-Santa Ana	I-605	300,000
California	Los Angeles-Long Beach-Santa Ana	I-210	298,000
Virginia	Washington (DC-VA-MD)	I-95	296,766
California	San Diego	I-15	295,000
New York	New York-Newark (NY-NJ-CT)	I-95	289,300
New York	New York-Newark (NY-NJ-CT)	US-9	289,300

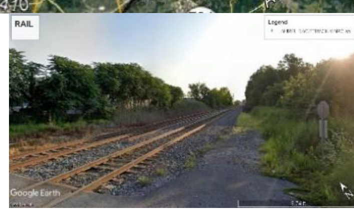
California	Los Angeles-Long Beach-Santa Ana	I-10	289,000
California	San Francisco-Oakland	I-80	288,000
California	San Diego	I-5	288,000
Puerto Rico	San Juan	PR 18	286,800
California	Los Angeles-Long Beach-Santa Ana	110	277,000
Georgia	Atlanta	I-75	274,060
California	Los Angeles-Long Beach-Santa Ana	57	273,000
California	Riverside-San Bernardino	91	267,000
Texas	Houston	I-610	265,220
California	Los Angeles-Long Beach-Santa Ana	55	265,000
Arizona	Phoenix	US-60	263,604
Nevada	Las Vegas	I-15	263,000
Arizona	Phoenix	I-10	261,785
Georgia	Atlanta	I-285	261,220
Georgia	Atlanta	I-85	258,490
Texas	Dallas-Fort Worth-Arlington	I-35E	258,324
California	Concord	I-680	258,000
Puerto Rico	San Juan	PR 22	257,000
California	San Francisco-Oakland	I-880	255,000
Colorado	Denver-Aurora	I-25	251,400
California	Los Angeles-Long Beach-Santa Ana	22	251,000
Maryland	Washington (DC-VA-MD)	I-270	250,763
	AVERAGE AADT		289,694

6.4 Calculations

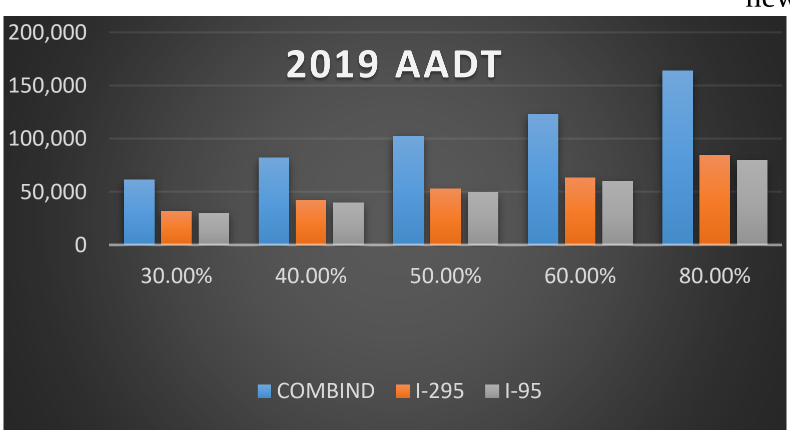
Consider building the NTS elevated toll road between Washington D.C. and Baltimore. The primary Interstates are I-95 and MD-295. Current traffic is generally heavy along the 39-mile routes and takes over 1 hour drive time. The NTS toll road would be built above an old Railroad right-of-way that is between the highways and runs parallel to them. See the red line that is between the two highways.







The combined AADT in 2019 was averaged, and the sum of the two roads was 205,000 AADT. We can estimate how much of that traffic would use the new E.V. service. The chart is based on the percentage of the current traffic. The average AADT for each road I-95 and I-295 and combined totals are shown in the chart below. The size of each column is the percent of current AADT that might use the new service.



The combined traffic load of both I-95 and I-295 is 205,000. If 30% or 61,500 vehicles were to use NTS for the total length of 40 miles, then 61,500 vehicles would make the 40 mile trip per day.

The AADT number shown is a count that was average over several points along the routes. An average trip length is assumed to convert the AADT to trips. The NTS toll road has entrance and exit stations every 4 miles along the route. The shortest trip would be between two stations or 4 miles. If everyone made a trip of 4 miles and the average traffic along the 40-mile route was 30% of 205,000 per day, the number of trips per day is 615,000. The calculation is 30% of 205,000 is 61,500 AADT. If all trips were 4 miles, there are 10 simultaneous 4-mile trips in 40 miles for a total of 10 x 61,500. Then there are 615,000 4 mile trips. If the average trip were 8 miles, there would be 307,500 8-mile trips per day or half as many trips. And if the average trip was 16 miles, then 153,750 trips are made. If the average trip were 40 miles, there would be 61,500 trips if everyone went the full length of the toll road. Length of road/(trip length x AADT) = number of trips. These numbers are based on 30% of current Interstate Highway traffic.

High usage expected based on time saved and low cost
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TRIP COMPARISON WASHINGTON DC TO BALTIMORE		
TRIP 40 MILES	TRAVEL TIME	COST
BY CAR	1 HOUR 10 MIN.	$22.62 *
BY NTS TOLL ROAD	17.1 MIN.	$19.86

* IRS COST PER MILE

The net revenue created by various percentages of the AADT is shown below.

Average Trip 12 miles - Number of Trips Average vs Revenue in Millions					
Percent of Max Trips	30%	40%	50%	60%	80%
No. of 12 mile Trips	205,000	272,333	341,667	410,000	546,667
Annual Net Revenue	$277	$328	$379	$429	$531
PAY BACK*	9.5 yrs.	7.7 yrs.	6.5yrs.	5.6 yrs.	4.4 yrs.

*NTS TOLL ROAD COST FOR 40 MILES AND 11 STATIONS $2.115 BILLION

7. Trip Example

Grandparents living in Manhattan want to visit their grandchildren in Boston. They use a smartphone app to call for a car to pick them up at their apartment the next morning at 8:00 am. They also want the vehicle to bring coffee, juice, and Danish rolls.

The following day the car arrives at 8:00 am with the continental breakfast. The car confirms that the trip to the children's home will take 1 hour, 46 minutes, and will cost $108.00, or $216.88 round trip. The trip begins with an 8-minute drive to the closest mass transport station, the NTS station.

As the vehicle passes through the station, it undergoes diagnostics checks (tires, motors, electronics, computers, etc.) to ensure that the car is fit for the trip. As it proceeds through the station, the car warns the couple to secure their belongings and fasten their seatbelts as they are about to launch onto the NTS high-speed toll road. Their vehicle speed increases to 140 mph on the toll road, 20 feet above the ground.

The couple enjoys their continental breakfast as they watch the scenery. Ninety minutes later, the vehicle warns that they will be exiting the toll road in 3 minutes, and they need to prepare for stopping. The car exits the toll road and comes to a stop in the station. Is a restroom break needed? If not, the car then drives off to see the grandkids, now only 6 minutes away.

Compare that with current travel modes!

Comparison-Travel Time & Cost for NYC – Boston	**NTS vs. Other Modes (one-way travel) 2 people**	
TRAVE METHOD	TRIP TIME	COST (2 People)
Car - door to door	4 hrs, 50 min	$127.31*
Train 1st Class Acela 2154 10 am Departure	3 hrs, 47 min	$389.00***
Plane Delta 8 25 am Departure	1 hr, 20 min**	$260.00***
NEW NTS TIME 1HR 33MIN	**1 hr, 41 min******	**$110.39******

* IRS business travel cost allowance ** Flight time only; door-to-door time about 4.5 hrs
*** Plus cab fare **** Door to Door Time and Cost

It is doubtful this elderly couple would even make the trip using current travel options. However, with NTS, they would be in Boston at the kids' house before 10:00 am. They could spend the day, have dinner, and leave when the children go to bed at 8:00 pm and return home before 10:00 pm.

8. Safety Features

High ridership is dependent on people feeling safe using the transportation mode. According to the Association for Safe International Road Travel (ASIRT) [[xiv]]

- More than 38,000 people die every year in crashes on U.S. roadways. The U.S. traffic fatality rate is 12.4 deaths per 100,000 inhabitants.
- An additional 4.4 million are injured seriously enough to require medical attention.
- Road crashes are the leading cause of death in the U.S. for people aged 1-54.
- The economic and societal impact of road crashes costs U.S. citizens $871 billion.
- Road crashes cost the U.S. more than $380 million in direct medical costs.
- The U.S. suffers the most road crash deaths of any high-income country, about 50% higher than similar countries in Western Europe, Canada, Australia, and Japan.
- Pedestrian and bicyclist fatalities continue to rise in the United States. According to the National Highway Traffic Safety Administration (NHTSA), more pedestrians and cyclists were killed in 2018 than in any year since 1990.

The new NTS travel mode has two types of safety features, Inherent and Active, that would all but eliminate both deaths and injuries.

8.1 Inherent safety in the design

The inherent safety features are incorporated into the design of the roadway.

- Single file travel in a protected U shaped channel with high side walls
- One single file channel for each direction

- A third bi-directional channel supports redirecting traffic from either direction for maintenance or in case of a vehicle failure.
- Weatherproof travel with a roof over the roadway protecting from rain, snow, and ice
- The roadway is elevated 5 to 10 meters above the ground preventing any type of cross-traffic or anything from entering the path of the vehicles
- All vehicles travel at the same speed

8.2 Active safety features

The active safety features are designed to detect and mitigate system failures of both vehicle and control systems.

8.2.1 Station control

The stations maintain positive control of vehicles coming toward the station. As a vehicle passes through a station, control of the vehicles is passed on to the next station down the line. Stations broadcast speed and spacing singles to each vehicle coming toward the station and can force exit all vehicles if there is a problem down the line.

Stations will be 4 miles(6.44 km) apart, and the number of vehicles in the channel between stations could be as low as 45 at 5% of capacity to a high of 700 at 80% of capacity. 5% of capacity is 15% of available traffic, and 80% is 250% of available traffic for this route. All vehicles could be out of the system and at a stop in 2 minutes if some natural disaster like an earthquake were to happen. Stations can direct traffic to the third center lane for maintenance or if a vehicle fails during travel between stations.

If a vehicle were sabotaged to block traffic, the station control system would take the following actions;

1. It would detect the damaged vehicle's loss of speed and spacing in mill-seconds
2. It would stop all traffic within that segment between stations
3. It would signal the previous station to exit vehicles until the gate to the third roadway channel is opened, and the remaining traffic would continue using the third channel
4. Vehicles forced to exit could re-enter the system and continue.
5. Clean up vehicles would remove the damaged vehicle and repair the roadway channel if necessary, and then when traffic is low, redirect traffic back to the normal roadway channel.

8.2.2 Vehicle control

Each vehicle receives and decodes the speed and spacing signals broadcast by the station ahead and maintains its speed and spacing between vehicles every millisecond. The electric vehicle's control systems are hardened and not accessible from inside the vehicle. These systems include:

- Backup redundancy of critical components
- Independent backup systems that report on the performance of
  - Speed and vehicle spacing
  - Vehicle steering
  - Vehicle power rail tracking

    - Route location sensing
    - Tire pressure and temperature
- Degrading performance of any would cause a vehicle to take the next exit
- Failure of any would cause the vehicle to signal a failure to
    - All the vehicles traveling together in that segment of the roadway
        - Reduce the speed of all trailing vehicles OR
        - Emergency stop of all trailing vehicles
    - Signal the previous and the next station of a vehicle failure
    - Both stations would take automated action
    - The previous station would force exit all incoming vehicles until the diverting gate to the center channel can be opened (about 1 minute). Then traffic would resume using the third center bypass channel.
    - The next station down the line would send tow vehicles to remove the failed vehicle.
    - No collision would occur as all vehicles in that segment would slow at the same speed to a stop. Detection of the failure would happen in mill-seconds.

8.3 Station NTS Access Control

Stations function as gateways to the high-speed NTS roadway and run performance checks on vehicles entering the system. As a vehicle moves through a station, automated systems make numerous safety and performance checks that a vehicle must pass before entering the automated NTS roadway. Listed are some of the checks a vehicle must pass:

- Vehicle steering and power probe functions are checked and, if necessary, calibrated.
- Machine-Vision checks for
    - Tire defects or punctures
    - The body of the vehicle is check for damage that might come off during high-speed travel
- Vehicle performance logs are reviewed
    - Tire pressure log
    - Tire temperature log
    - Control computer logs of performance and corrections
- Failure to pass any review would stop a vehicle from entering the high-speed roadway

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9. Financial Infrastructure Implementation

The NTS toll roads will be built along high-traffic routes first. Revenue from these routes will then fund a nationwide NTS network. Implementation of 50 to 500-mile independent segments of the NTS toll road depends on the distance between the connected cities. Each section is proposed, funded, designed, and built as a standalone business entity linking up with others as needed, eventually creating the nationwide NTS network.

STAKEHOLDERS	PERCENTAGE
Government	5%
NTS Organization Franchise	5%
Railroad Rights-of-Way	5%
Small Investors – $2,500 shares max investment $250,000	85%

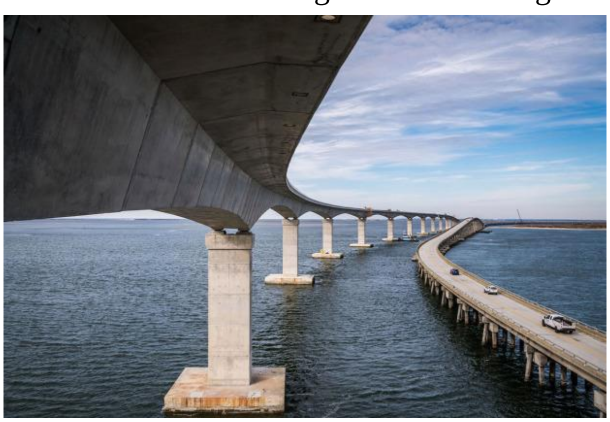
All stakeholders would invest in the NTS toll road and station infrastructure at the percentages shown above.

- The Government would receive 5% of net income as a transport tax.
- A government-like NTS organization is a franchise that funds and manages the construction and operation of each segment of the NTS Toll Road. The franchise would receive 5% of net income and 10% of gross income as a franchise payment. The organization would create an expansion fund for rural network expansion and to areas of low traffic density.
- Railroads would invest in 5% stake for 5% of net income using their Right-of-Way
- Small investors would have a different type of investment, based not on sales of goods but the transport of materials and people. The return on the investment would continue as long as the NTS infrastructure lasts. Small investors can trade shares and receive a shared dividend of 85% of net income.

It is funded mainly by millions of small investors and will not increase the tax burden.

9.1 New Infrastructure Cost Estimate

The estimated cost of the elevated roadway has been done by comparing the actual cost of bridge construction. Many factors will affect the exact cost. Included here are some of the considerations in building the Mark Basnight bridge.



The cost of build over water is far more than overland, but the construction techniques should apply. [xv]

"The design of a structure is generally carried out according to a deterministic approach. However, all structural problems have associated initial uncertain parameters that can differ from the design value. This becomes important when the goal is to reach optimized structures, as a small

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variation of these initial uncertain parameters can have a big influence on the structural behavior. The objective of robust design optimization is to obtain an optimum design with the lowest possible variation of the objective functions. For this purpose, a probabilistic optimization is necessary to obtain the statistical parameters that represent the mean value and variation of the objective function considered. However, one of the disadvantages of the optimal robust design is its high computational cost. In this paper, robust design optimization is applied to design a continuous prestressed concrete box-girder pedestrian bridge that is optimum in terms of its cost and robust in terms of structural stability. Furthermore, Latin hypercube sampling and the kriging metamodel are used to deal with the high computational cost. Results show that the main variables that control the structural behavior are the depth of the cross-section and compressive strength of the concrete and that a compromise solution between the optimal cost and the robustness of the design can be reached."

Another comparison comes from Florida's state DOT construction estimate for various interchanges and bridges.

TYPE	COST SQ FT	TOLL ROAD SQFT / MILE	COST MILE
New Bridge	$250.00*	195,360	$48,840,000
Replace Bridge	$260.00*	195,360	$50,793,600
Interchanges	$245.00*	195,360	$47,863,200

Table 1 costs * [xvi] (FDOT Document)

9.1.1 Construction Method

"A box girder (also known as a tubular girder) is a girder that forms an enclosed tube or hollow box-like structure with multiple walls. The development of roadway systems all through the world is generally the consequence of an awesome increment in movement, populace, and broad development of metropolitan urban territories. This extension has prompted many changes in the utilization and improvement of different sorts of scaffolds and bridges. As Span builds, the dead load is an essential expanding element. To decrease the dead load, pointless material, which is not used to its full limit, is evacuated out of the segment. This outcome in the state of box girder or cell structures is contingent on whether the shear disfigurements can be disregarded or not. Traverse range is more for box connect girder as contrast with T-bar Girder Bridge, bringing about a similarly lesser number of piers for a similar valley width and consequently brings about the economy." [xvii]

This type of construction allows for very efficient construction with minimal impact on the surrounding ground level area.

The hollow interior space can house utility high voltage power lines, communication lines including fiber, and other pip-lines protected from the environment. Such usage would be charged a fee and help reduce the cost of construction and maintenance.

9.1.2 National Implementation of NTS

National Network 47,000 Mile

Cost per mile: $52.2 Million
Cost Nationwide for 20,000 miles (32,186.8 km): $1,043 Billion

Revenue Generated Annually
Revenue derived from usage fees of 50.6 cents per mile

Average Net revenue per mile: $20.7 Million
Average Net revenue Nationwide: $413 Billion at 40% of the current traffic

10. Social Impact

A travel service that all can use would change society. If everyone had access to the same convenient, high-speed, door-to-door service, the advantages of car ownership would disappear. If all had access to efficient travel, it would level the playing field giving all the same access to shopping, jobs, medical services, and recreation. The low-cost group travel or shared vehicle travel feature of this service makes it possible to include all people regardless of financial, physical, or mental disabilities. Why? Because to use the travel service requires only three things, a pickup location, a destination, and a way to pay for the service: no driving skill set or physical or mental abilities. Revenue generated by millions of travelers can pay back the infrastructure very quickly. The significant revenue stream could accommodate the disadvantaged.

Trips using this technology will be automated, quick, low cost, and very convenient, causing many to use this as their only means of travel. A Phoenix AZ study showed that it currently has very high traffic volumes on I-10 and other major roads. If just 60 percent of that traffic would use NTS, then payback will be rapid, and the system can afford to offer free rides to those in need. NTS can provide no-charge rides of 35,000 per day and 50% off trips for an additional 35,000 per day. The free and half-off rides would total 70,000 per day and reduce revenue by only 10% in the Phoenix area. The same should be valid for NTS in any urban area in the country.

10.1 Millions of New Jobs

Creating a new transportation service and new infrastructure will create millions of construction jobs and maintenance jobs. When implemented nationwide with 47,000 miles of the NTS toll road and over 11,700 stations, people will be needed to manage and maintain the automated systems, manage the retail and fast-food space, and countless more to staff the services. Such a network would require 7 million new electric vehicles and 815 million solar panels.

10.2 Millions of Small Investors Will Have a Constant Income

Millions of people will have the opportunity to create a stable income stream based on a travel service rather than consumer markets. Small investors will provide 85% of the funding and reap excellent returns. With 40% to 80% of the trips made on the NTS, high usage of the system will provide substantial returns as long as the NTS toll road exists. Simulations have shown that any corridor with current interstates traffic at congestion levels of 250,000 to 350,000 vehicles per day will generate very high returns. If 60% of existing traffic of 289,000 per day used NTS, then each 100-mile segment with an average trip of 15 miles creates a 21.1% return. A $70,000 investment at this usage level would pay an annual dividend of $14,739.00. The direct yearly road federal tax would be $11 billion, and the education fund would be $70 billion. If 80% of the current traffic used NTS, the annual return would be 28.6%, with tax revenue of $15 billion annually and the education fund is $94 billion. These numbers are based on an initial NTS size of 20,000 miles.

10.3 New Travel Opportunities

Trips that are currently too expensive or time-consuming would now be possible with travel time cut by 50% to 80%, as in the travel scenarios previously described. Another example in California is that four business partners want to celebrate a good month by treating themselves to dinner in San Diego after work from their downtown office in Los Angeles. Three hours before the trip, they use a cell phone app to call for a limousine, with beverage service, to arrive at their office at 5:00 pm. The self-driving vehicle arrives promptly at 5:00 pm. The vehicle confirms the trip to Mitch's Seafood Restaurant in San Diego. The trip time will take 68 minutes, at the cost of $61.42 for four people, drinks extra. Their adventure begins with a 6-minute drive to the downtown LA NTS Station. With a station processing time of only 1 minute, the limo proceeds onto the NTS toll road, with a trip time of 52 minutes. It takes only 1 minute to exit the station and 9 minutes to arrive at the restaurant at 6:08 pm, with time to spare for their 6:30 pm reservation.

Had the partners traveled by today's conventional travel, their drive time would have been 2 hours, 51 minutes for the 120-mile trip(Based on MapQuest.com/directions).

Via train, this trip would have taken 2 hours, 52 minutes. The partners would need to leave work earlier to catch the 2:58 pm train, which would arrive in San Diego at 5:50 pm. This choice would have cost the partners $56 each, one-way. While at the restaurant, they would constantly be checking their watches, constrained by time in order to catch the last return train at 8:59 pm. They arrive back in L.A. at 11:59 pm, at a return cost of $56 each.

Commercial flights to San Diego for dinner and back that night are not available. Only with a private plane would it be possible. NTS time 1 hour, 8 minutes door-to-door for $61.42.

L.A. to San Diego travel time is cut to 40% of current drive time. Boston to New York took only 1 hour 44 minutes, shortening the current time of more than 4 hours. As stated, the elderly couple could leave their home at 8:00 am and arrive in Boston at their grandchildren's home before 10:00

am. They could spend the day, have dinner, and leave when the children go to bed at 8:00 pm, then arrive home before the 10:00 pm news. No other travel mode can provide that level of service.

10.4 Future Expansion At 80% of Current Traffic

As the NTS toll road expands, it would eventually equal the size of the interstate highway system at 47,000 miles. Total system revenue would approach $2 trillion, with the government tax revenue of more than $35 billion at 43% of roadway capacity. The education fund would be over $220 billion. 30 million small investors would share a dividend of $700 billion. More travel options with travel easily for young and old, and those that cannot travel on their own and increased leisure and sightseeing trips will significantly increase traffic above 100% of current traffic levels. Increased travel volume creates unprecedented investment dividends.

11. Summary

The new NTS travel service provides a green, climate-friendly 30% reduction in GHG emissions. It would impact transportation in significant ways, such as:

- COVID-19 safe, private door to door travel service
- Same transit opportunity for all
- All-electric National Transportation Service for passenger and freight
- 50% reduction in the city-to-city travel time
- 75% reduction in commute time over driving on city streets
- The low-cost toll of 50.6 cents per mile for the vehicle, not per passenger
- Very low-cost group travel (L.A. to San Diego cost $7.65 per person with an 8 passenger van)
- Elimination of most traffic accidents, injuries, and fatalities
- Elimination of most traffic congestion delays
- Elimination of most weather-related delays*
- 15% reduction in cost for transport**
- 70% reduction in air travel flights***
- More personal time (shorter travel time)
- More productive time (able to do other things while traveling)
- New job opportunities
- New economic development
- A new source of retirement income
- A new source of education funding

* The toll roadway provides weatherproof travel with a cover above the entire network.

** The actual cost of car travel is summed up by the IRS allowance for business car travel. For 2019 the rate was 58 cents per mile while the price for NTS is 50.6 cents per mile, which includes vehicle rental and energy.

*** 70 - 80% of domestic flights are less than 500 miles, and NTS is faster out to about 700 miles when airport time is added to the travel time. [xviii]

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