Don't Hold Your Breath for Highway Tunnels: Assessing the Resurgence of the Urban Tunnel Phenomenon

Dana DuPuis

Introduction

Anyone who has spent much time trying to get around in Los Angeles can tell you how horrible traffic congestion can get. In a global study of over 1,000 cities, LA placed highest in average hours a commuter could expect to spend in congestion per working year at 104.1 hours ("Global Traffic..."). This statistic likely came as no surprise to the many residents like Phil Rivera, whose 3.2 mile commute takes 30-40 minutes — only slightly faster than walking (Yu). The same study revealed the top 10 most congested American cities have only gotten more congested since 2015. Unless this trend is to continue, city planners have to adopt new visions for commuter traffic.

One such vision came on December 17th, 2016 when billionaire inventor Elon Musk angrily tweeted "Traffic is driving me nuts. Am going to build a tunnel boring machine and just start digging." Six hours later, and presumably free of the early morning rush hour that prompted the tweet, he reaffirmed his road rage fueled plan (Tracy). By the end of January, a hole had been excavated on SpaceX property in LA; Musk and the tech writers who idolize him proclaimed the experiment underway (Marshall). One of President Trump's infrastructure advisors, Richard LeFrak, hailed Musk's initiative on national television (Belvedere). After

the digging began, in an interview with *Wired*, Musk provided some logical reasoning behind a move underground:

> If you think of tunnels going 10, 20, 30 layers deep (or more), it is obvious that going 3D down will encompass the needs of any city's transport of arbitrary size… You have tall buildings, they're all 3D, and then everyone wants to go into the building and leave the building at a same time… On a 2D road network, that obviously doesn't work, so you have to go 3D either up or down. And I think probably down. (Marshall)

The urban automobile tunnel movement has taken firm root across the nation in the late 20th and early 21st century before Musk's personal project, from Boston's Big Dig to Seattle's Highway 99 excavation. Lok Home, President and CEO of the Robbins Company, a prominent tunnel boring machine (TBM) cutterhead manufacturer, wrote a public response to Musk's ambitions on his site's blog, praising him for "getting the general public to think about solving traffic by going underground." At their core, these projects offer a palatable solution to the everyday troubles of traffic and the environmental impact of countless cars idling in the middle of the city — out of sight, out of mind.

The reality on the ground (or underground as the case may be) is far more complicated than simply boring through the earth. While this project and ones like it appear to promise much, they oversimplify the interconnected systems that make up traffic, and will further damage urban areas. Not only is Musk's specific tunnel scheme questionable, so too is the entire concept of underground highways. I will detail the significant challenges urban tunnels face before their opening, specifically

their cost of construction and legal barriers.[1] In valuing these costs, I will also assess the benefits these tunnels provide in both environmental and traffic impacts, as well as the expected beneficiaries. Although high capacity car traffic tunnels have certain advantages, their duration of construction and extreme cost severely limit immediate application. In some cases these tunnels have improved accessibility, however their introduction often brings many disadvantages, and their advantages are mostly only felt by commuters and other nonresidents.

Can you dig it? Construction Barriers

While Musk has technically broken ground on his own property, the immediate scale of the project is far smaller than his tweets first let on. The tunnel in progress today is by no means a cross-city highway — more appropriately it should be called a cross-boulevard alley, as its only effective purpose will be to link the employee parking garage with the SpaceX facility by tunneling under Crenshaw Boulevard ("Elon Musk's..."). Admittedly, it will provide an opportunity for Musk to develop technological improvements he desperately needs to make a cross-city tunnel effective. During a site visit to a tunneling machine in Washington, DC, Musk asked the machine operator if a tunneling goal of mile per week was possible (Chafkin). That Bloomberg reporter Max Chafkin was invited to attend this site visit calls into question Musk's mile per week goal — was he exaggerating his question because he knew it would attract

[1] When discussing the construction and planning of these tunnels, highway and transit tunnels can be used interchangeably because they follow the same important construction procedures, however as explored in the second half of this paper, the impact of automobile tunnels is entirely different.

more attention? It is entirely unclear how seriously he can be taken,[2] or if the entire project is nothing more than a publicity stunt to generate more headlines for SpaceX and Tesla, Musk's other ventures.

If Musk is to be taken at face value, however, a mile per week would be an incredible improvement, at almost 2,000% higher than the machine's current speed (Chafkin). Construction of tunnels is notoriously slow, from Boston's 15 year long "Big Dig" to San Francisco's projected 9 year long Central Subway Project (Hofherr; SFMTA). Construction times greatly increase when engineers account for the incredibly varied geological strata which must be bored through. In a Robbins Company white paper, employee Noah Johnson emphasized the difficulties his company faced when working in San Francisco, particularly when they had to switch out the cutterheads of their TBMs (127). According to the US Army Corps of Engineers, seismic activity along tunnel routes and "[t]unnel damage [caused by earthquakes] is expected," of particular note for LA and other cities near fault lines (124). Groundwater reservoirs and underground gasses must also be accounted for before construction begins, as well as carefully watched for during boring (U.S. Army Corps of Engineers 38, 79).

Drilling in urban environments is considerably more difficult than tunneling that takes place outside of cities, since the impact of tunneling must not seriously impede the lives of the city's citizens. Although they function out of sight of the surface, no tunnel is bored in a vacuum. The existing layer of underground piping and access tunnels — which are

[2] Chafkin does note that Musk has also suggested nuking Mars to Stephen Colbert and developing an *Iron Man* suit for the US military, "outlandish statements designed to troll the press or simply amuse himself." It is possible that Musk's Boring Company will dissolve once the employee tunnel is complete.

often either unmapped or poorly mapped — is far denser than many initially believe, and must also be avoided or moved out of the way with little interruption to life on the surface (Graham 284). Residents are also forced to cope with increased traffic and noise near entrances and exits of the tunnel during construction. The complexity of removing the bored earth further limits the capacity to tunnel. With increased tunneling speed, speed of waste removal must increase. A mathematical analysis of Musk's goal clearly demonstrates the challenges he faces. If his company did innovate in TBM technology enough to accomplish tunneling the length of a mile in one week, he could end up filling a single 20 ton hauling truck (Fig. 1) every second. If any significant part of this monumental increase in traffic is felt on surface streets, the project would quickly become politically doomed. For widespread tunneling to become practical, advocates still face substantial technological barriers before their implementation can become widespread.

Hey, that's my dirt you're digging! Legal Barriers

Urban tunnels (like any urban construction) face a multitude of legal challenges. Whether through simple negotiation or eminent domain, tunnel projects must currently acquire permission to drill beneath private property from each landowner (Marshall). In a city, this can mean thousands of households and businesses must be at least officially included in the project's planning. For many urbanites, these kinds of projects seem inexorable, but wealthier neighborhoods are often sources of extreme resistance. LA's subway system was prevented from tunneling beneath Beverly Hills High School for almost a decade thanks to consistent legal challenges from its wealthy neighbors (Fig. 2) (Broverman). Neal Broverman with the LA Magazine unsympathetically

blames the city's Westside for unnecessarily halting expansion of public transit, ostensibly for safety concerns, but with the unstated fear that "they [city officials] won't be able to build more underground parking." Tunnel projects have to be presented to city officials in a way that convincingly argues their value to constituents, which can be difficult if the tunnel is oriented towards providing commuter support.

Objections from wealthy citizens to use of their underground space is not limited to public officials. In his book *Vertical*, Newcastle University's Professor Stephen Graham explains how extremely wealthy citizens in London are increasingly turning to "iceberg houses," which occupy more underground area than on the surface, "like the clichéd arch-villains of a James Bond movie" (313-314). These basements usually serve lavish entertainment purposes, equipped with "bowling alleys, swimming pools… billiard rooms," and various other diversions (Graham 314). One need not look across the Atlantic to find these domestic bunkers, as the trend has spread to some wealthy neighborhoods in the US as well, including the Hamptons and Silicon Valley (Higgins and Scheinin). Building below ground allows homeowners and developers to inflate the value of houses, while circumventing height or historical regulations. This inversion of the traditional view of the basement as a storage room

Fig. 1 M917 dump truck(Freightliner LLC) If work continues every day of the week for a mile tunnel with a 30 foot diameter, and using volume and weight standards used by the US Army, excavators would fill 44 of these trucks every minute, totaling 5 million yd^3 of dirt and stone, weighing up to 8.75 million tons.

invokes a perceptual shift in the value of underground space. As knowledge of these constructions spreads, leaders of tunnel projects should expect more resistance from wealthy neighborhoods, who may want to hold construction off when faced with the possibility of their own personal underground complexes.[3] Like many other NIMBY-style resistances, serious objections to tunnels should be expected from wealthy residents who perceive a risk to their sovereignty. The usefulness of such objections appears to be decreasing, especially when they

Fig. 2 ("Route of the Purple Line extension")
Here the Beverly Hills obstructionism is clearly demonstrated. The LA Metro's Purple Line is currently composed of only 2 stops unique to that line. The other five light rail lines have an average of 16 stops unique to each line ("Metro Rail & Busway").

interfere with a project the rest of the community agrees upon as necessary. Before highway tunnels become mainstream, national property rights reform would likely be required, a process which could take decades.

[3] Musk in particular probably need not worry about iceberg-houses interfering with his LA tunnel — instead he should worry about the earthquakes interfering with the iceberg-houses.

Where's the Air? Environmental Impact

Before more of these tunnels are constructed, it is vital to assess their impacts. One possible (yet traditionally unexpected) impact of highway tunnels is their potentially decreased environmental footprint. Since tunnel air must be circulated to keep their internal atmospheres safe for cars and their passengers, they provide a unique opportunity for capturing of car exhaust. Brusselen et al. demonstrated this ability when modeling a proposed project to replace an existing "open air ring road" in Antwerp, Belgium with a "filtered tunneled ring road" in a study funded by both the Belgian government and the tunnel's developers, Ringland (1). They predicted measurable, "considerable health gains for the approximate 352,000 inhabitants living in a 1,500 meter perimeter around the current open air ring road," giving tunnel proponents a trendy, concrete benefit they could present to city councils and state governments (2). The ring road of a city as large as Antwerp will always have traffic on it, regardless of the money poured into public transit, so arguably planners should make some effort to contain its pollution.

Antwerp's ring road is not the only case of a tunnel being touted as the more environmentally friendly or healthy option. Sydney, Australia's Cross-City Tunnel, (CCT) was also marketed to residents and officials as a way to filter downtown car exhaust. Ultimately, the project has come under fire as an example of what experts like Professors Graham Haughton and Phil McManus have called "rollout neoliberalism," in which a government and project advocates "work[ed] with the grain of greater public sensitivity regarding environmental and social concerns to gain public acceptance" (91). The private sector oversold the value of the CCT to Sydney and Australia at large as a healthy and environmental option when in fact it did little to promote either issue. The evidence for tunnels

as an environmentally healthy option are mostly based on projections and modelling, since it is difficult to quantify the exact impact these kinds of improvements can have unless particular attention is paid before and after construction, and of course, the accuracy of these models heavily depends on their origin and funding.

Breaking Free of Gridlock: Traffic Impact

The picture painted of highway tunnels so far has been particularly bleak, but I have so far almost exclusively focused on their indirect effects and problems of construction, not their actual effectiveness at their true goal: to ease surface level traffic congestion. Like their environmental impact, their effect on traffic cannot be stated with absolute certainty. As stated above, tunnels do not exist in a vacuum, and many variables affect traffic congestion. However, by examining a variety of tunnels, hopefully a greater picture will emerge.

Few would argue the failure of the Sydney CCT to mitigate traffic. Surface traffic increased, entrances lacked proper signage, and the projected usage far exceeded the actual result, meaning the tunnel was far less profitable than originally claimed (97). Through collusion or circumstance a number of free alternative surface roads closed in what the public saw as an attempt to extort toll money, further worsening congestion and public opinion (Haughton and McManus 98-99). Estimates for ridership were so inaccurately low that the tunnel has changed owners three times, and its current owner, Transurban, is reportedly seeking to force the Australian government to lower the toll (O'Sullivan). Haughton and McManus caution against Australia's preference for neoliberal "public-private partnerships," (PPPs) which have also been suggested in the US, most notably by the previously

discussed Presidential advisor LeFrak (Haughton and McManus 102, Belvedere). These PPPs "rhetorically [present] failure as success and opposition as 'short-sighted,'" claiming to be "reflexive" and "open to adaptation and change" despite neglecting or ignoring "opportunity costs" and regulation until a crisis point is reached and the government is forced to intervene (Haughton and McManus 102). In the case of the CCT, government officials were incorrectly convinced that a need for the tunnel existed and have been saddled with a piece of expensive and underperforming infrastructure.

Boston's Big Dig also presents itself as an important example, most notably how profoundly its frustrations embedded themselves into the municipal memory. It's planning and construction were fraught with costly missteps, wasting time, money, and the life of an innocent citizen (Hofherr). Despite the projects failures, however, public planning experts have identified the Big Dig as part of a broader renewal movement in US infrastructure characterized by a "privatization of political power… ironically… stemm[ing] from popular efforts during the 1960s and '70s to restore citizen control to transportation planning" (Fein 48-49). In her article "Can We Talk Rationally About the Big Dig Yet?" with Boston.com, Justine Hofherr explains that for all the benefits the project brought to the city, "the numerous snafus that occurred tend to overshadow." Hofherr identifies three lasting legacies of the Big Dig: financial, environmental, and public relations disasters — none of which relate to the day to day traffic of the city, which serves as an indicator of popular value of the Big Dig's traffic contribution.

According to the Boston Globe at the time of the Big Dig's opening in 2006, however, the average time to travel through the city center decreased from 19.5 minutes to 2.8 minutes, and the number of people

living within a 40 minute drive of Logan International Airport increased by 800,000. The discrepancy between the popular perceived value and the measurable traffic impact is a direct result of the poor project management. If tunnel advocates want tunnels to spread across urban areas, they will need to avoid the precedent set by the Big Dig, and accurately estimate project costs, as well as ensure construction is carried out smoothly.

The Holland and Lincoln Tunnels connecting New York City to Jersey City underneath the Hudson River have been vital to the health of both regions since their constructions in the early 20th century (Gillespie 49, 57). Their age makes them two of the oldest urban tunnels in the world, with the Holland Tunnel predating the Big Dig and subsequent tunnels by more than 60 years. These tunnels provide insight into their long term impact, free from the complaints of construction. While both entrances are located in city centers, the tunnels are primarily used by commuters driving to New York from New Jersey's suburbs during morning rush hour and returning home after work (Gillespie 137). In his book about the two tunnels, Angus K. Gillespie[4] notes that "predictably, this is the group that is least satisfied with their tunnel experiences," and associates it with a cultural desire to own a large enough house to support a family (137-138). When these urban employees are unable to buy near the city, they end up purchasing houses increasingly further away from their places of employment. In a metropolis like New York City, this can mean commuters live 90 minutes away from their workplaces, leading to getting up earlier and leaving work later (138, 141).

[4] A professor of American Studies at Rutgers University

But what do drivers think of their experiences with the Holland and Lincoln Tunnels? Congestion inside the tunnel is rarely a problem. Instead, frustration and delays are found on their approach roads, which bottleneck the tunnels (Gillespie 149). One Port Authority cop described the approach roads as "stuff[ing] one hundred pounds of potatoes into a seventy-five pound sack" (Gillespie 149). If city planners want to expand the tunnels to accommodate the extra 25 pounds of potatoes, they would either have to shut down the tunnels to expand them, or construct additional tubes. As discussed in the next section, however, this approach will only invite more commuters and bring more cars. When critically evaluated, these two tunnels provide the same tradeoff as many other highway infrastructure improvements, such as increased access to more surface streets with the cost of enabling a commuter culture and worsening surface street congestion near its entrances.

Who's down there?

Taking a closer look at the people who use these tunnels helps in evaluating the tunnel movement. While there are no significant studies of the demographics of highway tunnel users, certain characteristics about the majority of the group can be assumed because of the tunnels' requirements. First, users must be using a car to take advantage of these tunnels, and second, they must be able to afford any additional fees, such as tolls, that using the tunnel may incur. As is the case with the Holland and Lincoln tunnels previously discussed, if a tunnel connects a city center with a suburban periphery, typical users will be commuters or other visitors to the city. Urban residents stand to gain very little from tunnels such as these, except through the indirect benefit of having commuters working in their communities, which some might argue is no

benefit at all. In her renowned book *The Death and Life of Great American Cities*, Jane Jacobs dedicates an entire chapter to the "Erosion of cities or attrition of automobiles" (338- 371). Jacobs claims that "increased city accessibility by cars is *always* accompanied by declines in service of public transportation," presenting increases in car accessibility as fundamentally opposed to increased public transit accessibility (352). By expanding surface streets, planners invite more cars to fill the vacuum, and close that space off from public transit, bikes, and pedestrians. If expanding surface roads has a demonstrated negative consequence on urban life, one could expect a similar result from high capacity tunnels.

Commuters are not the only group that stands to benefit from urban tunnels. Cargo delivery within cities as well as truck routes through them could serve to benefit from urban tunnels by both saving trucking companies money and isolating trucks' pollution, allowing it to be filtered out through ventilation systems. The idea of segregating traffic based on its type is not new to this new wave of tunnel advocates. In his 1929 text, *City of To-Morrow*, Le Corbusier advocated putting "heavy goods traffic" where he called "below-ground" (164). His meaning of "below-ground" really meant underneath the giant stilts on which his enormous skyscrapers were planned to be perched, however the principle is essentially the same; all other traffic was physically elevated above heavy goods traffic (164). In execution, both solutions also share a similarity: total impracticality due to cost. Neither urban highway tunnels nor Corbusier's stilted skyscrapers provide enough measurable benefits to justify their cost.

Conclusion

Any project that promises to immediately alleviate all of Earth's traffic problems should be held under close inspection. "One-size-fits-all" approaches often neglect the cost to the public, and for the foreseeable future the cost of tunnels remains tremendous. Put simply, there is no one solution to the problem of traffic. Neglecting roads entirely leads to difficulties not only for commuters, but also for cargo deliveries, which are just as important to a strong urban economy. Overemphasis on roads will likely lead to increased congestion as more cars fill the new space. Increasing availability of public transit will only go so far, as some commuters will continue to be disappointed with its coverage regardless of efforts, while an underfunded transit system will likely force more users to drive, worsening congestion even more and hurting the urban residents who depend on it. Urban planners and city officials must be wary of proposals like Musk's and be aware of their unintended consequences.

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