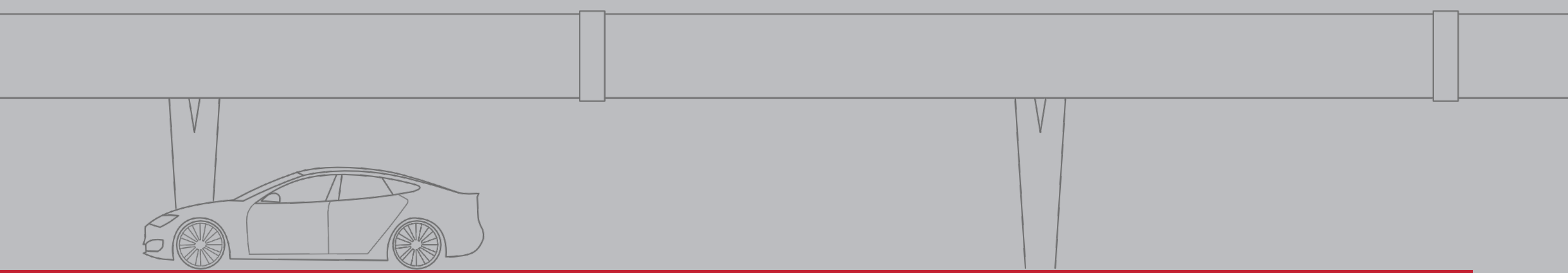

THE AUTOMATED CITY.

COULD ELON MUSK'S TRANSPORT TECHNOLOGY PLAY A ROLE IN DEVELOPING AN OPTIMAL URBAN FABRIC FOR THE FUTURE OF THE UNITED STATES OF AMERICA?

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CONTENTS

PREFACE

“Londoners…bear the brunt of…the longest commute in the country at 74 minutes – almost twice the worldwide average of 40 minutes” (Cotton, 2018).

The motivation for this research stemmed from a six-month period I spent living in London to complete my Part 1 architecture placement. While enduring a 45-minute commute, each way, to and from work I began to question the impact that the transport networks had on the urban fabric of London. The London Underground somewhat governed me from an economic and social perspective. Starting to think about the sustainability of a commuter lifestyle, and whether or not it was a form of existing instead of living, I wanted to use this opportunity to extend my thinking and to look in depth at the sustainability of the three-way relationship between a city’s built form, society and transport networks. London, however, was only an initial springboard for my thinking. Upon further research into this topic, I realised that the USA exhibited much greater issues in terms of transport than the UK.

This research would not have been possible without continued support from my tutor, Richard Coyne, family and friends throughout the research and writing process. Thank you all for your unwavering support.

ABSTRACT

“The automated city” offers an analysis of the social, economic and environmental impact that Elon Musk’s proposed transport systems could have on creating an optimum urban future for the USA. Additionally, it will highlight, if implemented, how well Musk’s thinking aligns with urban theories that put architecture and urban design at the forefront, and how these could be affected by Musk’s transport innovations.

While Musk’s concepts have been written about extensively from an economic and technical perspective, there is a gap in analytical literature discussing their impact on both the physical urban landscape and the way humans interact with it. This research, therefore, presents an initial infill of this gap; could Elon Musk’s transport technology play a role in developing an optimal urban fabric for the future of the USA?

WHAT IS ARCHITECTURE?

Architecture is so much more than the design and construction of buildings. For the purpose of this exploration, in the words of Bjarke Ingles (2014), architecture can be defined as,

"*the art and science of making sure that our cities and buildings actually fit with the way we want to live our lives: the process of manifesting our society into our physical world.*"

If the current urban fabric of the USA, especially its low-density suburban sprawl character, is a reflection of how society manifests itself into the physical world, and architecture is the process of manifesting our society into the physical world, then the importance of transport to this manifestation makes transport itself an integral part of architecture.

ABBREVIATIONS

ICE – Internal Combustion Engine

EAV – Electric Autonomous Vehicle

VMT – Vehicle Miles Travelled

USA – United States of America

GHG – Green House Gases

GDP – Gross Domestic Product

INTRODUCTION

The current urban fabric of the USA, subject to increased climatic concerns, social and economic segregation and suburban sprawl does not offer an optimal urban model for the future of humanity. As the population continues to grow, with increasing amounts of people finding their place within the urban fabric of cities, it is more important than ever before to improve such urban fabric while there remains the opportunity. The issue, following the widespread acknowledgment by society of the need to move towards an optimal urban future, centres on how this will be achieved.

Responsible for this non-optimal crossroad is the transportation industry and the built environment with which it is intertwined. Therefore, one of the proposed solutions for creating an optimal future involves substituting the carbon-heavy and manual transport systems already in place, with high tech, clean and autonomous upgrades or alternatives. At the forefront of developing these solutions are individuals such as Elon Musk with their Silicone Valley-style transport advancements.

This dissertation offers an exploration into how Elon Musk's transport innovations through Tesla, Hyperloop and Loop have the potential to play a part in the creation of optimal urban fabrics. Using a broad understanding of the technical aspects surrounding his innovations, the relationship between transport, the city, and architecture and future urban forms that support an optimal future, this dissertation will begin to fill a visible gap within literature. While the technical aspects and aspirations of Musk are largely documented along with future urban forms, there is a gap that discusses the reality of how the city and its societal complex will affect Musk's implementation and the impact that, if implemented, his concepts could have.

This exploration will be split into three main parts which together will offer an in-depth and comparative analysis of the relationship between Musk's concepts, the urban fabric and an optimal future. The first will investigate the import role that transport has in the urban fabric of the USA and the necessity of altering it to achieve an optimal urban model. The second will go into depth discussing and analysing Musk's concepts, plans for the future and accreditation for the role that he could play in society's future. Finally, part three, using comparative analysis, focusing on economic, social and environmental factors, offers an understanding of the reasons why Musk's concepts may or may not be welcomed into the existing and future urban fabrics, followed by a speculative analysis of the possible impacts his technology could have if his concepts were indeed implemented. To conclude, an insight is offered into whether or not Musk really does have a role to play in developing an optimal urban fabric for the future.

PROCESS

“The automated city” utilises secondary sources from within the last 10 years in order to develop a base framework of theory and statistics which can then be analytically compared. Extensive attempts were made in order to carry out primary research, in interviews, with Musk’s companies directly and architecture/urban design practices involved in early design collaborations. However, due to the confidential nature of innovative technology, there was a general consensus of companies not willing to comment beyond what is already within the public domain.

Transport is currently experiencing some of the largest technological innovations since the invention of the ICE with enormous amounts of research and development in electrification, autonomous vehicles and new high-speed mass transit systems. Engagement on a global scale from governments, corporate organisations and the majority of car manufactures in at least one form of transport highlighted the breadth of topic that is technological transport innovation. Therefore, in order to carry out an effective analysis, it was important to establish parameters in which to look at in greater detail.

Musk’s investments in both private transport and mass transit make him incredibly relevant to broad discussion on the influence of transport. He provides not only a comprehensive level of innovation but covers multiple methods of transport that most cities utilise, at least to some extent (Rode, 2015). Musk has also focused and tested the majority of his developments within the USA in response to their carbon-heavy, auto-dependent, growing nation. The USA is addicted to driving while boasting one of the most unsustainable urban forms in the world – economically, socially and environmentally (figure 1.0) (Calthorpe, 2011, p.37). Musk, not driven primarily by money, aligns in thinking with many urbanist theories with intent to provide an optimal future to ensure that humanity can function to the best of its ability.

Upon selecting Musk and, inherently, his associated transportation concepts as the focal point of transport innovation, in order to effectively analyse his intersection with the built environment it was important to establish an understanding of how the urban fabric, independent of transport technology, is evolving to obtain its optimal form. Looking specifically within the USA, there are a number of urban design strategies that promote optimisation through the densification of buildings, walkability and the use of mass transit. Although often contested, for the purpose of this paper, such an urban design approach was best suited to contrast with Musk’s transport focused approach.

Figure 1.0 – Low-density suburban sprawl - Atlanta, USA.

MURPHY, D. (2017) *Suburban Atlanta*. Available at: https://www.theguardian.com/cities/2017/apr/19/where-world-most-sprawling-city-los-angeles#img-2 [Accessed 14/11/2018]

In order to begin this exploration and develop a sound understanding of both transport technology and the architecture of urban design, research began with some key secondary sources. A complete comprehension of Musk’s aims, concepts and reasoning came from his biography, “Elon Musk: How the billionaire CEO of SpaceX and Tesla is shaping our future,” supported by interviews, media coverage and company mission statements written by Musk himself. Urban design theories, used in contrast to Musk, are those of Peter Calthrope, Vishaan Chakrabarti and Hank Dittmar. The research is further supported by independently-found secondary sources that look more generally at transportation technology and the relationship it has with, and the importance of, the future optimal city. Case studies are also used where appropriate to contextualise the speculative outline in reality whether in the USA or elsewhere. Due to the rapid developments being made within the field of sustainable technology the majority of sources found in order to provide backing evidence are sourced through online journals and media articles, a developing area that has progressed even in the 12 weeks taken to write this paper.

01

TRANSPORT AND ARCHITECTURE

A COMPLEX RELATIONSHIP

As the world's population grows, and is expected to reach 9.725 billion by 2050, there is an increasing pressure to design cities that can not only accommodate this expanding population but do so in an optimal manner. This pressure is further increased by the fact that predictions from the United Nations show more than 50% of the global population living in cities by 2050 (Urbanet, 2016).

While possibly considered by Musk as a future where finite fuels are not used, the optimal urban fabric expands to include but is not limited to, land use, social capital and economic equity. Simply, it is important to create an urban fabric that can both accommodate the increased volume of people while not inversely affecting but, ideally, improving the lives of those who inhabit it. Some may also think of urban as the centre of a town or city, however, at least in the case of this paper, urban can be used to reference any developed land that is used for living, working or recreation – be it through buildings or purposed green space.

"Cities exist to provide access to people, goods, services and information: the better and more efficient this access, the greater the social and economic benefits of urban living" (Rode, 2015).

Not only are transport systems a physical part of the urban fabric, but they also play an important role in providing people with mobility and access. This integration is so fundamental that it can be "impossible to abstract the vision of the cities of tomorrow from that of the future configuration of their transport systems" (Alessandrini et al., 2015, p.146). If the influence of transport on the development of the urban fabric is as strongly connected as suggested, then it follows that transport must be intertwined with a city's optimal performance. Since the optimal urban fabric has an influence upon and is influenced by social factors, it is clear that the population and the transport systems found within the urban fabric are interdependent. For example, a population increase forces transport to adapt in order to cope with increased demand and, if dealt with appropriately, in theory, the population should receive the benefits of having city access (Debnath, 2013, p.47). Nonetheless, if dealt with ineffectively then the results could prove to be sub-optimal.

Using the USA as an example, it is easy to contextualise this relationship between transport and urban optimisation in a real life setting, a relationship that has ultimately left the urban fabric one of, if not the most, unsustainable in the world. The USA is not only consuming land at twice the rate of population growth (Chakrabarti, 2013a, p.20), the largest producer of GHG (of which two-thirds is produced by buildings and transport), but also continuing to invest more money in the oil and gas industry than any other energy industry (Chakrabarti, 2013a, p.92). These listed effects are only a few unsustainable repercussions as a result of a shift from public to private motorised transportation due to the global adoption of the automobile (Rode, 2015). Additionally, the destruction of mass transit systems, for example the streetcars of Los Angeles by large corporations, added to America's auto dependency (Marshall, 2016).

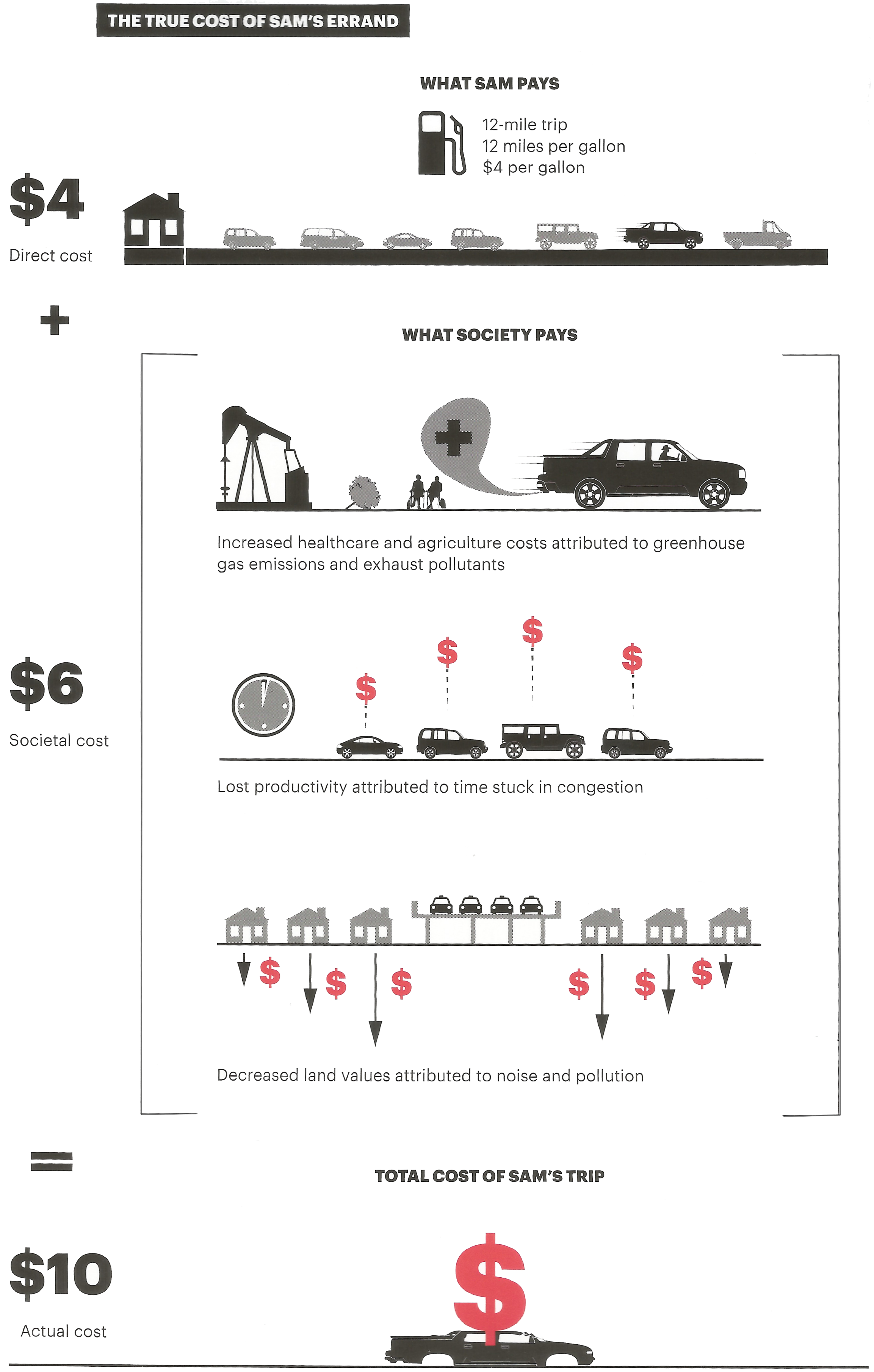
The mass adoption of cars within the USA during 1920 to 1960, and the subsequent changes in behaviours and attitudes towards transport, are considered a major driving factor behind the sub-optimal urban fabric the USA faces today. With exceptions like New York or Washington DC, where density prevails allowing mass transit to thrive, the private automobile has allowed for low-density sprawling developments (Alessandrini et al., 2015, p.146) (suburbs) in which 68% of Americans live (Chakrabarti, 2013a, p.30). Not only promoting unsustainability through an increased consumption of finite resources (oil and gas) and more pollution, automobiles have a wider impact on social, economic and environmental wellbeing. An initial analysis would bring to light community destruction through land zoning, social segregation as the car became a status symbol and a greater societal cost, when comparing the car to mass transit systems (figure 1.1 & 1.2) (Chakrabarti, 2013a, pp. 162-164). America's current sub-optimal urban model, therefore, could be partly attributed to the uprise of the private motorised method of transport.

Just as sub-optimal transport over the past 50 years has been a major contributor to the sub-optimal city, improved transport can also be a contributor towards a more optimal future. This could be achieved through a change in attitude towards transport, a change in the type of transport or a reduction in the reliance on transport. Such changes would be encouraged by, simplified for this analysis, a reduction in transport use through land use alteration, policy reformation or technological advances within the transport industry, in order to increase efficiency in both energy and use. These are taken individually, or sometimes combined, in order to establish additional solutions.

The walking city, a dominant model of the optimal city, focuses on the alteration of land use. Achieved by creating compact, diverse and walkable mixed-use neighbourhoods they not only reduce the need to travel but make people want to walk or use easy to access mass transit (Calthorpe, 2011, p.8). This optimal theory places at the forefront a whole system design involving a magnitude of

Figure 1.1 – True cost of a trip using a conventional car.

CHAKRABARTI, V. (2013) *A Country of Cities*. New York: Metropolis Books, p. 162, diagram.



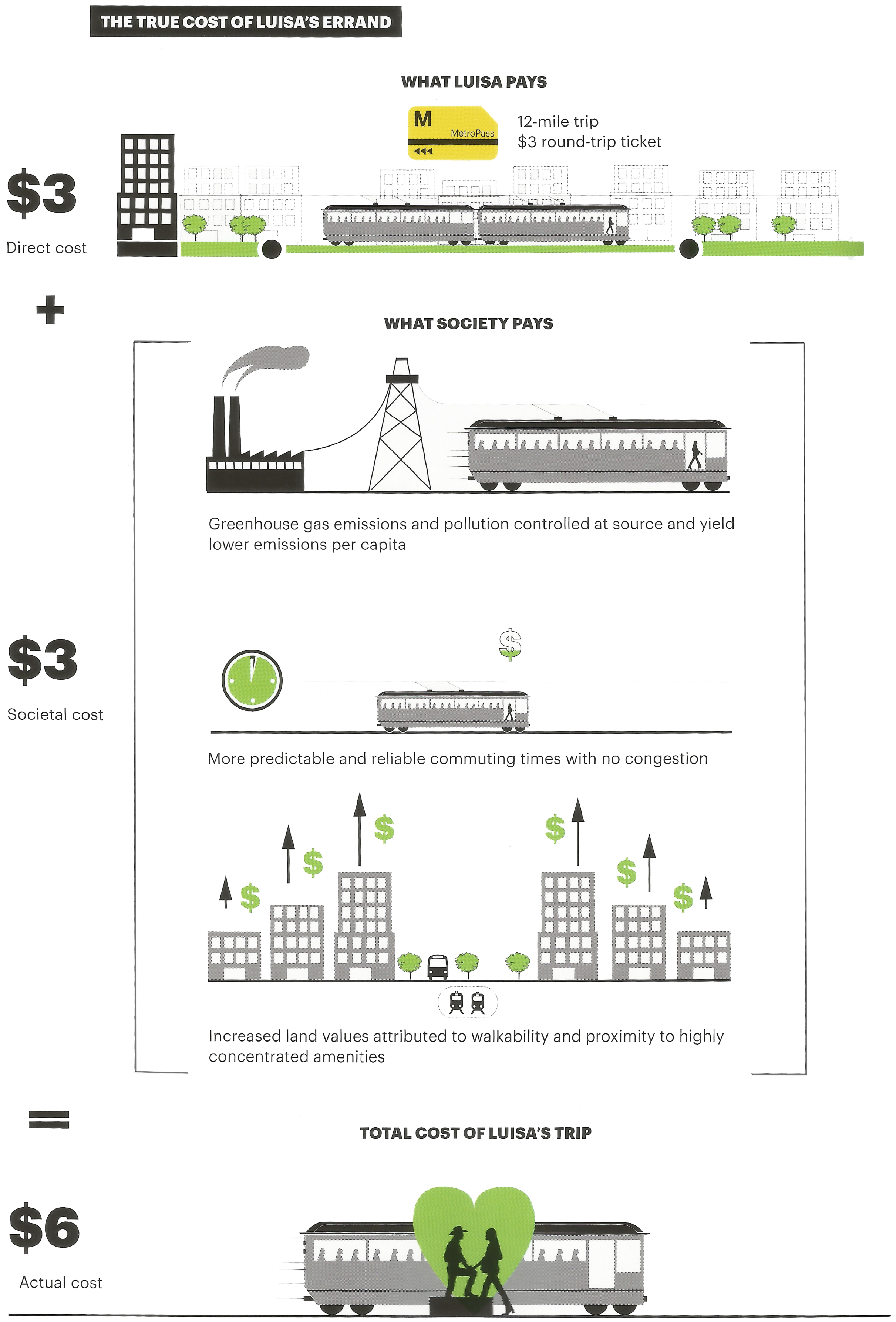


Figure 1.2 – True cost of a trip using mass transit.

CHAKRABARTI, V. (2013) *A Country of Cities*. New York: Metropolis Books, p. 164, diagram.

professions that prioritise architecture and design over transport technologies (Calthorpe, 2011, p.52). A walkable city does not only reduce the carbon consumption through decreased auto dependency but also sports collateral benefits in terms of social and economic equity, affordable housing, savings to public health and land conservation, to name a few (Calthorpe, 2011, p.5). A walkable city is a minimal cost, maximum benefit solution that according to New Urbanism theorist Peter Calthorpe (2011), deals with:

“our land use patterns [that] were, and still remain, precariously out of sync with our most profound economic, social, and environmental needs,” (p.6)

creating a more optimal future urban fabric.

While many theorists maintain that walkable, dense urban environments are the way forward for urban America, many argue that no matter the intent of designers there needs to be a reciprocal support from both the population and the policymakers. However, this desire for an optimal urban fabric does not yet seem to be fully adopted by society with Americans still placing a social expectation on the necessity of driving (Angueira, 2013) and 40% of people still wanting larger low-density housing (Hampson, 2012). There still remains a governmental emphasis on the low-density development, echoed by the amount of continual investment into the highway and road systems (Chakrabarti, 2013a, p.168). Furthermore, while policy reformation from a government level would be ideal, this does not appear likely with the current American political administration. With Donald Trump negating the scientific evidence proving climate change, cutting funding for renewable energy (Smith, 2018) and the USA once-again becoming the worlds largest crude oil producer, it is unlikely that there will be any major policy change from the US government in the near future (Crooks and Sheppard, 2018).

This lack of engagement from the government therefore leaves open the opportunity for technology companies to further movement towards an optimal future. In terms of transport, this finds substance in both evolved methods of transport, through electrification and automation, and completely new forms of both short and long-distance mass transit systems. While many technology giants and auto-manufacturers are developing within these areas, Musk is one of the leading innovators within the USA market. Instead of relying on land use change, he places technology and innovation at the forefront of achieving an optimal future.

02

ELON MUSK

SILICON VALLEY STARTUPS

Elon Musk, a globally recognised name, due to his constant desire to tackle the impossible, can, without doubt, be considered one of the most prominent technological innovators and businesses figures of the twenty-first century (Vance, 2016, p.5). As a major investor and authoritative figure in companies changing the future of EAVs, solar energy and the aerospace industry, he claims his ultimate goal is to "save the human race from self-imposed or accidental annihilation" (Vance, 2016, p.17).

As the owner of the two most successful green companies in the USA (Vance, 2016, p.321), Musk claims not to continue to innovate in order to make money but instead places an alternative focus to "solve cars, global warming and make humans multiplanetary" (Vance, 2016, p.353). His entire operation, 'Musk Co.', which includes Tesla, The Boring Company, Solar City and SpaceX, is driven by his concern about how things are going to function in the future, and the sadness he experiences when he thinks about things manifesting in a sub-optimal manner (Smith, 2017).

After completing dual degrees in economics and physics, selling his startup technology companies and netting over $250m, he then used this self-made fortune to start Tesla and SpaceX (Vance, 2016, p.89).

Musk's aim to create an optimal future for the human species was not initially driven from an environmental perspective but instead, one that focused on the continued progression of civilisation (Smith, 2017). However, he now has a strong environmental motive, cultivating Tesla as a way to move the economy from mine-and-burn hydrocarbons towards sustainable energy (Musk, 2006). Tesla, a company dedicated to accelerating the advent of sustainable transport through mass market EAVs and solar power, is only one of Musk's transportation concepts (Musk, 2013). The second and third, both relying on advanced tunnelling technology to create more sustainable methods of transport, are part of Musk's The Boring Company. Hyperloop is a high-speed long-distance mass transit system, while Loop is an intra-city point-to-point rapid mass transit system. Undoubtedly, Musk's plans for an optimal future revolve largely around transport innovations.

TESLA: THE RISE OF THE EAV

Tesla, the first successful automotive startup since 1925 (Vance, 2016, p.152), focusses on using improved solar, battery and automotive technology in order to accelerate the world's transition to sustainable energy (About Tesla, no date). Tesla, known to most as a company that focuses on making EAVs, also invests large amounts of money into the development of battery technology for products like the 'Powerwall' and solar technology for their 'Solar Roof' (figure 2.0). Employing Musk's vertical integration business model, there is an aim to not only achieve sustainability but make it as affordable as possible (Vance, 2016, p.351).

The first part of Musk's four-part plan to grow Tesla is the integration of energy generation and storage, making individuals their own utility and encouraging the adoption of the 'Tesla Lifestyle' (Vance, 2016, p.312). This lifestyle will allow people to produce their own power, store it efficiently using batteries and use it as required to power their house and EAV. The second, to cover all major forms of terrestrial transport with the introduction of different personal vehicles, commercial and high passenger density urban transport (Musk, 2016). The third and fourth being intertwined: autonomy and sharing. Teslas will eventually be completely self-driving, once the software has been fully developed and approved by the associated regulators, aiming to make Teslas 10x safe than human drivers (Musk, 2016). This autonomous mode will allow drivers to summon their car from anywhere, sleep or work while 'driving' and, most revolutionarily, 'share' their car while not using it (allowing owners to effectively reduce the cost of their vehicle) (Musk, 2016).

While not initially started by Musk, he became Tesla's biggest shareholder in 2003 after an initial investment of $6.5m (Vance, 2016, p.154). Although as a company they had very little experience in the automotive industry they followed the Silicon Valley model, employed large amounts of talented young engineers and figured it out as they went along (Vance, 2016, p.155). With earlier models released in order to generate capital for research and development, one of Tesla's goals has always been to build more affordable EAVs for everyone. The Model S, released in 2012, along with their more recently launched Model X and Model 3, make up Tesla's current EAV range (figure 2.1 & 2.2) (Vance, 2016, p.265) . All of Tesla's current models are fully electric and equipped with the hardware to allow for the operation of autopilot, Tesla's fully autonomous system, once software has been fully developed. While all these vehicles offer something different, in size, price, and performance, Musk plans to incorporate additional vehicles into the Tesla range, with a semi-truck (figure 2.3) and performance sports car already announced. Although largely focused around vehicles, Tesla's mission state remains the same, "to accelerate the world's transition to sustainable energy" (About Tesla, no date).

Figure 2.0 – Example of an extra suburban property utilising the Tesla Lifestyle package with Solar Roof, Powerwall and Tesla Model 3.

Energy. Available at: https://www.tesla.com/en_GB/energy [Accessed 12/09/2018]

Figure 2.1 – Model X SUV.

Model X. Available at: https://www.tesla.com/en_GB/modelx [Accessed 12/09/2018]

Figure 2.2 – Tesla Superchargers at road side station.

Charging. Available at: https://www.tesla.com/en_GB/charging [accessed 12/09/2018]

Figure 2.3 – Semi-truck.

Semi. Available at: https://www.tesla.com/en_GB/semi [accessed 14/09/2018]

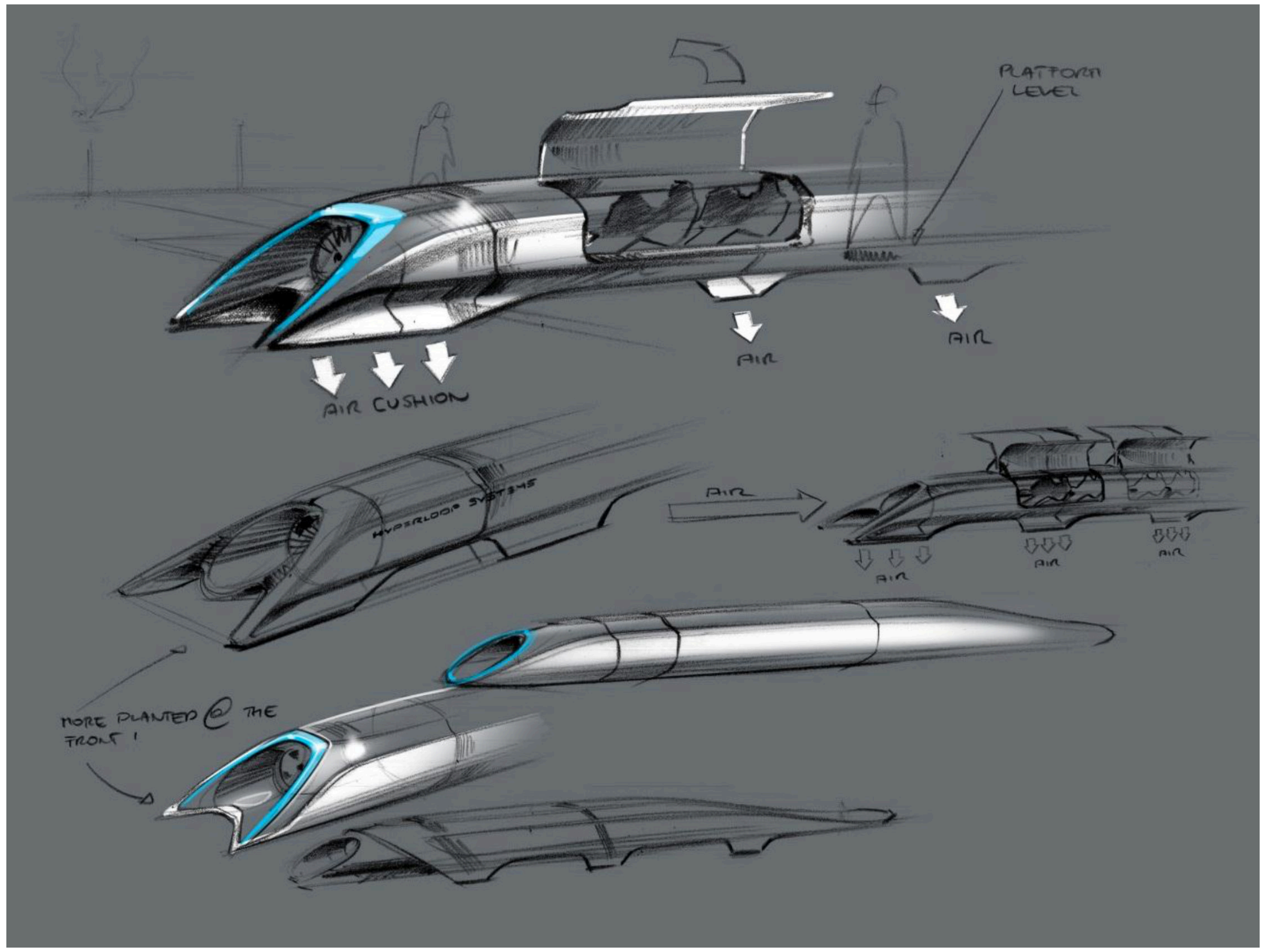


Figure 2.4 – Hyperloop Concept sketches, part of Musk's white paper.

(2013) *Hyperloop Alpha*. Available from: https://www.spacex.com/sites/spacex/files/hyperloop_alpha-20130812.pdf [Accessed 17/10/2018]

Figure 2.5 – Loop concept showing passenger vehicles being lowered into the underground tunnel network.

Loop concept. Available at: https://www.boringcompany.com/ [Accessed 19/10/2018]

THE BORING COMPANY, LOOP AND HYPERLOOP: TUBES AND TUNNELS

Aside from Tesla, Musk's The Boring Company is working to develop technology to support his other transport concepts, Hyperloop and Loop. Hyperloop is fundamentally a new high-speed mass transit system, more environmentally friendly and economically efficient than any other city to city rapid transit currently available. The Hyperloop concept (figure 2.4), outlined in detail with the white paper 'Hyperloop Alpha' in 2013, is a mass transit system that operates with passenger 'pods' carrying a minimum of 28 passengers travelling along a partially evacuated tube, either above or below ground. (Hyperloop Alpha, 2013, p. 11). These 'pods' would travel at around 800mph and could depart at up to 30-second intervals. This concept was born out of frustration over the plans for a Californian high-speed rail link between Los Angeles and San Francisco that Musk did not believe was good enough, nor worth the vast cost (Hyperloop Alpha, 2013, p. 1). If used for distances under 900 miles then Hyperloop, the so-called 'fifth method of transport', has the chance to be safer than driving, cheaper than trains, more convenient than flying, immune to weather, sustainably powered and earthquake resistant, according to Musk (Hyperloop Alpha, 2013, p. 1). While the technology is not yet fully developed, Musk's Hyperloop concept, which was open source, is being commercialised by independent companies across the globe.

The Boring Company is focused on developing new tunnelling techniques in order to make tunnelling an affordable construction method for both intercity and intracity travel in densely populated regions, by reducing costs by at least a factor of 10. It is also developing another of Musk's proposed transport systems (Musk, 2017). The Loop concept, a three-dimensional network of tunnels below cities, like Los Angeles, is a point-to-point intercity express transit system unlike any other subway system (FAQ, no date). Loop is aimed at reducing congestion in dense urban areas that currently operate on a two-dimensional road network. The system operates using individually controlled electric skates, carrying between 8 and 16 passengers or a single passenger vehicle, travelling through a network of tunnels at between 125mph and 150mph (figure 2.5) (FAQ, no date). Loop's tunnels would be accessed by side entry/exit tunnels, with skates being lowered from stations no larger then 2 parking spaces at street level. These stations would be located at numerous locations across the urban fabric (FAQ, no date).

AN ENGINEER, NOT AN ARCHITECT

Musk, ultimately focused on engineering, has no noted experience relating to architecture, urban planning or understanding the complexity of cities. It is evident from previous transportation innovations, for example the automobile and its encouragement of low density sprawl, the magnitude in which transport impacts the urban environment and in more than one way. Qualified in physics and economics, this leaves open contention about how Musk's new transport concepts will affect and shape the physical and architectural aspects of the urban fabric in which he plans to implement them. He talks in interviews about his concepts from a technical and economic perspective, mentioning Hyperloop and Loop 'stations' and their placement in brief passing. From material used to research for this paper, it is apparent that Musk does not concern himself with how his transport would fit into an evolved urban fabric of the future and whether or not their design would still be fit for purpose. This lack of forward thinking and risk-taking are exemplified by the numerous times in which his companies have almost reached bankruptcy (Vance, 2016, p.210). Musk either thinks on the scale of an engineer, very specifically, or on a utopian level, thinking with far-fetched concepts that are too broad. Musk shows a lack of wider thinking within the urban fabric range.

AN EXPERIMENTAL PROTOTYPE COMMUNITY OF TOMORROW

Musk's biography discusses in detail the reason for his work and how his aims have developed over time, however, it never mentions Musk's sources of inspiration. A lack of reference to prior 'transport visionaries' raises possible concern over the originality of Musk's concepts. In the media, during interviews and other publications, his concepts are portrayed as completely unique. This, of course, might be a strategic decision because of the failure that similar concepts experienced before.

Although reference is never made to a source of inspiration, it is possible to draw close comparisons with some previous transport 'visionaries' that placed transport at the centre of their plans to create the optimal city of the future. Aligning closely with Musk's reasoning and execution were Walt Disney's plans for EPCOT (Experimental Prototype Community of Tomorrow) (figure 2.6), also transit-oriented while sharing a common concern for the environment (Mannheim, 2002, p.xviii).

The first similarity in infrastructure can be seen between Disney's monorail (figure 2.7) and Musk's Hyperloop - both high-speed mass transit systems for longer distances between populations centres (Thomas, 2011, p.105).

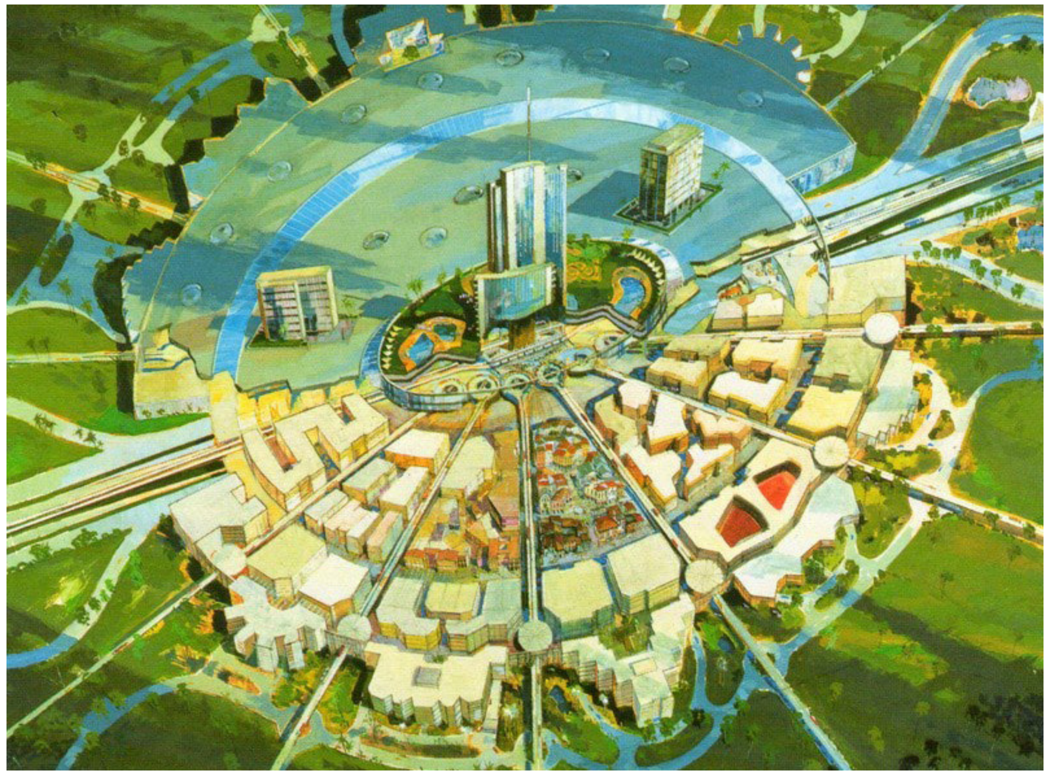


Figure 2.6 – Walt Disney's original EPCOT design.

Walt Disney's original EPCOT [Illustration]. Available at: https://sites.google.com/site/theoriginalepcot/ [Accessed 24/10/2018]

Figure 2.7 – Disneyland Monorail Mark II – 1961-1969.

GLOVER, E. (2013). *The History of the Disneyland Monorail: Mark II, 1961-1969*. Available at: https://disneyparks.disney.go.com/blog/2013/11/the-history-of-the-disneyland-monorail-mark-ii-1961-1969/ [Accessed 19/10/2018]

Secondly, the centre of EPCOT featured a multi-layered transportation system reducing traffic on the 'surface' (Mannheim, 2002, p.33), this time showing similarity to Musk's mission for The Boring Company to decrease traffic by making transport '3D' using a layering of underground tunnels (figure 2.8) (FAQ, no date). Finally, EPCOT's WEDWAY PeopleMover, an electric powered semi-autonomous continually moving shared transportation system could, in abstract, be seen to resemble Tesla's autonomous car sharing plans for the future (Mannheim, 2002, p.34).

Although it could be a complete coincidence that Musk's concepts align so close with Disney's, a lack of reference from Musk and Vance to previous transport visionaries, or the origin of his ideas coming from a source of human

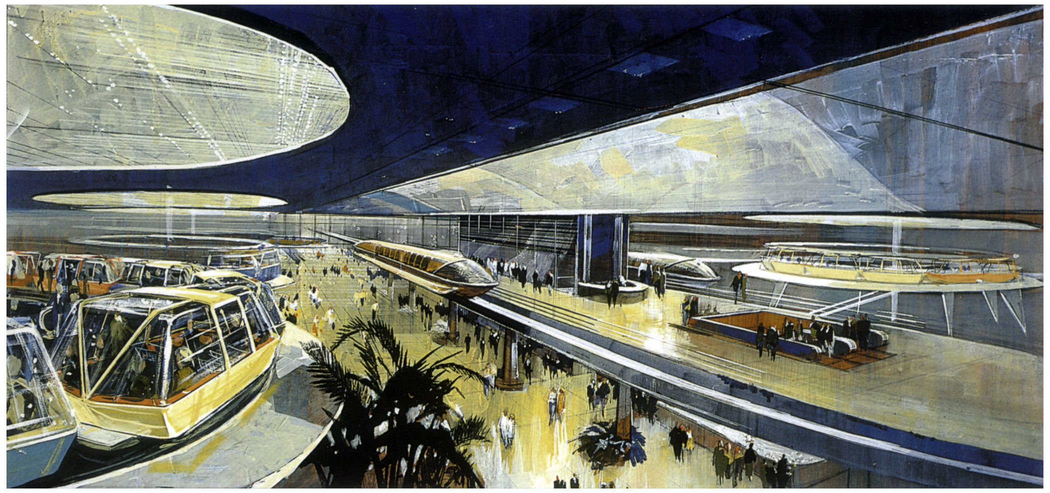


Figure 2.8 – EPCOT's transportation hub showing the Monorial, WEDWAY People mover and the below ground network of tunnels for vehicles.

Tomorrow Land: Disney in Space and Beyond (1966) Directed by Ward Kimball, Hamilton Luske and Jeff Kurtti [Film]. USA: Walt Disney Company

inspiration, could be an attempt for Musk to maintain a positive image in the public eye. Musk does not want people to think that since Disney failed, he will too. Musk, however, has wisely decided not to attempt to redesign the city from scratch, but instead to redesign transport and implement it into an existing urban fabric. Since it was not proved that EPCOT failed due to the proposed transport systems, Musk may not experience the same failure. However, Disney did receive criticism for being a corporation attempting to make large changes to the city, when it was believed that changes like this should come from the government. Of course, Musk could also be accused of doing the same. (Calthorpe, 2011, p.122).

While his transport concepts align closely with Disney's plans for EPCOT, Musk's transport visions also are similar to Archigram's, a 1960's radical architecture collective, plans for the city of the future. Although the collective was based in Britain, they were offering an architect's perspective on how transport was fundamental in creating the optimum city, realised through concepts like The Living City. Archigram talked openly about transportation, discussing how the flow of traffic didn't only provide the city with movement, but was also a generator of form (Sadler, 2005, p.78). They also noted that one couldn't think about the city of the future until traffic, in all forms, had been fully considered, while also making accurate predictions regarding the increase in air travel (Sadler, 2005, p.79). Archigram also discussed concepts for future transport technology, beyond the private car, including a monorail system and even jet powered personal travel. However, a real comparison can be drawn in the fact that neither Archigram then, nor Musk now, attempt to slow down the consumption of movement (Sadler, 2005, p.80). These similarities help to solidify the connection that transport, architecture and the optimal urban fabric have, this time from solely an architectural perspective.

CORPORATE STORYTELLING

While Musk goes into detail about the logistical statistics behind his products, occasionally mentioning them in a worldly situation or in the case of The Boring Company, Los Angeles, his concepts are more often than not marketed without a physical context or a context utterly disconnected from American reality.

Tesla's vehicles are largely photographed on idyllic country roads or in sterile environments with no relation to where Musk intends on them to operate. Marketed mainly through their website or within their minimal stores, their imagery also lacks interaction with the user (figure 2.9 & 2.10) (Vance, 2016, p.15). This contrasts with other major car manufacturers that do not shy away from exhibiting their products functioning in the urban environment with human interaction (figure 2.11, 2.12 & 2.13). Further to Tesla's vehicles are the remaining components of the Tesla Lifestyle package. Like the vehicles, 'Solar Roof' and 'Power Wall' are marketed in disconnected contexts from the reality of how Americans live (figure 2.14). Solar Roofs are shown installed on large suburban American homes where roof areas would likely exceed those in a medium or high-density urban environment.

This marketing imagery does not help demonstrate an equal performance of Musk Co. products in a variety of common contexts. It also begins to raise the question whether or not Musk really does understand who will use his products and where they will be used, if implemented across the USA. As discussed previously, transport systems are an integral part of the urban fabric, and if Musk doesn't fully understand this urban fabric it is unlikely that he can design his transport technologies to operate at their full potential and assist in creating an optimal urban fabric for the future.

Simply, Tesla and their products are very rarely contextualised outside the wealth of the American suburb. This, therefore, outlines that Musk may not actually have a complete understanding of the term 'affordable' within the context of the American population. While he might be confident in producing the Solar Roofs for less than a conventional tiled roof plus the cost of electricity (Tesla Unveils, 2016) and affordable family cars, he is yet to confirm their success if one cannot afford the hypermodern extra suburban sun-bathed house upon which he has proved functionality.

Figure 2.9 – Extra suburban house with Solar roof.

Energy. Available at: https://www.tesla.com/en_GB/energy [Accessed 17/09/2018]

Figure 2.10 – Model X with opened doors showing large amounts of interior space.

Model X. Available at: https://www.tesla.com/en_GB/modelx [Accessed 01/12/2018]

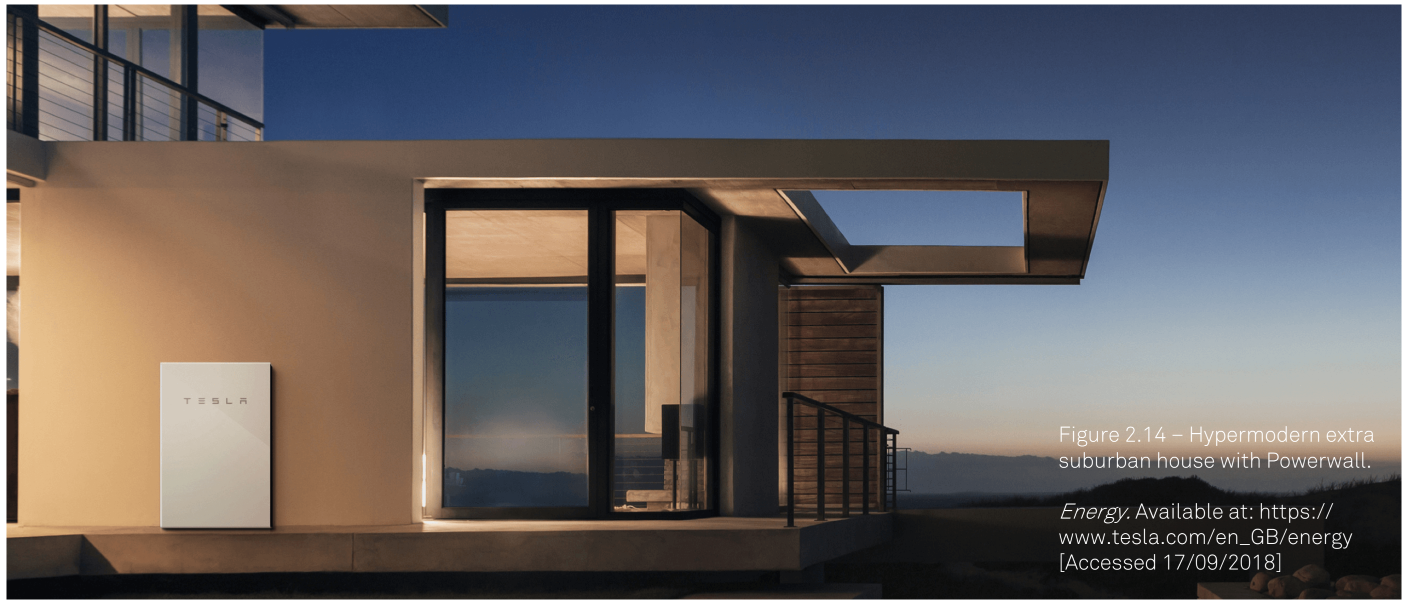


Figure 2.14 – Hypermodern extra suburban house with Powerwall.

Energy. Available at: https://www.tesla.com/en_GB/energy [Accessed 17/09/2018]

Figure 2.11 – Volkswagen Polo, parked within music festival camping area.

Polo. Available at: https://www.volkswagen.co.uk/new/polo-nf [Accessed 19/11/2018]

Figure 2.12 – Volkswagen Atlas with three rows of seats occupied.

Atlas. Available at: https://www.vw.com/models/atlas/section/design/ [Accessed 19/11/2018]

Figure 2.13 – Volkswagen Golf family car.

Golf. Available at: https://www.volkswagen.co.uk/new/golf-vii-pa [Accessed 19/11/2018]

03

IMPLEMENTATION AND IMPACT

MUSK'S CONCEPTS WITHIN THE URBAN FABRIC

As outlined previously, the USA is in clear demand for a more optimal and sustainable urban fabric, not only to ensure its social, economic and environmental longevity but also to ensure that the rest of the world, especially developing countries, are provided with a worthy precedent. While the need for it is clear, how this optimisation is going to be achieved remains debated, prototyped and fluid. Musk's Tesla and The Boring Company are two of the leading competitors covering both EAVs and mass transit. This technology-oriented approach both complements and contrasts with urban design's, dense and walkable cities.

In order to fully analyse Musk's effectiveness in assisting the movement towards an optimal future, one must examine the opposing urban design and transport focused solutions to not only asses their legitimacy in implementation and integration but also their impact if implemented. The first section of this chapter, using current urban forms and proposed dense walkable cities as an architectural landscape, examines how economic, social and environmental factors will affect the implementation and integration of Musk's concepts. The second, optimistically assuming implementation is successful, looks at how his concepts will affect both current and future urban forms and the associated social, economic and environmental repercussions.

Riding on the belief that Musk will be able to execute technological development to the level he outlines, all Tesla vehicles will be capable of Level 5 automation where "always and everywhere, all dynamic activities are automated with no need for human interaction" (Disruptive change 2018, p.5), resulting in the full adoption of the 'Tesla Lifestyle'. As for The Boring Company, tunnelling will be a much more cost-effective and efficient process and used to implement Loop, an underground point-to-point transit system that carries pedestrians, cyclists and cars upon electric 'skates'. Additionally, Hyperloop will connect major cities within 900 miles of one another achieving both the speed and regularity proposed in Hyperloop Alpha (Hyperloop Alpha, 2013, p. 2).

IMPLEMENTATION

Often regarded as a product of the automobile is America's dominating low-density suburban sprawl. Although moulded largely by the automobile, this development method was and still is strongly supported by government policy (Chakrabarti, 2013a, p.19). This urban model both encourages and discourages the integration of the Tesla Lifestyle, Hyperloop and Loop concepts within the urban landscape.

From the simplest perspective, the current urban model supports the integration of Tesla due to a continual increase in VMT caused by a spreading population. This is solidified by statistics showing that since 1960 the average house size has almost doubled while the amount of occupants has almost halved in the USA (Chakrabarti, 2013a, p.44). There is also established infrastructure of arterial highways and cul-de-sacs that work to connect the created zoned areas (Dittmar, 2008, p.19), however, the urban landscape does differ largely from city to city, state to state and of course from country to country. This complex and spread out environment raises the issue of Tesla being able to establish an accurate model of this entire network in reasonable time (Musk, 2016), meaning Tesla's driverless features will be unlikely to roll out countrywide but instead by city by city or even road by road (Disruptive change, 2018, p.4). Although it may present time constraints, the physical urban form does not place too many other constraints on Tesla's integration.

The low-density suburban model, if it continues to prevail, does, however, pose fundamental challenges to the integration and viability of Hyperloop and Loop. Numerous studies have identified that in order for mass transit systems to be successful surrounding residential density must equal or exceed 30 units per acre (Chakrabarti, 2013a, p.28). Currently, only about 4% of Americans live in areas that match or exceed the required density, with over half living in housing that is 1 unit to 1 or more acres of land (Chakrabarti, 2013a, p.28). Due to Hyperloop and Loop being mass transit systems, the current urban model simply would not allow them to be a national alternative to current transport. Further, the implementation and cost-effectiveness of a Hyperloop system is dependent on the physical distance between destinations and the terrain that lies in between. The route that Musk defines as an alternative to the California high-speed railway, San Francisco to Los Angeles (from which he also bases his costing example), is rather unique compared to the majority of the USA. The proposed Hyperloop infrastructure for this route would be able to follow the existing, almost straight-line, Interstate 5 and sits well within the 900-mile feasible range (Hyperloop Alpha, 2013, p. 5).

If the urban environment was to change and embed walkable city theory to create compact and walkable neighbourhoods there would be sufficient density to support the mass transit element of both Hyperloop and Loop. Combined with the reduction in automobiles that walkable cities would likely bring and with the remaining cars now being fully autonomous, the highly reduced need for parking could see these once used spaces repurposed as Loop 'stations' (FAQ, no date). This condensation would afford people the opportunity to walk to transport stations, however, the demand for using transport would also be reduced due to more services and amenities that are required on a daily basis being located within walkable distances.

It is clear, therefore, that the current physical urban landscape is much more suited to the implementation of Tesla without any immediate changes required. The continually increasing VMT, with a spreading population and already established infrastructure of roads and highways, is not only supportive of Tesla but is preventative of Hyperloop and Loop being implemented. This is simply because the average residential density is far below the minimum of 30 units per acre. Hyperloop and Loop would only be viable if urban designers are able to implement the denser, walkable urban fabrics they are aiming for, which in itself would be a lengthy process.

Further environmental factors affecting the implementation of Musk's technologies stem from the climatic sustainability of his concepts. The issues surrounding this area do not stem from his concepts being environmentally irresponsible, as Musk aims to power all new transport using renewable energy, but instead within policy. The primary focus of government transport strategy appears to betray the importance of reducing the amount of carbon dioxide (CO_2) pollution the transport industry creates (Dittmar, 2008, p.6). While polices may mention the reduction of CO_2, this is for efficiency and economic benefits with environmental benefits being given second priority (Dittmar, 2008, p.6). While not directly supporting either Tesla or Hyperloop, it would appear that policy aligns more with Tesla's technological innovations due to the continued investment in the expanding road infrastructure.

Further to environmental factors, economic factors have a strong influence on the likelihood of Musk's technology being implemented within the USA. Economic factors are complicated, not only due to enormous costs involved with the development of the technology and infrastructure, but also the upkeep

ANNUAL FEDERAL INFRASTRUCTURE BUDGET

The Federal government spends a disproportionate amount building and maintaining highways, totaling to more than nearly four times the amount spent on all other transit modes.

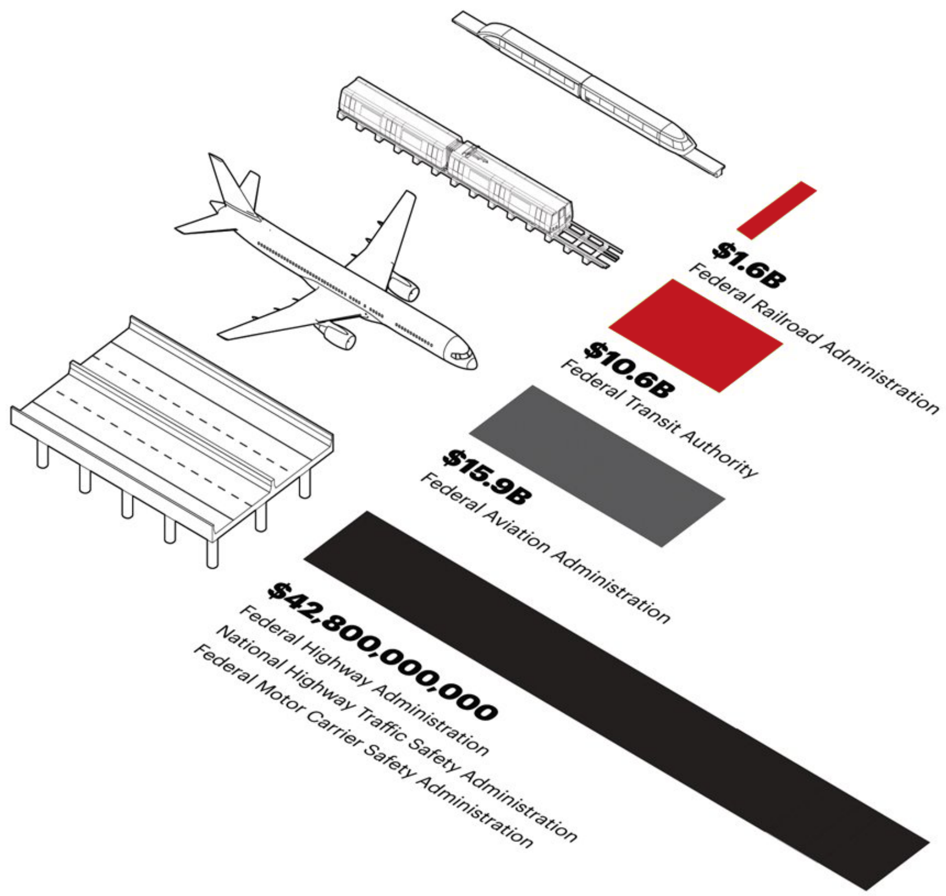


Figure 3.0 – Annual federal infrastructure budget.

CHAKRABARTI, V. (2013) *A Country of Cities*. New York: Metropolis Books, p. 168, diagram.

of infrastructure. The question is usually over who would be responsible for funding these projects – with the likely answer being both private and public investment. Studies show that public funding results in much greater levels of private funding.

“Reconnecting America, a non-profit research centre focused on transit, concludes that every dollar of public investment in transit leverages $31 in private investment. The results speak for themselves” (Calthorpe, 2011, p.85).

From this, it is clear to see that the process of future transport technology being funded and subsequently implemented could be successfully prompted by initial government backing. Although Musk has already personally funded a large percentage of Tesla and The Boring Company’s development (Cuthbertson, 2018), along with other private investors, economic backing from the government could see further private investment into both the technology and the supporting infrastructure. Examining recent annual federal infrastructure budgets, a disproportionately large amount of funding for the highway systems can be seen compared with transit systems funding. While the highway system had a budget of $42.8B, the Federal Rail Association, Federal Transit Administration and Federal Aviation Administration only saw

$28.1B, combined (figure 3.0) (Chakrabarti, 2013a, p.168). These economic differences would therefore suggest that federal government investments would favour Tesla through its support of highway infrastructure. If examining federal energy investment, there is again a disproportionate expenditure which favours oil and gas with $41B of investment compared to only $6B in renewable fuels (Chakrabarti, 2013a, p.92). It is clear that neither Tesla nor Hyperloop and Loop operates in a sector which has direct federal economic backing; instead, there is continued investment into the ICE automobile and the infrastructure that supports it, which Tesla can utilise to support their technology and achieve quicker societal integration.

From a consumer perspective, one of the greatest appeals of Hyperloop or Loop is that it addresses the issues associated with the lack of ridership on current mass transit systems within the USA: they are too expensive and too slow (Calthorpe, 2011, p.83). Musk has a somewhat proven track record of implementing more advanced technology at a dramatically lower cost. With the USA Department of Energy aiming to have battery costs as low as $125/kWh by 2022 in order to compete with the ICE, Tesla are already proving progress by lowering costs from $1000/kWh in 2010 to $190/kWh in 2018 (Electric Vehicle Battery, 2018). This aligns greatly with Musk’s aim to supply a family Tesla for only $20,000, less than two thirds of the cost of an average new light vehicle (Office of Energy Efficiency and Renewable Energy, 2017), and Hyperloop tickets that would get you between San Francisco and Los Angeles for as little $20 (Hyperloop Alpha, 2013, p. 57), less than one third of cheapest average cost and 15 times faster than current rail transit (Hyperloop Alpha, 2013, p. 6). The improved financial benefits for the consumer therefore encourages their support, however, there are further economic issues which could halt the likelihood of federal funding. Although Musk claims he can reduce the costs of tunnelling dramatically by reducing tunnel size, electrifying the process and drilling quicker (FAQ, no date), the historical costs for past subway systems have been extremely volatile, resulting in government hesitation, with costs per mile which can reach $217.4M (Chakrabarti, 2013a, p.160). Additionally, the cost of infrastructure required to support Tesla does not only extend to the upkeep of the road network, as the electricity grid would also require extensive upgrading in order to cope with the increased demand created by electric vehicles (Disruptive change, 2018, p.8). Given this would likely require government funding, it would almost certainly reduce the amounts available for investment in mass transit.

After examining the economic incentives for the consumer and public funding, it is clear that while large investment is required Musk's transport concepts could prove to be beneficial for the consumer in the long run. However, with the government most likely to be responsible for kick-starting the funding and implementation process with an initial economic backing, which the current administration will not likely agree to, the implementation process could be slowed down. Instead, funding will need to come from private sources, which will not reach its full potential without the initial government funding.

While environmental and economic factors strongly influence the likelihood of the implementation of Musk's transportation concepts, there must also be a demand from society. Simply creating a network of driverless cars, or constructing Hyperloop and Loop, does not create the optimal city. Society needs to want to change and accept these new methods of transport in order for them to become the main form of transport, instead of being supplementary. While some social factors favour Tesla over Hyperloop and Loop, and vice versa, there are many social factors that strongly work to prohibit either of them being implemented into both the current and future urban fabrics.

Time is a consistent part of society that could prohibit implementation. Primarily lies an issue with the length of time taken for widespread comfort surrounding new technology. Neither self-driving technology or high speed vacuumed travel are concepts easily understood, especially by the older generation, meaning their adoption will be slow (Legacy et al. 2018, p.6). Like Teslas 'learning' the physical world around them, it will be an incremental process which could take many years to be trusted by everyone and become standard (Higgins, 2018, p.1). There is further time uncertainty surrounding the speed of technological development and Level 5 autonomy being accepted within policy. Relying on transport technology to achieve optimisation, not yet fully developed, accepted or understood, is a timely and risky approach that could fail without any movement towards creating an optimal city for the future (Dittmar, 2008, p.62).

Continuing with the factor of time, but from a different perspective, it is possible to see some social factors that would encourage the implementation of Tesla and EAV technology. Driverless technologies appeal to the consumer as they are able to gain back at least some of the driving time, if not all, that would have before been considered 'dead time' – using it to work, eat or even sleep (Vince, 2013). This positive social attitude towards the time-saving benefits of EAV's is matched by one that supports car sharing, visible through the continually increasing uptake of car sharing programmes like ZipCar (Chin, 2013). While currently utilising ICE vehicles, ZipCar does show positive changes in society's previous attitude that everyone must own their own car (Angueira, 2013), suggesting Tesla's car sharing scheme would be accepted.

There are a number of societal factors that contradict the conditions a Tesla Lifestyle could create. As a society we are beginning to see a revival of the human scale, for example, smaller local businesses. However, construction and infrastructure, especially of highways and the low-density spread that would be a requisite part of the Tesla Lifestyle, do not reflect this (Calthorpe, 2011, p.54). Further, the technology is unlikely to be initially adopted by all consumers, instead early adopters will likely be professionals keen to create a comfortable environment to work in while commuting (Disruptive change, 2018, p.5). This contrasts with blue-collar workers that see driverless technology as a threat to their job (Calthorpe, 2011, p.158). For example, it is accepted that goods transport could become autonomous putting the drivers out of work (Hyperloop Alpha, 2013, p. 6). Another social factor opposing the integration of Tesla is the limited distance from a singular charge and, concurrently, the length of time that battery charging currently takes (Disruptive change, 2018, p.8). Although advancements have been made to decrease this, society may see this as a limiting factor that will reduce the freedom brought with the ICE and its ability to almost continually operate. This could be overcome by switching empty batteries with fully charged batteries at road-side service stations, however this technology has still to be proven (Gunther, 2013).

Possibly one of the strongest resisting factors against Musk's implementation is society's addiction to cheap travel, which if reduced may be viewed as a disadvantage rather than an advantage (Dittmar, 2008, p.7). This addiction, originally fuelled by the commute to work, could see reductions as society's working patterns and methods see change. Improved technology, such as Skype, has resulted in people going into their office less which has reduced the VMT of some individuals (Dittmar, 2008, p.8). Additionally, this reduction in VMT could result in people being happier about taking and more willing to take public transport as it would be a much less frequent than before. However, Hyperloop and Loop, reliant on a dense urban fabric, could face further social rejections. Firstly, their reliance on people walking to transport stations would be benefited by the creation of a walk that was more appealing than driving. It is therefore a complicated yet necessary relationship between societal comfort, the physical environment and new transport systems (Speck, 2013). NIMBYism, a societal standpoint that objects to something that could be perceived as negative being implemented in their neighbourhood, in this case a denser urban fabric, could stand in the way of Hyperloop and Loop's integration (Calthorpe, 2018).

It is clear that economic, social and environmental factors of both the current and possible urban forms of the future play a large role in controlling the implementation of Musk's transport technologies. While the current urban form and societal attitude favour the implementation of Tesla, neither Tesla, Hyperloop or Loop are particularly favoured by current economic factors. In order for any of Musk's transport technologies to be implemented, there must be economic, social and environmental benefit. If one is adversely effected, then it can stand in the way of a new technology being adopted.

IMPACT

Assuming that technological development and their implementation into society and the urban fabric go as Musk has planned, Hyperloop, Loop, Tesla and other transport technologies could have the largest impacted on the cities' economic, environmental and societal future since the invention of the car (Legacy et al. 2018, p.8). Like their integration likelihood, Tesla, Hyperloop and Loop will all have differing economic, environmental and societal impacts, but there will be significant overlap.

"Automatic driving should enhance safety, avoiding accidents currently caused by driver distraction or bad driving behaviour...In some cases the basic, maybe simple, idea is that, since driver error can be considered the main contributing factor in a vast majority of road accidents, a self-driving vehicle should eliminate nearly all accidents" (Alessandrini et al., 2015, p.156).

When one considers that driverless cars could be as safe as flying (Alessandrini et al., 2015, p.156), it is without a doubt that Teslas could play a major role in improving transportation safety, simply due to the removal of human error, estimated to be the reason for 94% of car crashes (Schneider, 2017). However, if everyone is trusting in driverless technology, it has the ability to be programmed to avoid people and have far greater vigilance than human drivers (Piatkowski, 2018). Building this trust could be difficult or, at best, slow, given the incremental integration of EAVs, with technology needing to be proven before cyclists and pedestrians have entire faith in their safety. Extending far beyond safety, EAVs would give access to those who cannot drive, for example children, those with disabilities, or simply extend an element of 'public' transport to those who live outwith the dense centre (Alessandrini et al., 2015, p.152). This would give those previously unable to benefit from access to the city the same mobility as those currently able to drive.

Expanding on the previously discussed factor of time, driverless car technology would eliminate the 30% of driving time in business areas that people waste finding a parking space (Bilton, 2013). Directly reducing time within a car, instead of repurposing it, would theoretically create more time for the user to spend with their family and friends (Chakrabarti, 2013b). This saved time as a result of more efficient driving with less congestion could give back to the average American some of the 293 hours they spend a year driving (Schneider, 2017). Combined, these reduce the societal cost of private transport. However, contrary to the buying back of time, "people might be more open to a longer daily commute", according to Bilton (2013). Longer commutes could essentially counteract the societal benefits brought by driverless vehicles. People that commute further to work are less likely to get their 30 minutes of recommended exercise, be overweight (Chakrabarti, 2013a, p.106) and be more likely to have relationship breakdowns (Chakrabarti, 2013a, p.108). It is not yet clear whether or not people would maintain current commute times, enjoying the benefits of being able to repurpose previously 'dead time', or whether people would be happy to take longer commutes. It would likely depend on society being able to see the ancillary benefits of keeping commute times to a minimum.

In regards to the social divide, if federal investment continues to be focused on road infrastructure, favouring the implementation of Tesla, those on middle to low income salaries could become under-serviced by transport, restricting their access to the city and the associated benefits. This is a direct result of an increase in car usage, lack of new public transport systems, if not cuts to existing ones, and cars being too expensive to buy. While car sharing could combat this issue, with those not able to afford to buy being able to 'borrow' and pay for what they need to use, it relies on those that can afford to buy being willing to let the public have access to their private cars. If the car again becomes a status symbol (Alessandrini et al., 2015, p.146) and those wealthy enough to buy a Tesla decide against sharing it, those unable to buy one for themselves could potentially be left without any form of transport. If this were to happen, it could only be combated with a large fleet of sharable cars owned by the government or private companies, allowing them to make access a commodity. This could potentially lead to further wealth segregation, those able to afford a Tesla benefiting by having access to the city and those that cannot a afford a Tesla suffering the consequences of being outwith the city.

Hyperloop and Loop, requiring a dense urban model, offers health benefits by encouraging users to walk to their local station (Dittmar, 2008, p.18). This promoted walkability, with a reduction in cars on the road, would make the streets safer while re-establishing a sense of community and creating an environment suitable for a diverse community (Dittmar, 2008, p.63). While somewhat utopian, according to Peter Calthorpe, the re-establishment of community is what people want, although they are unaware of how much the ICE car obstructs this (Calthorpe, 2017). Musk is also quick to promote how Loop and Hyperloop would be safe, cheap, sustainably powered and immune to almost all weather, which, without doubt, would be beneficial to the users (Hyperloop Alpha, 2013, p. 2). While Tesla appears to offer the high level of convenience that often raises private motorised transport above public transport, the point to point travel convenience offered by Tesla is matched if not beaten by Loop but with additional ancillary benefits (FAQ, no date).

"While some believe enhanced public transportation will provide benefits for communities that have limited public transit now, others worry the technology might favour the rich" (Higgins, 2018, p.3).

The possible social divide caused by Tesla, especially through private ownership, is likely to be driven by the economics of affordability and individual wealth, although the economic impact of implementation stretches far beyond social divide. This initial economic divide, between those that can and cannot buy, poses a threat to increase the cost of the suburb due to its increased desirability, once again favouring the rich and pushing others further out from the centre. If met with cuts to public transport this further limits access to the cities and its benefits which, if coupled with car owners refusing to engage with car sharing, could create an even larger economic divide (Higgins, 2018, p.3). Those being pushed out are the same blue-collar workers who fear that driverless technology will result in them losing their job.

Musk does, however, claim that Tesla's $20,000 family car can be made even more affordable by allowing for it to be shared with other users, using the money made from this to offset the cost of the car. While this could allow those being pushed further out of town to afford a Tesla (Musk, 2016), this model only works if there is a demand of hire equal to or greater than the availability of shared privately owned vehicles. If demand dropped below supply, the cost off-setting potential drops, again favouring those able to afford a Tesla without the need to 'share' it.

A sprawling urban model, encouraged by Tesla, has a wider economic impact than social divide, for example, the ensuing costs incurred to expand resources and infrastructure. This expansion of road network, utilities, schools and fire services, to name a few, all come at a monetary cost and with the risk that quality with be diluted if additional funding is not available (Calthorpe, 2011, p.43). While there is a stereotype that, in America, the urban centres are subsidised by the suburban and rural economies, it is in reality the inverse. If sprawl continues, more money will be drawn from the cities' economies that currently contribute 90% of the USA's GDP while only using 3% of the land (figure 3.1) – money that could be invested in improving public transport (Chakrabarti, 2013a, p.167). For car manufacturers, EAVs also have an economic impact both in terms of manufacturing and sales. With around 40% fewer parts than traditional cars, there is physically less manufacturing required. As for sales, with potentially decreasing unit sales existing car manufacturers will have to increase continued customer engagement, become service-oriented and asses their workers' skills in order to remain profitable and competitive (Disruptive change, 2018, p.10). While Tesla might not experience such issues, established with EAV production as its end goal, they have contributed to an economic shift within the automobile sector that could have a wider societal impact.

While there are many negative impacts, if adopted as a balanced private ownership or a government-owned fleet of cars, Tesla does offer a number of economic benefits in both the current and future urban fabrics. If sharing were to prevail, people would effectively be paying for only the time they are using the car, which when coupled with theoretically reduced congestion and increased efficiency would reduce the cost of driving (Alessandrini et al., 2015, p.155). This reduced congestion and regaining of time would help contribute to the reduction of the current $101B societal cost caused by congestion and lost time (Chakrabarti, 2013a, p.165). Of course, eliminating the need to find

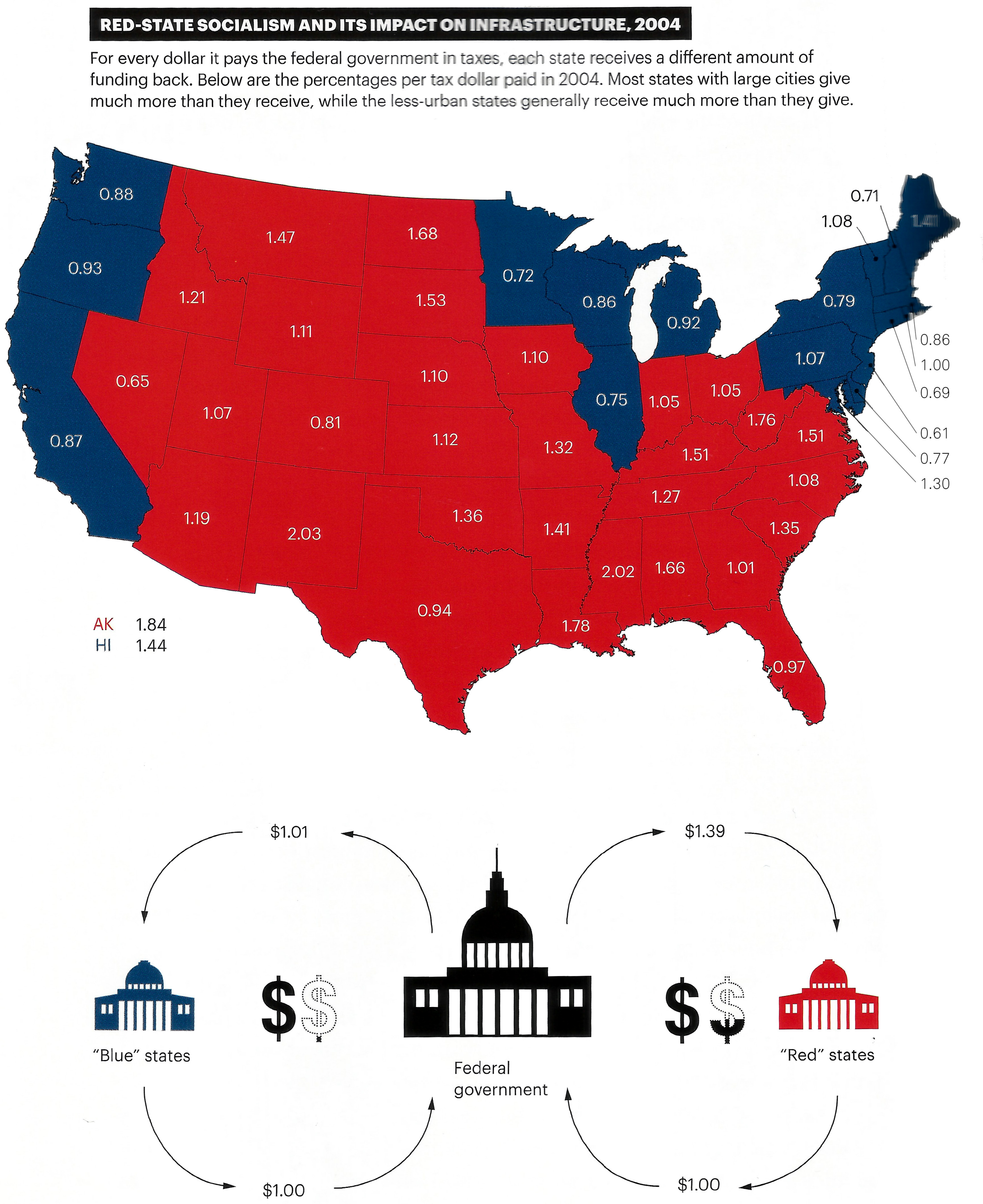


Figure 3.1 – Red-state socialism and its impact on infrastructure, 2004

CHAKRABARTI, V. (2013) *A Country of Cities*. New York: Metropolis Books, p. 166, diagram.

parking saves time, but also reduces the current 33% of urban land that is used for parking. Additionally, driverless shared cars could, on the rare occasion they are not in use, park in a much denser form (figure 3.2) (Alessandrini et al., 2015, p.155). The now unused land could be developed to provide further housing that would not require the extra costs associated with low-density sprawl (Bilton, 2013).

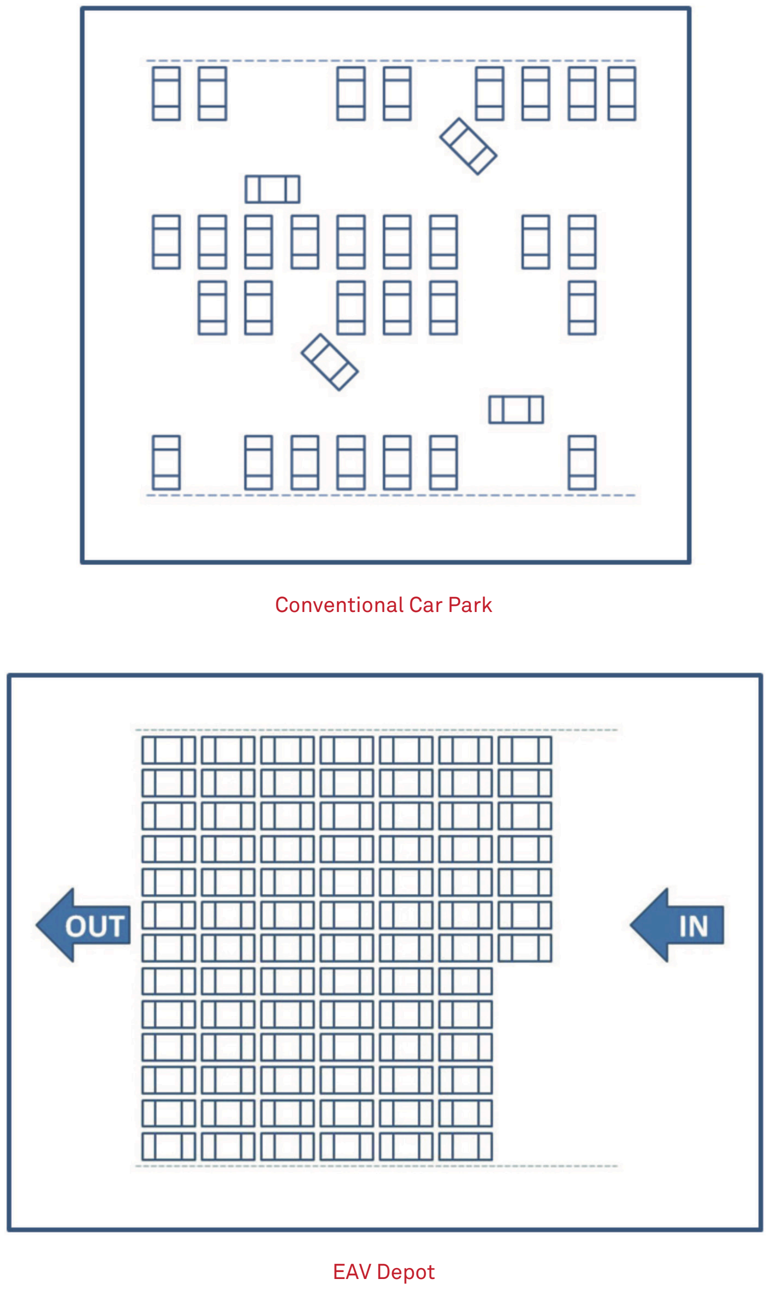


Figure 3.2 – Conventional car parking vs high density EAV depot

ALESSANDRINI, A., CAMPAGNA, A., SITE, PD., FILIPPI, F., & PERSIA, L. (2013) *Automated Vehicles and the Rethinking of Mobility and Cities*. Elesevier. Report Number: Transportation Research Procedia 5, p. 155, diagram.

In contrast, Hyperloop, and its requirement for dense urban environments with sufficient ridership density, has the opposite economic impact. A dense and walkable neighbourhood urban landscape is conducive to lower infrastructure, service and utility costs compared to sprawl. While a growing population will inherently increase costs, an increase in urban sprawl and distance between houses, work and entertainment has been removed, keeping infrastructure and service costs to a minimum (Calthorpe, 2011, p.10). This environment would also reduce healthcare costs by encouraging walking and cycling and improving air quality. Such a reduction in VMT is often met with incorrect stereotypical thinking that it will reduce GDP, however, cities like New York prove this wrong by boasting some of the largest GDP contributions and mass transit ridership in the USA (Chakrabarti, 2013a, p.167).

“In the United States, there is virtually no investment in tunnelling Research and Development (and in many other forms of construction). Thus, the construction industry is one of the only sectors in our economy that has not improved its productivity in the last 50 years” (FAQ, no date).

Additionally, the development of Hyperloop and Loop is not only contributing new transport technology but also developing new privately funded infrastructure to support this technology. The Boring Company, using private investment, is developing new tunnelling technology which is not only quicker and cheaper but advancing a construction industry that has remained stagnant for the last 50 years. These developments have the potential to generate economic benefits beyond Musk Co. and the wider construction industry (FAQ, no date).

The impact that Hyperloop and Loop could have, of course, does not happen without the technologies being implemented, which, if following the USA’s federal agenda that supports investment into private motorised transport and urban sprawl, is unlikely to happen. However, some states on an individual basis show economic support towards systems like Hyperloop and Loop. For example, the state of California have decided to invest $400B in transit, with no investment into new highway systems since 2008 (Calthorpe, 2017). Investment into Hyperloop infrastructure that could provide an alternative to short distance intercity flying could also provide economic benefits to airports and their surrounding economy, by freeing up slots used for short flights and allowing them to be used for more profitable international flights (Chakrabarti, 2013a, p.175).

While economic and social structures would undoubtedly be impacted by the implementation of Tesla, Hyperloop and Loop, the most prevalent and visible change could be in the shaping of the physical urban landscape. Development strategies, sprawling or dense, play an import role in this shaping along with the associated dominant supported transport network.

The most obvious physical change, as a result of Tesla, would be the increase in urban sprawl with larger houses, fewer inhabitants per house and fewer units per acre (Bilton, 2013). The reduction in parking Tesla brings also has a physical impact on the city. Since, on average, half a building’s footprint is currently used for parking, some of this land would become available for building development, repurposed green space or allow for larger buildings like shopping centres to move closer to the centre of the urban fabric. The reduced need for parking also allows for narrower streets which encourages cars to driver slower, thereby creating a safe walking environment. This is one way in which driverless cars could work to help promote a denser urban fabric, as opposed to sprawl, thereby facilitating Loop and Hyperloop.

“Traffic lights could be less common because hidden sensors in cars and streets coordinate traffic” (Bilton, 2013).

The physical changes to the urban fabric will not only be seen in parking re-assignment or building density but also in the road infrastructure and its operation. Due to the removal of human error, cars could continuously flow whilst avoiding each other and pedestrians, thereby removing the need for dedicated crossings, traffic lights or roundabouts and completely changing today’s road system. This improved road system combined with car sharing could cut congestion by 15% in most US cities (Higgins, 2018, p.3). This system of computer-controlled ‘drivers’, respondent to live demands, would also allow for virtual lanes to be created within cites to allow emergency vehicles through or to divert traffic to create space for events or street maintenance (Higgins, 2018, p.2). This would allow for reduced emergency service call times and reduced road closure times for events. However, such benefits could only be realised with every car on the road being an EAV.

“We cannot fool ourselves – or the public – any longer: we can no longer build our way out of the highway congestion problems. It is not an environmentally or financially feasible solution” (Glendening, 2000 cited Calthorpe, 2011, p.84).

Although Tesla's adoption may have some minor positive impact on the USA's urban fabric, it would have much greater negative physical impacts. Firstly, the sprawling land use pattern created would exacerbate the sub-optimal zoning originally created by the ICE car. This environment is far from conducive to character and community (Calthorpe, 2017). Hyperloop and Loop, unlike Tesla, have little impact on the physical environment directly. Of course, the high-density environment that is required to support it impacts unit density, street width and many other physical aspects, however, the majority of new infrastructure would be placed alongside existing highways or in tunnels deep underground. In fact, due to the depth of the new tunnels being excavated, it is effectively undetectable above ground (Musk, 2017).

Further to a physical impact is the impact that Hyperloop, Loop and Tesla could have on the climactic sustainability of the future urban fabric. Tesla, with its aim to replace the hydrocarbon burning ICE vehicles that are often blamed for the adverse climatic affects caused by the transport industry, could be considered at the forefront when it comes to reviewing the climatic impacts of transport. While switching to electric vehicles removes the obvious element of hydrocarbon burning at the point of use, it has been questioned how the electricity to power said vehicles would be produced. Musk's plan to power Teslas using solar energy generated using Solar Roof is an idealistic green vision but requires further investment from Tesla owners. However, without the adoption of Solar Roof technology but continuing down the route of solar energy, a switch to all vehicles being charged by solar energy by 2050 would require 130,000 acres of photovoltaic panels to generate sufficient energy (figure 3.3) (Calthorpe, 2011, p.20). While the energy being produced in such a manner may be clean energy, the environmental footprint of such an installation alone is substantial, with the development of virgin land, large amounts of raw material consumption during manufacture and possible GHG production during transportation. Even though the climatic benefits are relatively large from the implementation of Tesla, these could easily be cancelled out by Tesla's encouragement of increased VMT, suburban sprawl and the building of larger, less sustainable buildings.

Figure 3.3 – Visual representation of 130,000 acres compared to the city of Edinburgh.

Diagram by author.

THE MUSK CO. PARADOX

Musk Co., has a powerful internal contradiction that could prevent any of their transport technologies being adopted on the scale that they hope for. This internal contradiction stems from their investigation, research and development in the field of rapid long-distance mass transit, intracity mass transit and the development of private EAVs, all at once. An initial and obvious contradiction resides in the fact that Hyperloop and Loop are mass transit systems while Teslas are forms of private motorised transport. Hyperloop and Loop also rely on brand new tunnelling infrastructure that currently lacks government economic backing, while Tesla can utilise the heavily funded and already constructed highway network. However, a further internal contradiction is highlighted when examining the urban land use patterns that Tesla compared with Hyperloop and Loop require in order to operate and their influence upon the surrounding urban form.

Through exploration of economic, social and environmental factors, all of which play a vital role in creating society's urban fabrics, one can see that Tesla, Hyperloop and Loop are supported by completely different land use strategies. Hyperloop and Loop find successful placement within a dense and walkable urban form, characterful of urbanist thinking, as it offers a sufficient density of 30 or more units per acre to support viable ridership. The technologies therefore encourage a dense environment where the use of private vehicles is vastly reduced, if not almost completely eradicated, except for those unable to access stations or the minority living outside main urban forms. There would be very little place for Teslas in such urban forms.

Tesla, in contrast, thrives within low to medium density settlements, where highways and roads are continually prioritised. These allow for Tesla to maintain a demand for large VMT and the large 'American Suburb' house that Musk so clearly demonstrates as a suitable framework for the Tesla Lifestyle. In fact, this spread environment and increased VMT would assist in Tesla reaching the required miles driven to achieve Level 5 automation quicker. Tesla would draw money from investment into mass transit systems due to the cost of road maintenance and construction combined with encouragement of longer commutes and a larger volume of sprawl. An acceptance that time in EAVs is no longer wasted and its subsequent influence on the spread of form and people inherently reduces the density needed to support Hyperloop and Loop.

It is thereby clear to see that neither the land use required or encouraged by each of these technologies is complementary to the other, reducing their likelihood of becoming widely adopted forms of transport. In fact, they are diametrically opposed. Simply put, the success of one company would prohibit the success of the other and, in fact, their continued paradoxical co-existence could ultimately prevent the success of either.

CONCLUSION

Musk, without doubt, has advanced the transport industry, delivering transport concepts the public didn't even know they wanted (Vance, 2016, p.295). With Tesla continuing to make cars at an accelerated pace and testing going well for both Hyperloop and Loop (Hawthorne Test Tunnel, no date), it would appear that Musk is moving towards achieving his goal to accelerate the world's transition to sustainable energy (About Tesla, no date) while giving humanity the bright future that it deserves (Vance, 2016, p.5) .

With Musk self-proclaiming himself as the 'architect of an exciting future' (Vance, 2016, p.114) lies a key point of contention over his eligibility to lead the integration of transport technology that could have such a monumental impact on creating the optimum city of the future. Trained as an engineer, with no urban design experience, it must be queried whether Musk sufficiently takes into consideration the important relationship that transport, architecture and the city possess. Additionally, when a rare attempt is made to contextualise the Tesla Lifestyle, it manifests within the hypermodern extra suburban America, outwith the average American's reach. While not conclusive to his likelihood of success in altering the urban fabric for the better, a further cause for concern arises from Musk's lack of reference to inspiration, despite following in similar suit to failed concepts for future cities based upon transport. It would therefore appear that Musk doesn't fully understand the implications of his transport being adopted within the urban fabric beyond a reduction in burning hydrocarbons.

In order to asses if Musk does have any role to play in the creation of the optimal urban form of the future, analysis regarding which transport could, or is prevailing, and which urban form is closest to being conducive of a theoretically optimal urban future, must be brought together. The current urban fabric and established supportive infrastructure, combined with the ability to sell directly to the consumer in small but continuous numbers (Vance, 2016, p.15) and thereby allowing for quicker trust development and implementation, puts Tesla ahead of Hyperloop and Loop. As long as Tesla dominates, it will only become increasingly difficult for Hyperloop and Loop to find a footing both in society and a supportive urban form. Tesla, although reducing America's reliance on hydrocarbons, does not support optimisation in terms of social and economic equity. If viewing optimisation as equity, then design that pushes for a dense urban environment supported by mass transit, in this case favouring Hyperloop and Loop, creates as close as possible to the optimal urban future.

If Musk continues to push for both Tesla, Hyperloop and Loop to be implemented across the USA simultaneously, neither will have a fully supportive urban form nor have optimal impact on the urban form surrounding it. The result would likely be an exaggeration of the split that is seen today - urban forms that adopt mass transit like New York would become denser and closer to being optimal models, while the sub-optimal character of low-density suburbia increases. There also lies the potential for Musk's transport technologies to cancel the others out, without any being successful in their own right.

In order for Musk to have the greatest impact upon an optimal future, he must work as part of a whole system design team. Working with architects, urban planners and other disciplines he could fully understand how the urban environment and its population, economically and socially complex as it is, can affect and be affected by the implementation of his concepts. As idyllic as a singular transport system would be, the reality is that different parts of the USA require different strategies for both urban planning and transport systems, potentially allowing for Hyperloop, Loop and Tesla to co-exist in the same country but not the same city.

Musk will very likely play a role in the creation of an optimal urban future for mankind. If working closely with others, he without doubt has the technological ability to reduce the climatic impact of transport.

While Musk has so far based his concepts within the USA and has not had the most effective impact on creating an optimal urban fabric for the future, there remain markets where the automobile and low-density sprawl do not prevail. Implementation of Hyperloop and Loop in these countries could see them go straight from their current urban models to one that is optimal, completely avoiding the sub-optimal auto-dependent urban form the USA currently exhibits. Musk, if he elected to expand rapidly beyond the USA, could have a much stronger influence on creating a sustainable urban fabric for humanities future (Disruptive change, 2018, p.12).

Musk's transport innovations are therefore very likely to play a fundamental role in the creation of the optimum urban fabric of the future. Whether Tesla or Hyperloop and Loop will prevail, and play a role in the physical shaping of the architecture of urban forms, will likely be determined on a country to country, if not city by city basis.

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