ABSTRACT

Title of Thesis: RETHINKING MOVEMENT

Jose A. Gomez, Master of Architecture, 2024

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Today, there are numerous transportation methods that are constantly changing our landscape. Despite the diversity of transportation options, our approach toward movement has become outdated. The emergence of autonomous vehicles, electric vehicles, sustainable power sources and advanced infrastructure are currently shaping the way we move throughout the world. The advantages of these technologies are clear; high performance, low to no carbon emissions, automatic systems, and improved safety are clearly the direction of the future. However, their adaptation and implementation is slow and ineffective. Emerging technology presents a viable opportunity to design architecture and mobility as a *synergetic system* that can facilitate movement, improve accessibility, and reclaim the human experience from outdated infrastructure. It is therefore important to rethink how we move through space in order to design for *human wellness*. This thesis will explore transportation problems in cities, emerging technologies, sustainable practices, and design guidelines and precedents in search of an efficient moving, self-sufficient, wellness focused future.

Thesis Question: How can *autonomous* and *electric* transportation *technology* promote *wellness* and safety through the redevelopment of existing infrastructure?

RETHINKING MOVEMENT

by

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Chapter 1: Introduction to Rethinking Movement

Intro

Today, we move through our built environment in a variety of ways. Be it by foot, on wheels, or by air, technology has advanced to allow us to travel wherever we want, whenever we want, by any means necessary. Unfortunately, the trajectory of our transportation advancements has led to the destruction of our landscape, rising carbon emissions, unsafe transportation habits, and poor adaptation of new technologies. The widening of highways, erratic traffic behaviors, internal combustion engines, and poorly designed infrastructure has created transportation mayhem. In recent years, innovative technology to improve our transportation methods have been put to the test. Autonomous vehicles are seeking to automate transportation while improving efficiency, hybrid and electric power sources are seeking to improve sustainability and reduce vehicle emissions, and new design guidelines are seeking to improve safety and experience while interacting with vehicles. The biggest obstacle these advancements face is their integration as *a system*; how can emerging technology and design principles prioritize the safety and wellbeing of people? What are these systems capable of doing in order to improve our day to day traffic? And how can these systems promote sustainable communities? It's time to rethink how we move.

Structure

This thesis project focuses on four core topics of exploration to derive a potential solution; 1) Transportation Infrastructure & Problems, 2) Emerging

Technology, 3) Sustainable Practices, and 4) Urban Planning. The core of the project focuses on designing a multi-modal transportation system; far too often are roads and buildings designed separately based on what already exists on a site. This thesis will propose infrastructure be designed in tandem alongside a transportation network to prompt healthier, sustainable options for movement while servicing and promoting the wellbeing of a community.

The section on current transportation infrastructure and their problems will focus on the effectiveness of our current networks. Specifically, the drawbacks that make a (questionable) good transportation network inefficient, unsafe, or damaging to our environment. Topics include the destruction of land to accommodate expanding roads and unappealing structures for the storage of vehicles as well as a variety of safety issues regarding our current driving habits and regulations. These issues range from pedestrian safety to vehicle efficiency.

The section on emerging technologies will present new tools, methods, and techniques for the adaptation of new forms of vehicles, such as drones, electric cars and bikes, and autonomous vehicles. These vehicles present a new way of dealing with sustainability and improve efficiency at the macro and micro mobility scales, however, they come with serious drawbacks, specifically in terms of reliability, range, refueling, and architectural interaction. It is critical to cater architecture to fill in the gaps that make vehicles difficult to adapt. The use of artificial intelligence is one of the biggest topics worldwide, and it has its place in architecture and transportation in the form of autonomous mobility and system controls. While independent research and studies are claiming their effectiveness in real world

experiments (driverless cars), the technology is met with resistance, specifically in the form of trust; peoples' willingness to ride on Autonomous Vehicles varies based on demographics but is constantly negative. The technology does present a forward thinking approach that, when paired with new vehicle types, can revolutionize the way we move.

Sustainable practices are crucial to both architecture and mobility; both are large sources of carbon emissions. The way we build, the way we use buildings, and the way we move have significant impacts but also provide an opportunity to minimize our carbon footprint. Specifically, the way buildings incorporate technology in the form of power systems presents the opportunity to minimize energy draw. The ability to offer multiple programs in one space takes advantage of a building's purpose. Finally, the promotion of autonomous vehicles and micro-mobility for short distances present the opportunity to create self-sustaining communities through on demand, efficient, and sustainable transportation options.

Finally, urban planning and design strategies can create and improve communities through the critical placement of transportation networks, mobility centers, and the redesign of our roads. At the micro scale, improved road design can improve safety, street level programs, and traffic congestion. At the larger scale, a reduction in vehicles will allow nature to regrow in destroyed areas, streamlined highways will present opportunities for additional transit options, and the use of autonomous vehicles and dedicated lanes will allow for safer mobility and reduced traffic.

Chapter 2: Transportation Problems in Cities

Introduction

Walking. Bike. Car. Transit. Flight. These are the transportation options in use in the twenty-first century. Advancements in technology have allowed mankind to create new modes of transportation to adapt to our constantly changing landscapes. With these advancements, however, come multiple problems. Today, we see many transportation problems all over the world, so many that multiple books can be written on them. This thesis will only focus on the most significant transportation issues as they relate to architecture; those that affect our landscape, our interaction with buildings, and our living experience and safety.

Three general categories of problems will be discussed. At the macro level, the destruction of our landscape is seen through the shrinking of roads as they are filled with parked cars, the expansion of highways to accommodate high levels of traffic, and the defacing of areas with antiquated infrastructure. At the micro level, pedestrian, cyclist, and driver safety is at risk. Failure to protect pedestrians and cyclists from vehicles in the form of safe sidewalks and dedicated transportation lanes is evident. Finally, sustainability and our overall well being is affected by noise pollution, carbon emissions, and transportation efficiency.

Destruction of Landscapes

Landscapes are primarily affected by highway widening, building construction, and chaotic use of space. Highway widening, although beneficial for the

connection between cities and traffic experience, is damaging our landscape.[1] In many cities around the world, especially in developing countries, highway widening is allowing for increased levels of traffic, which in turn improves transportation times directly affecting many sectors and the economy. However, expansion causes ecological damage to nearby flora and fauna. At a minimum, the construction of new roads introduces contaminants and particles into the air, and at a maximum, the process destroys land inhabited by various animals and organisms. The process also introduces new pollutants in the environment. The introduction of contaminants mixed with vehicular fluids can create runoffs that further damage surrounding soils.[2] Overall, air, soil, and water quality is affected. Highway widening is occurring everyday with the goal to improve traffic often caused by various driving habits. Traffic congestion is a global problem that is partially resolved through the expansion of highways, but lacks efficiency and does not guarantee success. Despite highway expansion, the core of the issue boils down to driving behaviors. Bottlenecks, areas where traffic lanes reduce, alongside accidents, are primary generators for traffic congestion.[3] Often, we drive on highways that are growing and face the inevitable rush hour or accident that slows traffic down. The addition of express lanes, paid lanes with less traffic, have been shown to reduce traffic, which is beneficial for long distance trips.[4] However, it's evident there is no clear solution for solving these

[1] Kashish Walia, R K Aggarwal, and S K Bhardwaj, "Environment Impact Assessment of Highway Expansion – A Review," *Current World Environment* 12, no. 3 (2017): 507–519,
[2] Kashish Walia, R K Aggarwal, and S K Bhardwaj, "Environment Impact Assessment of Highway Expansion – A Review," *Current World Environment* 12, no. 3 (2017): 507–519,
[3] Afrin, Tanzina, and Nita Yodo. 2020. "A Survey of Road Traffic Congestion Measures towards a Sustainable and Resilient Transportation System" *Sustainability* 12, no. 11: 4660.
[4] Kadeha, C., Alluri, P., & Sando, T. (2020). Quantifying the Mobility Benefits of Express Lanes using Real-Time Traffic Data. Transportation Research Record, 2674(11), 414–423

issues, and highway expansion is not the answer that will bring the most value to the environment.

Pedestrian, Cyclist, & Driver Safety

At a micro scale, pedestrian and cyclist safety are the largest issues related to transportation. Pedestrian safety is characterized by the design of sidewalks including the width and any available coverage/barrier between the road and sidewalk. Additionally, intersections and crosswalks present a major area of concern. Inadequate walking times, poorly marked crosswalks, and pedestrian detection by humans and technology can cause fatal accidents.[5] Researchers argue that speed, visibility, and vehicular interactions are key factors for urban planners to consider when designing for pedestrians.[6] It is noted that traffic control can help make roads and the neighborhoods they service safer. One study shows the effectiveness of reducing speed limits in a residential area; the results show that although adoption of the new posted limits are not initially kept in the first few months, over time more and more people begin to adhere to the new limits.[7] A deeper problem regarding pedestrian safety lies in the definition of walkability; cities may be designed to be walkable; but there is no clear or consistent definition that contributes to a specific goal.[8] Multiple definitions exist ranging from simple having access points for walking

[5] Stoker, P., Garfinkel-Castro, A., Khayesi, M., Odero, W., Mwangi, M. N., Peden, M., & Ewing, R. (2015). Pedestrian Safety and the Built Environment: A Review of the Risk Factors. Journal of Planning Literature, 30(4), 377–392.
[6] Stoker, P., Garfinkel-Castro, A., Khayesi, M., Odero, W., Mwangi, M. N., Peden, M., & Ewing, R. (2015). Pedestrian Safety and the Built Environment: A Review of the Risk Factors. Journal of Planning Literature, 30(4), 377–392.
[7] Md. Tazul Islam, Karim El-Basyouny, Shewkar E. Ibrahim, The impact of lowered residential speed limits on vehicle speed behavior, Safety Science, Volume 62, 2014, Pages 483-494
[8] Forsyth, Ann. "What is a walkable place? The walkability debate in urban design." *Urban design international* 20 (2015): 274-292.

to creating a diverse walkable landscape with a variety of transportation options. Some definitions prioritize safety over others. Ultimately, a lack of consistent definition regarding walkability and priority alongside safety issues affect the pedestrian experience.

Bike safety issues, like pedestrian safety, are important to consider in cities. A primary concern many cyclists have is the availability of dedicated bike lanes for safe travel. All too often bikers are exposed closely to motor vehicles which pose a huge risk to cyclists. Like sidewalks, many bike lanes which are marked on existing roads rather than designed completely, suffer from poor markings, distance from vehicles, and physical barriers for separation. Although many would be eager to bike, these concerns become a major deterrent for prospective cyclists.[9] Researchers argue that thoughtful design should be implemented when designing new bike lanes, making them completely separate from streets and sidewalks to improve safety for automobiles, cyclists, and pedestrians alike. Furthermore, there is a lack of research done on the storage and interaction of bikes with buildings.[10] At a minimum, there is evidence that bike storages are often overcrowded, offer inadequate security, and are difficult to move through. The lack of proper research on bike trends, use, and culture presents itself as a significant opportunity for input that can improve future street and storage designs for cyclists.

[9] Friedman, Avi, and Avi Friedman. "Urban Design for Safe Walking and Biking." *Fundamentals of Sustainable Urban Design* (2021): 171-179

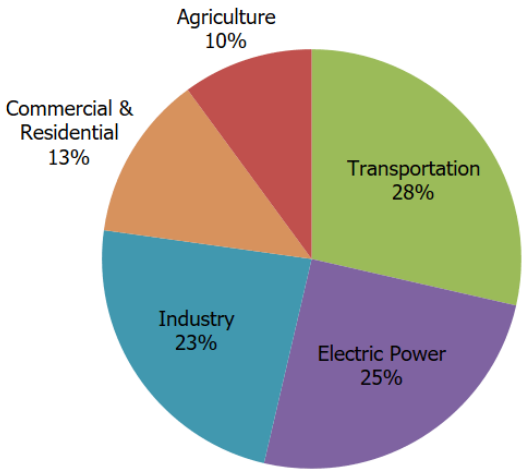
[10] Smith, Cail. 2017. "Making Spaces : Bicycle Storage in Multi-Unit Residential Buildings on the University of British Columbia Campus." R. UBC Social Ecological Economic Development Studies (SEEDS) Student Reports (Graduate). August 10.

Sustainability & Wellbeing

Sustainability and wellbeing are affected by inefficient transportation patterns including large carbon emissions produced by vehicles, especially when stuck in traffic, and a variety of factors such as noise and low movement levels, that affect our health. According to the Environmental Protection Agency, a passenger vehicle can release approximately 4.6 metric tons of carbon dioxide every year, which is considerable when compared to the zero carbon emissions produced by electric vehicles.[11] At a larger scale, transportation as a whole category accounts for 28% of carbon emissions globally, making it the leading source of emissions followed by electric power generation at 25%, industry emissions at 23%, and commercial/residential at 13%, and agriculture at 10%.[12] As the leading source of emissions, with over 94% of the emissions coming from gas and diesel based fuels,

[11] *Greenhouse Gas Emissions from a Typical Passenger Vehicle*, accessed December 15, 2023, https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle.
[12] *Sources of Greenhouse Gas Emissions | US EPA*, accessed December 15, 2023, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.

it's important to take action to reduce the effects of emissions through the adoption of new power sources and better efficient transportation habits.[13]



Noise pollution is a significant problem experienced by many. According to the World Health Organization, noise pollution, specifically prolonged exposure to loud sounds that are above 70 decibels, can cause hearing damage.[14] Additionally, noise pollution has been linked to increased levels of stress, blood pressure, and even lost productivity according to the EPA.[15] Vehicular noise, according to various researchers, has been linked to negative impacts on mental health. Although previous research on the matter has found weak evidence to support the claim, new research has shown that aircraft noise has been linked to increased depressive qualities.[16]

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[13] Image - *Sources of Greenhouse Gas Emissions | US EPA*, accessed December 15, 2023, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.
[14] "Public Health and Scientific Information," *Centers for Disease Control and Prevention*, December 11, 2018, accessed December 15, 2023, https://www.cdc.gov/nceh/hearing_loss/public_health_scientific_info.html#:~:text=The%20World%20Health%20Organization%20(WHO,period%20to%20avoid%20hearing%20impairment.
[15] *Clean Air Act Title IV - Noise Pollution | US EPA*, accessed December 15, 2023, https://www.epa.gov/clean-air-act-overview/clean-air-act-title-iv-noise-pollution.
[16] Janice Hegewald et al., "Traffic Noise and Mental Health: A Systematic Review and Meta-Analysis," *International Journal of Environmental Research and Public Health* 17, no. 17 (2020): 6175, https://doi.org/10.3390/ijerph17176175.

Traffic noise has not yet been proven to show an increase in mental illnesses, though recent research has found questionable effects on mental health that warrant further research.[17] Despite the results, traffic noise is a significant source of disruption in cities, and it is evident that speed reduction combined with new pavement materials as well as the banning of certain vehicle types can greatly reduce noise from roads.[18]

Inactivity while driving has shown to also have negative effects on health. Specifically, higher driving times have been linked to increased risky behaviors, such as smoking and higher consumption of alcohol, and higher levels of inactivity and obesity.[19] Census statistics show that the average one way commuting trip is about 27.6 minutes as of 2019, which, according to previous data, is an increase of 2.6 minutes from data collected in 2009.[20] With increased times and negative effects on health, it's important to consider ways to reduce inactivity and promote healthier transportation options.

Conclusion

Ultimately, it is evident that our current transportation networks are failing in many areas. While this is not good, the presented issues open opportunities for integration of emerging technologies, sustainable practices, and new urban design guidelines to create safer, efficient networks while encouraging sustainable and health

[17] Janice Hegewald et al., "Traffic Noise and Mental Health: A Systematic Review and Meta-Analysis," *International Journal of Environmental Research and Public Health* 17, no. 17 (2020): 6175, https://doi.org/10.3390/ijerph17176175.
[18] Bunn, Fernando, and Paulo Henrique Trombetta Zannin. "Urban planning-Simulation of noise control measures." *Noise Control Engineering Journal* 63, no. 1 (2015): 1-10
[19] Ding Ding et al., "Driving: A Road to Unhealthy Lifestyles and Poor Health Outcomes," *PLoS ONE* 9, no. 6 (2014), https://doi.org/10.1371/journal.pone.0094602.
[20] US Census Bureau, "Census Bureau Estimates Show Average One-Way Travel Time to Work Rises to All-Time High," *Census.Gov*, accessed December 15, 2023, https://www.census.gov/newsroom/press-releases/2021/one-way-travel-time-to-work-rises.html.

transportation options. Rather than taking these issues and fixing them immediately, it is important to look at the cause and root of these issues. Transportation methods often extend from our cultural perception of vehicles; for many a car or bike is an extension of one's character. Our streets and buildings are designed to make one form of mobility convenient over others even if they negatively affect our surroundings. Therefore, we must look at the issue of transportation as a symptom of an unhealthy lifestyle and look at alternatives to develop new, healthier, sustainable habits. In addition, we can use emerging tools and technology to help mitigate issues and solve problems.

Chapter 3: Emerging Technologies

Introduction

Today, many new technologies have been introduced. At the forefront of modern transportation technology is the use of Artificial Intelligence and autonomy for self-driving vehicles, electric and hybrid power sources for cars and bikes, and a variety of aerial and amphibious vehicles, including drones. These new technologies are leading the way for clean, safe, and efficient transportation options. It is evident that hybrid and electric power sources are reducing carbon emissions. Artificial intelligence is helping to automate many tasks and is leading the development for smart, self-driving cars, advanced cruise control systems, and even traffic control. Finally, drones are leading the way for small scale deliveries and rapidly expanding into human transportation. However, these technologies are not without their drawbacks. Substantial analysis, testing, and regulation are still necessary to fully adopt these technologies everywhere.

Autonomous Vehicles & Artificial Intelligence

At the pinnacle of modern technology is the use of artificial intelligence in conjunction with autonomous systems. The technology has seen an explosion in use across multiple sectors and industries including academia, design, and transportation. Specifically regarding transportation, autonomous vehicle systems have grown tremendously over the last decade. The technology has garnished attention as early as

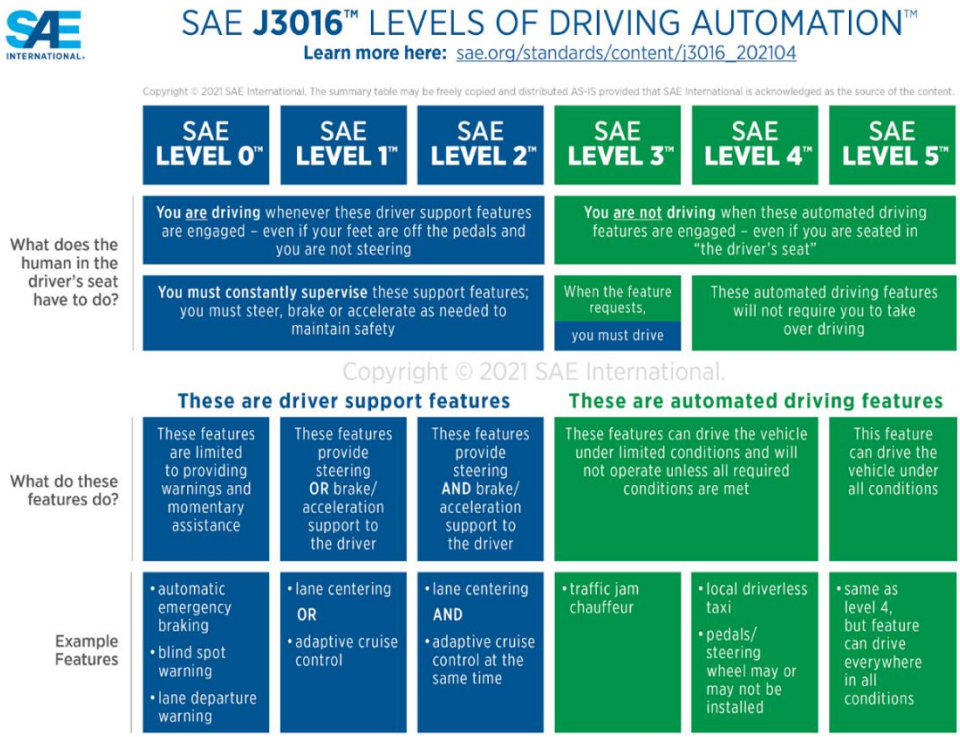
1918 with some research beginning in the 1960s, but the early 2000s.[21] With the early introduction of cruise control systems such as automatic acceleration and braking and the modern evolution encompassing complete, self-driving capabilities, autonomy has grown to include various levels of human involvement.[22] In 2015, five levels of autonomy were introduced by the society of automotive engineers that is frequently used internationally. These levels range from 1) no automated control, only human control, 2-4) some automated control and human control, and 5) fully autonomous

[21] Faisal, Asif, Md Kamruzzaman, Tan Yigitcanlar, and Graham Currie. "Understanding Autonomous Vehicles: A Systematic Literature Review on Capability, Impact, Planning and Policy." *Journal of Transport and Land Use* 12, no. 1 (2019): 45–72

[22] Faisal, Asif, Md Kamruzzaman, Tan Yigitcanlar, and Graham Currie. "Understanding Autonomous Vehicles: A Systematic Literature Review on Capability, Impact, Planning and Policy." *Journal of Transport and Land Use* 12, no. 1 (2019): 45–72.

control.[23]

According to researchers, the use of autonomous technology opens the possibility for the development of smart cities.[24] With autonomous vehicles, sustainable driving methods can be better implemented, safety measures such as collision detection can be improved, and traffic can be better managed for efficient transportation. The technology even opens doors for improved ride sharing capabilities.[25] The technology is not perfect however. According to researchers, the



[23] Image - "SAE Levels of Driving AutomationTM Refined for Clarity and International Audience," *The Mission of SAE International Is to Advance Mobility Knowledge and Solutions*, accessed December 15, 2023, http://www.sae.org/blog/sae-j3016-update.

[24] Faisal, Asif, Md Kamruzzaman, Tan Yigitcanlar, and Graham Currie. "Understanding Autonomous Vehicles: A Systematic Literature Review on Capability, Impact, Planning and Policy." *Journal of Transport and Land Use* 12, no. 1 (2019): 45–72

[25] Michael W. Levin, Kara M. Kockelman, Stephen D. Boyles, Tianxin Li, A general framework for modeling shared autonomous vehicles with dynamic network-loading and dynamic ride-sharing application, Computers, Environment and Urban Systems, Volume 64, 2017, Pages 373-383

autonomous world requires much more research for implementation.[26] A major obstacle for the large scale implementation of autonomous vehicles lies in the publics' "willingness-to-ride".[27] According to a group of researchers who studied various demographics in different countries, they found that many people present an unwillingness to ride in autonomous buses due to safety concerns, questions regarding the technology's reliability, and even demographic backgrounds.[28] It is evident that the autonomous vehicle movement needs to overcome multiple obstacles and present itself as a viable candidate for transportation use.

Electrified Cars & Bikes

Similar to Autonomous mobility, electrified and hybrid vehicles are rising in popularity year by year. Although the sourcing for electric vehicle materials is an area of concern, it is outside the scope of this thesis. That said, it is important to note the benefits and opportunities new power sources are providing. Electric and hybrid vehicles are vehicles that use electric motors, sometimes in conjunction with an internal combustion engine, to power a vehicle. Today's market encompasses electric bicycles, cars, buses, and even drones. Electric vehicles primarily market improved characteristics and performance due to their direct power output while claiming

[26] M. Daily, S. Medasani, R. Behringer and M. Trivedi, "Self-Driving Cars," in Computer, vol. 50, no. 12, pp. 18-23, December 2017

[27] Scott R.Winter, StephenRice, RianMehta, Nathan W.Walters, Matthew B.Pierce, Emily C.Anania, Mattie N.Milner, and NatashaRao. 2018. Do Americans differ in their willingness to ride in a driverless bus?. *Journal of Unmanned Vehicle Systems*. 6(4): 267-278

[28] Scott R.Winter, StephenRice, RianMehta, Nathan W.Walters, Matthew B.Pierce, Emily C.Anania, Mattie N.Milner, and NatashaRao. 2018. Do Americans differ in their willingness to ride in a driverless bus?. *Journal of Unmanned Vehicle Systems*. 6(4): 267-278

substantial sustainability efforts in the form of zero carbon emissions.[29] The introduction of the e-bike, for example, has proven to be a valuable transportation option. According to researchers, the electric bike presents itself as a formidable form of micro-mobility for cities, allowing for many users to ride anywhere, even without the physical fitness required for traditional bikes.[30] The ability to use electric power allows the bikes to accelerate, power features such as lights, and offer higher speeds, making them excellent for city travel. However, its biggest obstacle comes down to battery technology. Batteries are heavy and provide a limited travel range; it is necessary to find a good balance of weight and power capability for day to day use.[31] Ultimately, the technology has proven to be effective and, with battery developments

[29] Aiman Albatayneh et al., "Comparison of the Overall Energy Efficiency for Internal Combustion Engine Vehicles and Electric Vehicles," *Environmental and Climate Technologies* 24, no. 1 (2020): 669–680, https://doi.org/10.2478/rtuect-2020-0041.
[30] Geoffrey Rose, "E-Bikes and Urban Transportation: Emerging Issues and Unresolved Questions," *Transportation* 39, no. 1 (2011): 81–96, https://doi.org/10.1007/s11116-011-9328-y.
[31] Geoffrey Rose, "E-Bikes and Urban Transportation: Emerging Issues and Unresolved Questions," *Transportation* 39, no. 1 (2011): 81–96, https://doi.org/10.1007/s11116-011-9328-y.

coming soon, the effectiveness and adoption of e-bikes as a form of micro mobility

[32]will only improve with proper regulation.

Currently, multiple brands such as Lime Micro Mobility employ electric bikes and scooters in many cities across the world with great success. Lime has over 5000 bikes and scooters in the city of Washington, DC, that are available for use through the brands' own mobile app that allows users to unlock the vehicles.[33] With new, swappable batteries for quick refueling, over 25,000 metric tons of carbon emissions have been reduced, allowing users to ride clean in multiple cities.[34] Ultimately, the technology has proven to be effective and, with battery developments coming in the near future, the effectiveness and adoption of e-bikes as a form of micro mobility will only improve with proper regulation.

[32] Image - "Why Lime," *Lime Micromobility*, accessed December 15, 2023, https://www.li.me/why.
[33] "E-Scooter & E-Bike Rental in Washington, DC," *Lime Micromobility*, accessed December 15, 2023, https://www.li.me/locations/washington-dc.
[34] "Lime Electric Bike - Bike Rentals near Me," *Lime Micromobility*, accessed December 15, 2023, https://www.li.me/vehicles/electric-bike.

Electric cars offer improved performance and sustainability, like e-bikes. Manufacturers such as Tesla, Rivian, and more are leading the way into an electrified transportation network. Today, Tesla for example, has over 45,000 supercharging stations around the United States, making it the largest electric refueling provider available.[35] With a goal of producing and delivering 1.8 million vehicles for 2023, Tesla has already produced and delivered over 1.3 million vehicles as of October of 2023.[36]

Unfortunately, like e-bikes, battery performance is its biggest hindrance.[37] Weight, reliability, and mile range are important considerations when analyzing electric cars. A major obstacle is the lack of charging stations in addition to a low number of charging speed options. Researchers call for improved connectivity with buildings in order to harness renewable energy sources to maximize charging potential.[38] Specifically, some call for the inclusion of electric vehicle power draw in electric load calculations when designing buildings; essentially, a building can act as a large battery for vehicles.[39] Additionally, studies have shown that simple tiered charging offerings at charging stations, similar to the multiple grades of gasoline at gas stations, can improve charging times and reduce costs, suiting individual and

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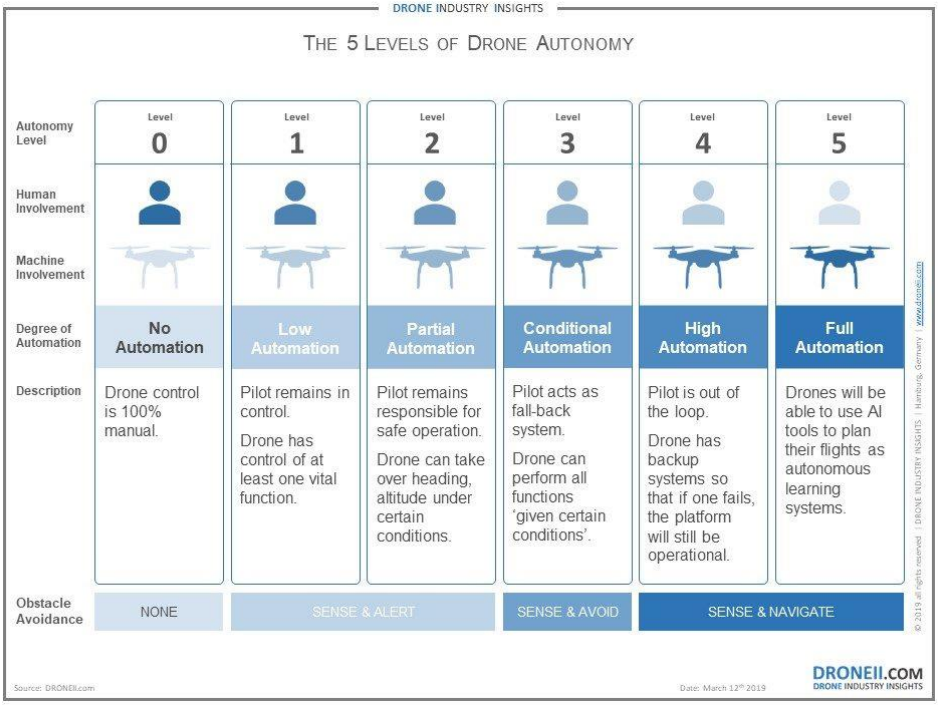
[35] "Product Impact," *Tesla*, accessed December 15, 2023, https://www.tesla.com/impact/product.
[36] "Tesla Vehicle Production & Deliveries and Date for Financial Results & Webcast for Third Quarter 2023: Tesla Investor Relations," *Tesla Vehicle Production & Deliveries and Date for Financial Results & Webcast for Third Quarter 2023 | Tesla Investor Relations*, accessed December 15, 2023, https://ir.tesla.com/press-release/tesla-vehicle-production-deliveries-and-date-financial-results-webcast-third-quarter-2023.
[37] Buonomano, A., Francesco Calise, F. L. Cappiello, Adolfo Palombo, and Maria Vicidomini. "Dynamic analysis of the integration of electric vehicles in efficient buildings fed by renewables." *Applied Energy* 245 (2019): 31-50.
[38] Buonomano, A., Francesco Calise, F. L. Cappiello, Adolfo Palombo, and Maria Vicidomini. "Dynamic analysis of the integration of electric vehicles in efficient buildings fed by renewables." *Applied Energy* 245 (2019): 31-50.
[39] Musik Park, Zhiyuan Wang, Lanyu Li, Xiaonan Wang, Multi-objective building energy system optimization considering EV infrastructure, Applied Energy, Volume 332, 2023, 120504, ISSN 0306-2619, https://doi.org/10.1016/j.apenergy.2022.120504.

instant charging needs.[40] Ultimately, the framework for electric vehicle adoption exists and has proven to be effective. Time and research will address the technical obstacles of the technology, leaving regulation and inclusive design to maximize the benefits and use of the technology to create a modern, smart city.

Aerial Drones (UAS & UAVs)

Finally, the emergence of drone technology is currently in full development. Drones are aerial vehicles that are usually battery powered and are remote controlled or completely autonomous. A new technology in the 21st Century, drones were originally used for military purposes and are now currently being tested as aerial delivery vehicles, surveillance vehicles, and even for construction projects. One major advantage drones have over ground vehicles is their separation from existing transportation networks; their aerial abilities allow them to use direct paths for transportation and mobility instead of being restricted to our current road system. Drones, like autonomous cars, have multiple levels of autonomy. These levels range from no automation to complete automation, and various levels of human input/interaction in between.

[40] Z. Moghaddam, I. Ahmad, D. Habibi and Q. V. Phung, "Smart Charging Strategy for Electric Vehicle Charging Stations," in IEEE Transactions on Transportation Electrification, vol. 4, no. 1, pp. 76-88, March 2018, doi: 10.1109/TTE.2017.2753403.

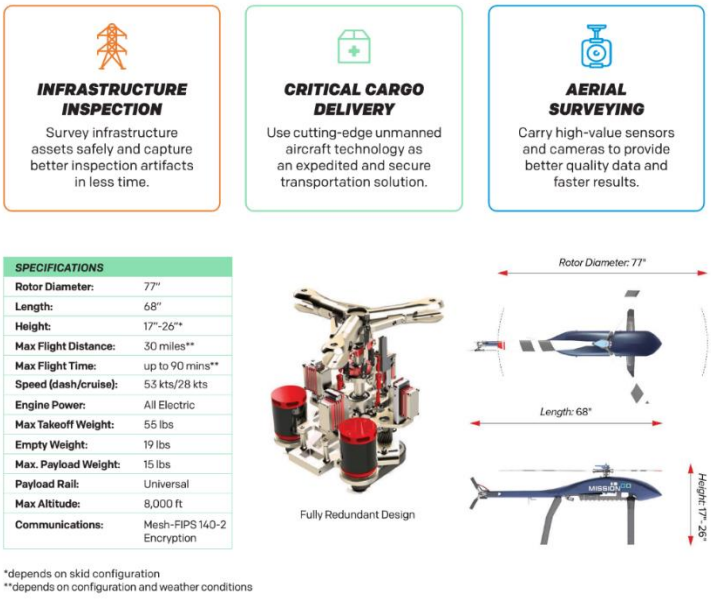


[41]

Companies such as MissionGO, Zipline, and Wing are currently offering drone delivery services for various industries. MissionGO has successfully experimented with organ delivery for hospitals. In 2019, a MissionGO delivered the country' first ever kidney transplant by autonomous drone, making history and paving the way for future transplants.[42] The drone, having FAA approved air worthiness criteria, flew from Saint Agnes Hospital to the University of Maryland Medical Center in Baltimore.[43] Wing, which is partnered with Walmart, is operating in Dallas,

[41] Image - Posted By: Miriam McNabb and Miriam McNabbMiriam McNabb is the Editor-in-Chief of DRONELIFE and CEO of JobForDrones, "Droneii: Tech Talk – Unraveling 5 Levels of Drone Autonomy," *DRONELIFE*, accessed December 15, 2023, https://dronelife.com/2019/03/11/droneii-tech-talk-unraveling-5-levels-of-drone-autonomy/.
[42] "'Faster, Safer, Cheaper,'" *Terp*, accessed December 15, 2023, https://terp.umd.edu/faster-safer-cheaper.
[43] "'Faster, Safer, Cheaper,'" *Terp*, accessed December 15, 2023, https://terp.umd.edu/faster-safer-cheaper.

Texas and is planning on servicing over 60,000 homes.[44] Wing provides a "last mile" delivery service where drones of various sizes can perform door to door deliveries; with a 6 mile range, 30 minute delivery time, and fully autonomous control, the drones have the potential to deliver goods up to 8lbs in a quick, efficient manner.[45] Both companies are leading the push for the use of autonomous drones as vehicles for last mile delivery of goods. Drone technology has expanded in both size, scale, and service to people as well. Companies such as eHang and Archer Aviation are testing Aerial Taxis- passenger drones- that can carry anywhere from 1-5 people. Archer Aviation, whose goal is to have over 6000 aircraft operational by 2030, is partnered with United Airlines on their mission to provide passenger AAVs that have up to a [46]100 mile range with speeds reaching 150mph.[47]



[44] Senior Vice President Innovation & Automation Prathibha Rajashekhar, "Walmart and Wing Team up to Provide the Convenience of Drone Delivery," *Walmart Corporate News and Information*, accessed December 15, 2023, https://corporate.walmart.com/news/2023/08/24/walmart-and-wing-team-up-to-provide-the-convenience-of-drone-delivery.
[45] *Wing*, accessed December 15, 2023, https://wing.com/.
[46] Image - "MGV100," *MissionGO*, accessed December 15, 2023, https://www.missiongo.io/mgv100/.
[47] "Archer Achieves Key Flight Test Program Milestone as Midnight Takes Flight," *Archer*, accessed December 15, 2023, http://www.archer.com/.

Like e-bikes and electric cars, they suffer from battery performance issues. Even more so, they suffer from a lack of inclusive infrastructure. Drones benefit greatly from appropriately designed landing zones that incorporate both gps and visual indicators.[48] A lack of networks and infrastructure is a major blockade for the development of drones and their integration in the built environment at a large scale.[49] Drones stand in the unique position of being used for construction; current research is focused on making them viable for construction projects where they can eventually help develop the architecture they need. According to a study from 2020, construction based drone research is primarily focused on five categories; 1) Data Processing and Management, 2) Safety and Health Management, 3) Areas of drone application, 4) Training Aid, and 5) Flight control systems.[50] These categories, resulting from the researchers' literature review of drone research, present opportunities for focus. Combined with the addition of AI and autonomous control systems, drone-integrated architecture, and improved refueling systems on drones and on structure, drone data processing and flight control can be significantly improved, leaving design to bring in mass drones for further training and safety management.

[48] Heru Supriyono and Amnaduny Akhara 2021 J. Phys.: Conf. Ser. 1858 012074 https://iopscience.iop.org/article/10.1088/1742-6596/1858/1/012074/meta

[49] W. Shi, H. Zhou, J. Li, W. Xu, N. Zhang and X. Shen, "Drone Assisted Vehicular Networks: Architecture, Challenges and Opportunities," in IEEE Network, vol. 32, no. 3, pp. 130-137, May/June 2018, doi: 10.1109/MNET.2017.1700206.

[50] Janet Mayowa Nwaogu, Yang Yang, Albert P.C. Chan, Hung-lin Chi, Application of drones in the architecture, engineering, and construction (AEC) industry, Automation in Construction, Volume 150, 2023

Conclusion

Emerging technology in the form of autonomous systems, electrified vehicles, and new aerial vehicles are improving the way we move ourselves and goods. The benefits of these technologies are clear, and so are the obstacles they are facing. It's clear we must design our future built environment to accommodate these technologies to maximize their potential. No longer can transportation issues remain with the available technology to solve them on hand, rather we must shift our focus on making these technologies readily available and sustainable for generations to come.

Chapter 4: Sustainability in Transportation & Architecture

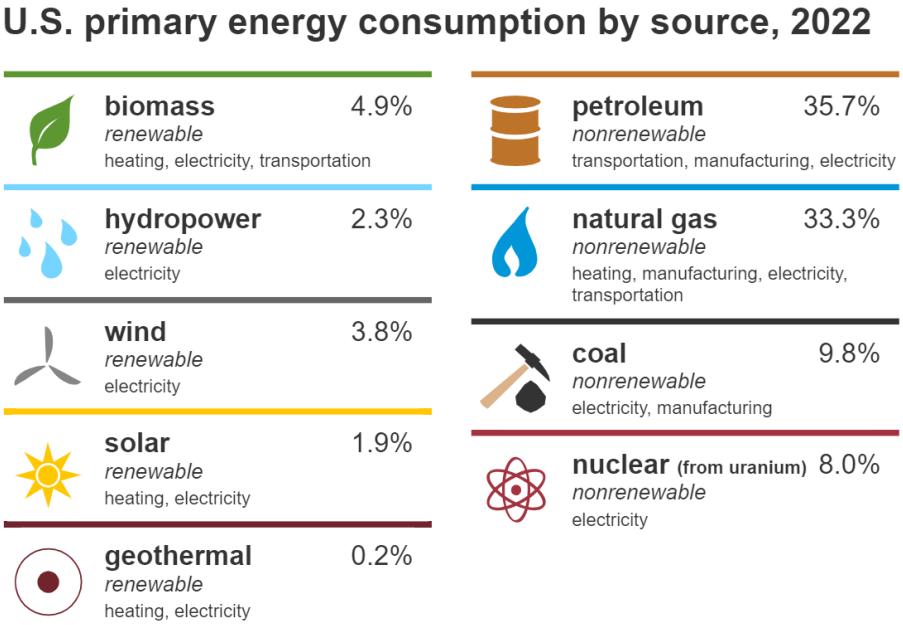
Introduction

Sustainability is a target of high priority in our built environment, our lifestyle, and our modes of transportation. Although sustainability often presents itself through technology that can harness energy or simplify tasks, sustainability can also be harnessed through passive design, material selection, and low-tech strategies and habits. In terms of transportation, sustainability is often referenced through vehicle emissions and power sources. Internal combustion engines and electric motors are often butted head to head when comparing the carbon emissions of one and the mining power of the other. In terms of infrastructure, sustainability is often referenced through building materials, passive bioclimatic strategies, and the incorporation of renewable power. The use of wood, solar shading, and solar panels are often praised in the industry for their environmental benefits.

Because of the nature of our built world that is dominated by buildings and vehicles, it is important to start thinking about both as *systems* rather than individual parts that are semi-compatible in order to take advantage of sustainable practices and create a self-sufficient transportation network. Furthermore, while we can create and implement sustainable strategies to improve our transportation methods and infrastructure, it is just as important and impactful to analyze our choices for movement; our reliance on certain vehicle types needs to be addressed while promoting alternative, sustainable modes of movement.

Power Sources & Applications

Today, there are a plethora of power sources used around the world that fall into three categories: fossil fuels, renewable sources, and nuclear power.[51] These power sources include natural oil, reactive pellets, hydro power, solar power, wind power, geothermal power, and biomass energy.



[52]

For transportation use, the most used power source is the use of natural oil in the form of gasoline or diesel fuel. These fuels are commonly used in internal combustion engines to ignite a mixture of fuel and air to move pistons and power a crankshaft. The internal combustion engine (ICE) has dominated the transportation

[51] A. Qazi *et al.*, "Towards Sustainable Energy: A Systematic Review of Renewable Energy Sources, Technologies, and Public Opinions," in *IEEE Access*, vol. 7, pp. 63837-63851, 2019,
[52] Image - "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis," *Sources of Energy - U.S. Energy Information Administration (EIA)*, accessed December 15, 2023, https://www.eia.gov/energyexplained/what-is-energy/sources-of-energy.php.

arena for many decades with great success, but it is in desperate need of redevelopment and updates. According to researchers, ICE (Internal Combustion Engines) are in need of improvements to reduce emissions and maximize efficiency in respect to fuel consumption and power generation.[53] In fact, emissions are the driving factor for engine/power source development as a result of various studies linking emissions to greenhouse gas generation.[54] Given that electric power is the future of transportation, hybrid vehicles are making a big push in closing the sustainability gap. Hybrid vehicles utilize both ICE and battery powered motors to power a vehicle. Although many configurations exist, a common one involves a smaller electric motor for low speeds and a larger ICE for higher speeds.[55] This layout takes advantage of both power sources' benefits such as battery charging through engine power, higher low end torque provided by the electric motor, and significantly reduced emissions at low speeds handled by the electric motor.[56] As previously mentioned in chapter three, the use of electric-powered vehicles have begun to saturate the market. These vehicles do not rely solely on onboard power generation such as ICE and hybrid vehicles, rather they use batteries as storage banks for power generated through other means. Typically, electric vehicles are charged at various charging stations using grid power.[57] Its clear sustainable sourced power used

[53] Avinash Alagumalai, Internal combustion engines: Progress and prospects, Renewable and Sustainable Energy Reviews, Volume 38, 2014, Pages 561-571
[54] Avinash Alagumalai, Internal combustion engines: Progress and prospects, Renewable and Sustainable Energy Reviews, Volume 38, 2014, Pages 561-571
[55] Prajapati, Karan C., Ravi Patel, and Rachit Sagar. "Hybrid vehicle: A study on technology." *Power (kW)* 2 (2014): 10-20.
[56] Prajapati, Karan C., Ravi Patel, and Rachit Sagar. "Hybrid vehicle: A study on technology." *Power (kW)* 2 (2014): 10-20.
[57] Z. Moghaddam, I. Ahmad, D. Habibi and Q. V. Phung, "Smart Charging Strategy for Electric Vehicle Charging Stations," in IEEE Transactions on Transportation Electrification, vol. 4, no. 1, pp. 76-88, March 2018

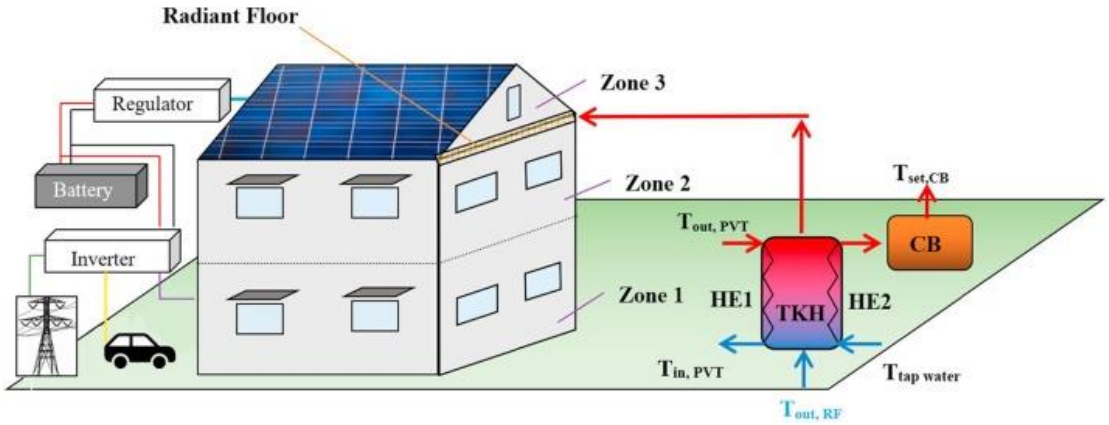
for electric vehicles presents a unique opportunity for reduced carbon emissions on the road. However, the many drawbacks from battery powered vehicles previously mentioned in chapter two are magnified by lacking infrastructure and battery technology.

Inclusive Infrastructure

Based on current trends, it's clear hybrid and electric vehicles will eventually replace traditional internal combustion engines. This calls for further research in electric power generation for these vehicles and their interaction with buildings. At the very least, improvement in charging station technology requires significant attention in todays' market. According to researchers, limited charging infrastructure is a major obstacle for high adoption of electric vehicles. Australian engineers propose a new charging strategy that can help facilitate vehicle charging by offering multi-level charging options. According to their research, by offering multiple levels of charging speeds based on alternating current and direct current charging, mirroring multiple grades of gasoline, users can save up to 25% on charging speeds and save almost 15% in charging costs.[58] To take electric vehicle integration a step further, designers can start to integrate electric vehicle power demands in building designs. According to researchers, it is important for designers to integrate electric load calculations for buildings; one study found that although larger buildings with sustainable initiatives remained relatively unaffected by additional power loads as a

[58] Z. Moghaddam, I. Ahmad, D. Habibi and Q. V. Phung, "Smart Charging Strategy for Electric Vehicle Charging Stations," in IEEE Transactions on Transportation Electrification, vol. 4, no. 1, pp. 76-88, March 2018

result of direct electric vehicle charging, smaller buildings noticed a significant increase in power demands.[59]



[60]

Given that electric vehicles are stored in the homes of buyers, its necessary to take into account new electrical loads for future residences. The emergence of electric vehicles and our markets' priority for sustainability means it is crucial for modern buildings to aggressively integrate passive power generation technology in their designs and construction in order to accommodate electric vehicles and push toward a self-sustainable future for mobility.

Sustainable Choices

Although sustainable initiatives are pushing advancements in power technology and vehicle drivetrains, our personal transportation choices cannot be overlooked. This thesis started by identifying the multiple modes of transportation that are the most prevalent in the modern era. Although large vehicles have dominated our landscape, choosing to use smaller forms of transportation can

[59] Musik Park, Zhiyuan Wang, Lanyu Li, Xiaonan Wang, Multi-objective building energy system optimization considering EV infrastructure, Applied Energy, Volume 332, 2023
[60] Musik Park, Zhiyuan Wang, Lanyu Li, Xiaonan Wang, Multi-objective building energy system optimization considering EV infrastructure, Applied Energy, Volume 332, 2023

significantly progress sustainability. The largest issue related to vehicle choice can be attributed to our cultural view of vehicles. For many individuals within Western cultures, personal vehicles are an extension of an individuals' identity.[61] It is difficult to let go of certain character traits vehicle manufactures instill in vehicles; design, safety features, and the sense of comfort and freedom are crucial in our decision to use our vehicles in the manner we please. Because of this, it is important to note that emerging technologies related to mobility must address these issues in order to facilitate a transition toward autonomous mobility and alternative transportation options. Alternative transportation options focused on sustainability include ridesharing, bus riding, and bike riding, a form of micro mobility. Bus and ride sharing options essentially pair multiple passengers in one vehicle headed toward a similar destination. Their advantages in terms of sustainability are clear- instead of multiple vehicles and carbon emission sources for multiple passengers, few vehicles can carry the same amount of passengers in a similar amount of time with reduced emissions and vehicle space. Finally, bike transportation provides exceptional benefits in terms of sustainability and health benefits. Finally, bike transportation, a form of active travel, provides exceptional benefits in terms of sustainability and health benefits. According to researchers, cycling can benefit cardiovascular health and reduce obesity.[62] Cycling in and of itself does not emit any carbon emissions associated with ICE. They are readily available at different price ranges and can provide an efficient mode of transportation in urban areas affected by heavy traffic.

[61] Peter Wells, Dimitrios Xenias, From 'freedom of the open road' to 'cocooning': Understanding resistance to change in personal private automobility, Environmental Innovation and Societal Transitions, Volume 16, 2015, Pages 106-119

[62] Laura Antón-González et al., "Cycling in Urban Environments: Quantitative Text Analysis," *Journal of Transport & Health* 32 (2023): 101651, https://doi.org/10.1016/j.jth.2023.101651.

Conclusion

While the emergence of electric vehicles and improved, integrated charging infrastructure is paving the path toward an efficient, sustainable future, it is important to point out that sustainability can be achieved through our transportation choices. By analyzing multiple modes of transportation, it is clear that the most sustainable forms include ride sharing, autonomous transportation, and micro mobility. Their common benefits include reduced carbon emissions and less vehicles on roads. The question now becomes; how can designers influence people to switch to these alternate transportation methods? Although architects are less likely to be involved in vehicular design, architects and planners do have the ability to create safer transportation networks and infrastructure that encourage ride sharing, active forms of micro mobility, and the use of autonomous vehicles such as cars and drones for daily transportation.

Chapter 5: Urban & Architectural Design

Introduction

Although the transportation technology to solve the problems of contemporary mobility exists or is being developed, it's important to study how we introduce them into the built environment. Proper integration of mobile technology is key in creating a unique, seamless experience between the built world and the methods we use to get around it. Efficiency, safety, and comfort are key elements to consider when deciding how to integrate technology and modify our current infrastructure to accommodate emerging technology. There are three main concepts this chapter will discuss related to the integration of transportation technology through urban planning and design. Firstly, it is important to reclaim the human experience in any approach taken. For many decades, roads and highways have expanded and become cluttered with vehicles. Occupiable space and natural habitats have lost the battle against automotive control. It is imperative to redesign roads, highways, and any/all transportation networks to refocus on the human experience. Second, transportation networks can be reorganized/repurposed to accommodate autonomous vehicles and ride sharing to help reduce the amount of vehicles on roads while taking advantage of the technology's safety benefits. Additionally, architecture can begin to accommodate vehicles more closely in their design to promote seamless integration and improved accessibility for many communities. The integration of vehicles in design will be crucial in the development of future drone technology, which currently lacks sophisticated infrastructure. Finally, the integration of wellness spaces is important in the development of a new, systematic, integrated transportation network. The

promotion of wellness comes with many benefits for human health and a dedicated space presents an opportunity for people to disconnect from the chaos of transportation. With the advancements of autonomous vehicles, drones, and vehicle electrification, it is important to draw out the main advantages, those being sustainability, safety, and efficiency. Additionally, we must prioritize human wellness and connection with the new time, space, and energy that will be conserved by means of new technology. Major changes are required on existing infrastructure to make this push feasible.

Street Design

Building. Sidewalk. Street. For many cities around the world, this layout is commonly seen. Although simple in nature, this layout can have a profound effect on the human experience. In many cities, especially in the United States, many places involve large or small buildings, very thin sidewalks, and wide roads that primarily benefit automotive use. The experience for pedestrians and cyclists is not appealing; fast vehicles zoom by within feet of oneself, putting anyone over the edge and questioning their safety. As previously mentioned, walking and cycling is a far more sustainable approach for mobility, but the infrastructure for these transportation options requires significant change.[63] The rise of cyclists and their claims for improved cycling roads has brought the issue of sidewalk and road design into question. Many European cities have implemented street designs that are pedestrian or cyclist focused. One example, Copenhagen, has completely changed its infrastructure to cater to cyclists. By changing its road designs to incorporate

[63] Friedman, Avi, and Avi Friedman. "Urban Design for Safe Walking and Biking." *Fundamentals of Sustainable Urban Design* (2021): 171-179

primarily bike lanes, the city has self-proclaimed to be the "greatest cycling city" in the world.[64] Although its streets, amongst many European cities, serve as great examples to mimic, it is evident that it will take decades for changes to take effect as claimed by one researcher. Radical changes, such as the banning of Internal Combustion Engines, would help propel design decisions forward, but be a difficult leap to take.[65] In addition to bike lanes, pedestrian crossings are areas to improve safety. One study shows that pedestrian crossings have claimed over fifty thousand lives between 2011 and 2020; the researchers' approach to improving safety involves further training of AI/Autonomous vehicles to better detect pedestrians at poorly designed crosswalks.[66] Additionally, researchers also call for additional focus and research on this topic as few studies and little action exists to resolve the matter.[67] Transit corridors, a type of street that is heavily reliant on public transportation, begins to redesign streets to accommodate multiple modes of transportation while improving safety for pedestrians and cyclists.[68]

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[64] Stefan Gössling, Urban transport transitions: Copenhagen, City of Cyclists, Journal of Transport Geography, Volume 33, 2013, Pages 196-206

[65] Stefan Gössling, Urban transport transitions: Copenhagen, City of Cyclists, Journal of Transport Geography, Volume 33, 2013, Pages 196-206

[66] Zou, Fengjiao, Jennifer Ogle, Weimin Jin, Patrick Gerard, Daniel Petty, and Andrew Robb. "Pedestrian Behavior Interacting with Autonomous Vehicles during Unmarked Midblock Multilane Crossings: Role of Infrastructure Design, AV Operations and Signaling." *arXiv preprint arXiv:2303.17717* (2023). https://arxiv.org/abs/2303.17717

[67] Stoker, P., Garfinkel-Castro, A., Khayesi, M., Odero, W., Mwangi, M. N., Peden, M., & Ewing, R. (2015). Pedestrian Safety and the Built Environment: A Review of the Risk Factors. Journal of Planning Literature, 30(4), 377–392

[68] Social Ink, "Transit Corridor," *National Association of City Transportation Officials*, accessed December 15, 2023, https://nacto.org/publication/urban-street-design-guide/streets/transit-corridor/.

 [69]

Efficient Transportation Accommodation

Accommodating efficient vehicular trends on roads and infrastructure can help create a seamless experience. By integrating mobility into architecture/infrastructure, three benefits can arise. One, accessibility can be improved: many cities suffer from transportation diversity, especially in low income neighborhoods that would highly benefit from public transportation. Two, repurposed or redesigned lanes can improve traffic flow, safety, and transportation options while keeping some existing infrastructure. Three, using sustainable technology previously mentioned in chapter three, the integration of transportation options in buildings can harness the power of electric charging for improved fueling. A common issue in multiple parts of the world include the disconnection between low income households

[69] Image - Social Ink, "Transit Corridor," *National Association of City Transportation Officials*, accessed December 15, 2023, https://nacto.org/publication/urban-street-design-guide/streets/transit-corridor/.

and access to public transportation.[70] They found that data regarding public transportation networks usually excludes low income backgrounds, which highly affects people who desperately need public transportation for efficient travel. Rather, because of distances, many low-income workers are forced to use private automobiles or travel by foot and wait for buses where available in order to get to work. Developing transportation networks in proximity to homes can help make public access available to everyone and is a crucial step forward in public accessibility. As mentioned before, the designing of structures to accommodate vehicle power loads can greatly assist in the development of electric vehicle fueling which is limited by availability. Vehicle integration incorporates more than just fueling however. As mentioned in the previous section, making vehicle access available to everyone is an important task, and bridging the space between roads and our doors can create a new level of comfort and safety. Although the concept may rarely be discussed in architecture, incorporating transportation related elements *into* architecture can create a new way to experience buildings.

Integrated Wellness Spaces

The ultimate goal in rethinking our transportation options is to create a healthier community and life. The integration of technology, the designing (and redesigning) of our roads and buildings, and our focus on sustainability is meaningless if it does not result in an overall healthier environment that puts human wellness above all matters. To push wellness in transportation forward, it is important

[70] Ignacio Tiznado-Aitken, Karen Lucas, Juan Carlos Muñoz, Ricardo Hurtubia, Freedom of choice? Social and spatial disparities on combined housing and transport affordability, Transport Policy, Volume 122, 2022, Pages 39-53

to promote active transportation such as cycling and walking, design with inclusivity for all people of all ages and abilities, and design spaces that promote safety, health, and satisfaction amongst community members.

Active Transportation, as mentioned previously, can be accomplished through improved safety features on roads and sidewalks that encourage the use of bikes and walking for short to medium distance traveling. Active movement is vital to our health, especially as we age.[71] Research has shown that it is important to stay active for our health as we age, but statistics show that physical activity reduces with age for a variety of reasons as well.[72] By making streets safer and integrating resting spaces, it is possible to increase active transportation. The introduction of parklets in many cities has begun to repurpose spaces typically used for vehicles and transform them for people.[73] When used as rest stops, places for wellness, parklets can begin to transform streets and make them a safer place to be in.

According to researchers who interviewed elderly citizens in Hong Kong, the sense of social inclusion by elderly people is heavily dependent on their satisfaction with existing transportation systems.[74] Additionally, overall wellness is improved through outdoor activities that foster social events.[75] By improving the outdoor

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[71] Jessica Stroope, Alex Garn, and Lisa Cadmus-Bertram, "Active Transportation and Self-Reported Change in Physical Activity," *Journal of Transport & Health* 27 (2022): 101528, https://doi.org/10.1016/j.jth.2022.101528.
[72] Jessica Stroope, Alex Garn, and Lisa Cadmus-Bertram, "Active Transportation and Self-Reported Change in Physical Activity," *Journal of Transport & Health* 27 (2022): 101528, https://doi.org/10.1016/j.jth.2022.101528.
[73] Luca Bertolini, "From 'Streets for Traffic' to 'Streets for People': Can Street Experiments Transform Urban Mobility?," *Transport Reviews* 40, no. 6 (2020): 734–753, https://doi.org/10.1080/01441647.2020.1761907.
[74] Sylvia Y. He et al., "Ageing in a Transit-Oriented City: Satisfaction With Transport, Social Inclusion and Wellbeing," *Transport Policy* 97 (2020): 85–94, https://doi.org/10.1016/j.tranpol.2020.06.016.
[75] Sylvia Y. He et al., "Ageing in a Transit-Oriented City: Satisfaction With Transport, Social Inclusion and Wellbeing," *Transport Policy* 97 (2020): 85–94, https://doi.org/10.1016/j.tranpol.2020.06.016.

experience and by introducing new, green spaces in buildings, wellness can be promoted for all people.

Conclusion

Properly integrated mobile technology is a key factor in developing a consistent, seamless experience from building to building. By carefully analyzing the details of our streets, we can emphasize efficiency and safety. Through efficiency and safety, we can improve accessibility of transportation methods through the integration of transportation technology in buildings. Finally, taking all aspects into account, we can create new wellness spaces that focus on human connection, entertainment, and health. The benefits of emerging technology and the redesigning of our buildings and transportation as synergistic systems will help save precious time and energy that can be used to build up communities.

Chapter 6: Program

Abstract

The presented TOC and overall research topics can be broken down into four major zones that will be looked at for program development: Autonomy, Accessibility, Technology, and Wellness. The autonomy zone will focus on data management and background/supporting programs that help automate certain tasks and provide a seamless experience with the built world. The Accessibility zone is primarily focused on both transportation options and multi use spaces offering a variety of programs (making certain programs accessible to everyone). The technology zone will focus on spaces with direct integration of technology into various programs. Like the autonomy zone, the technology zone can be seen as a supplemental and primary space with the difference being human involvement; the autonomy zone will have little to no human involvement (passive) while the technology zone will have lots of human involvement (active). Finally, the wellness zone will focus on health and wellness focused spaces that provide serenity and a distraction from the chaotic transportation-based realm.

Precedents

Dalaman International Airport

The Dalaman Airport is a new addition to the existing airport terminal that focuses on human wellness through the introduction of greenery within the building. Unlike many other airports, the Dalaman airport incorporates small landscaped gardens throughout the terminal offering moments of calmness and a distraction from the busy

transportation world. The exoskeleton of the terminal is loaded with solar panels to provide power for the building and an elevated road connecting to the entry area provides easy vehicular/multi-modal access. The design of the airport begins to integrate transportation networks (roads) into its design, rather than co-exist with it.

Vanke Community

The Vanke Community & Bus station promotes wellness through a multi-program concept that integrates transportation in the site without affecting the human experience. Specific to the project is an automatic car garage that stores your vehicle, which can later be reclaimed through a mobile phone application. The technology and design allows for efficient vehicle parking that minimizes vehicular space while maximizing green space. Additionally, the project offers a multitude of relaxing and multi-use spaces that creates a programmatically diverse village.

Transportation Hub

The Transportation Hub is designed to incorporate all programs, including tickets, boarding, and additional amenities, under one roof. The project takes advantage of the existing landscape topography and utilizes it to create an amphitheater, a space uncommon for transit stations. The multi-use spaces lends itself to a variety of activities to keep people entertained while they await their ride. Additionally, the positioning of the amphitheater steps provides relaxing views of local parks/greenery. The buildings' attempt to join together different programs unrelated to each other offers a glimpse at what the integration of multi-use spaces can achieve in a transit oriented project.

Cobe Charging Station

The Cobe Charging Station is a modern, sustainable approach to vehicle recharging. The charging station offers fast charging and a relaxing atmosphere to wait in. Wood construction and gardens create a clean, natural feeling that promotes wellness and provides serenity from the busy roads. The project takes on a modular and sustainable approach toward vehicle refueling using the already existing gas station canopy typology, which allows for multiple configurations and units to be built anywhere.

Concept

Zones with programs-

Autonomous (related to technology in TOC)

1. Bike room
2. Underground garage
3. Bus stops
4. Control tower
5. Data processing room
6. Service zone (self service kiosk)

Accessibility (related to urban planning/architectural design in TOC)

a) Transit station

b) Bike room

c) Coffee shop/cafes

d) Adaptive space

e) Drive through

f) Rest stop

g) Event center

h) Garage

i) Sidewalks

j) Air port

k) Rental space (car/bike)

l) Rideshare lounge

m) Pharmacy

n) Grocery store

o) Bathrooms

Technology (related to technology in TOC)

1. Battery/power room
2. “Drone Deck”
3. Repair shop
4. Research center
5. Showroom
6. Rideshare lounge
7. Charging stations (bikes and cars)

Wellness (related to sustainability and urban planning in TOC)

1. Solar room/greenhouse

2. Adaptive space
3. Training center/gym
4. Rest stop
5. Meditative spaces
6. Parks

Conclusion

The listed program is primarily based on the Dalaman Airport, which, it being a multi-modal transportation hub with aerial capabilities, lends itself for use in developing a verti-port, a VTOL specific mini airport. The diverse yet highly specific programs in the airport offer a multitude of combinations and services. The addition of wellness focused spaces deviates from the traditional program of airport typologies and begins to focus on people, rather than vehicles, as the primary focus. Ultimately, the building itself if for transportation use, but it design hints at a new style of design and thinking that incorporates sustainability, technology, and wellness.

Chapter 7: Site Selection & Analysis

Abstract

Selecting a site for a project to rethink movement is challenging. On one hand, transportation is a universal concept with advantages and disadvantages that are experienced similarly around the world. This presents the opportunity to select a site

that would benefit from the *modification* of its transportation networks and infrastructure. On the other hand, the universal quality of transportation lends itself to a particular disadvantage, the lack of transportation. Therefore, this approach opens the possibility to *introduce* a transportation network. Based on the thesis question this project covers, it is important to consider the impacts of the introduction of new, emerging technology. This means the site should be able to easily adapt, if not already incorporate or accommodate, new technologies. Therefore, an ideal site should have some existing infrastructure or proximity to a stable network to develop the project further. Ultimately, selecting a site based on *modification* seems to be the best approach to pursue.

With modification as the primary factor in site selection, it is then possible to look at sites through the lens of introduction or modification again. Modifying a site will require some existing elements to work with. No one site has all, if any, categories of problems, technology, sustainability, and design. Therefore, picking a site will require the introduction of one or more of these elements. On one hand, picking a site that has many problems or lacks crucial elements presents the opportunity to improve a place, while picking a site that has multiple elements presents the opportunity to better integrate systems.

Site Selection Criteria

1) Proximity to existing transportation infrastructure
    - Closer amenities assist with implementation of a network.
2) FAA Aerial Zoning

- Lenient Aerial Zoning allows for a fully developed fleet of aerial vehicles.

3) Planned Autonomous Vehicle Initiatives
    - Preexisting plans can be further developed and incorporated in the project.
4) Population Density
    - Higher population means more people can use the project services.
5) Vehicle to Household Count
    - Lower vehicles per household means a need for alternate transportation methods is present.
6) Proximity to Markets/Vendors
    - More vendors/markets allow for local delivery of goods and services to the neighborhood.
7) Proximity to Schools
    - More schools and local services allow for daily use of autonomous transportation.
8) Pedestrian Safety
    - Higher accident counts show a need for improved safety measures.
9) Average Travel Times
    - Higher travel times show a need for improved efficiency on roads.

10) Transportation Options

- Low count shows lack of diversity/car dependency for local travel.

Sites

College Park, MD

College Park, MD, is a highly populated city with over 70 thousand people (UMD Students and residents). Home to the College Park airport, the city offers a wide range of transportation options for use. With UMD research and support, existing infrastructure, and a high population, the site lends itself to a successful test-site for additional drone-based research, however, FAA zoning severely limits the extent to which autonomous aerial vehicles can interact with neighboring areas, especially Washington DC.

Burtonsville, MD

Burtonsville, MD, is a small town along Route. 29 that runs parallel to Interstate 95. With a population of just under 10,000 residents, a high level of dependency on cars, and limited transportation options, Burtonsville can be used to incorporate a smaller scale project that would more closely serve the entire community. Unfortunately, there are few local amenities and no planned initiatives that would help the project succeed.

Ellicott City, MD

Ellicott City, MD, is a highly populated city with existing, though defunct, transit infrastructure. With planned autonomous initiatives, high car dependency, and lenient aerial zoning, Ellicott city is a strong contender. Safer roads and higher vendor/amenity count make it less in need of a new transportation network, however.

Baltimore, MD

Baltimore, MD is the largest city on the list. With the largest population, low car ownership, and a high amount of pedestrian accidents, the city could definitely use intervention in the form of a new transportation based project. Lenient FAA Zoning, planned autonomous initiative, and a variety of markets and amenities help support an aerial transportation project.

Conclusion

Ultimately, the city of Baltimore, specifically the Baltimore Heliport, was selected as the final site through the site selection matrix. The city has a high population with lower vehicle ownership, high pedestrian accidents, and long travel times. With close proximity to large transportation networks, diverse markets and daily necessities, planned autonomous vehicle initiatives, and liberal FAA Zoning, the site lends itself as a well-rounded place for an autonomous transit-based project to be the most successful while servicing a community in need of improved safety and

transportation efficiency. The remaining sites lend themselves as potential sites for modular additions that are an extension of the main project in Baltimore.

Chapter 8: Conclusion

Baltimore Vertiport

Developing an architectural project out of a mobility related concept is not an easy task; as previously stated, the two are often designed as separate pieces in our built world. With the emergence of both autonomous and aerial vehicles that have a higher dependance on structures, specifically through charging, takeoff and landing, and communication infrastructure, it is possible to bridge the worlds of architecture and transportation while creating a meaningful experience. Taking advantage of the technology' s characteristics, including improved safety, aerial mobility, and efficient roads and traffic lanes, ground space can be reclaimed for human experience and wellness.

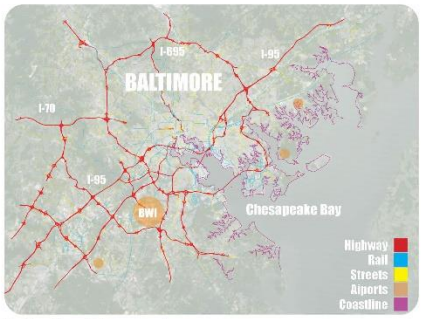
For the thesis proposition, a vertiport was designed in Baltimore that provides a new way to travel! The vertiport serves as a platform for new, aerial based technology, creates a node within a new transportation network, and changes the transportation realm into a clean, refreshing vertical experience. Comprising of a high-tech hangar, a collaborative tower, and a unifying "spine", the vertiport incorporates land, sea, and air travel at one destination. With an emphasis on vertical experience, the vertiport extends from the water-based pier up to the sky via an experiential spine. With FAA goals to have vertiports built by 2028, an aerial future awaits just around the corner for all to experience!

RETHINKING MOVEMENT

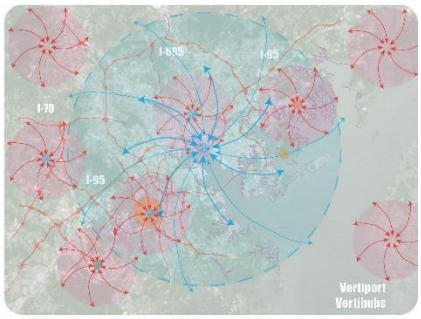
BALTIMORE VERTIPORT

Jose Gomez

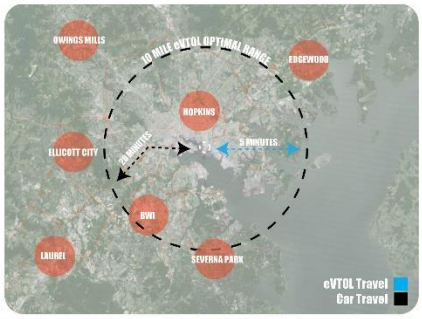
The Baltimore Vertiport: Experience a new way to travel! The vertiport serves as a platform for new, aerial based technology, creates a node within a new transportation network, and changes the transportation realm into a clean, refreshing vertical experience. Comprising of a high tech hangar, a collaborative tower, and a unifiying "spine", the vertiport incorporates land, sea, and air travel at one destination.



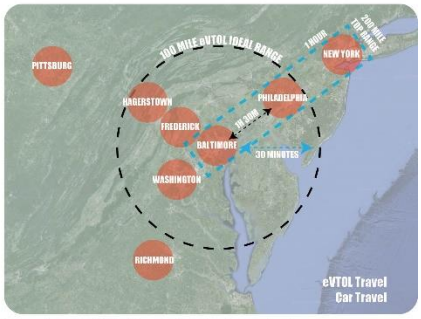
Existing Networks



Proposed Network

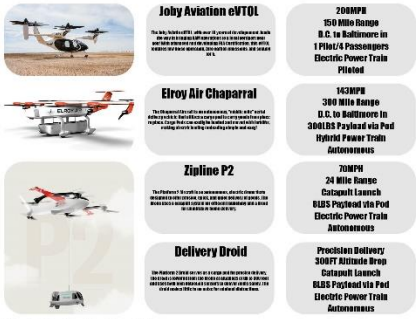


Vertiport Network - Local

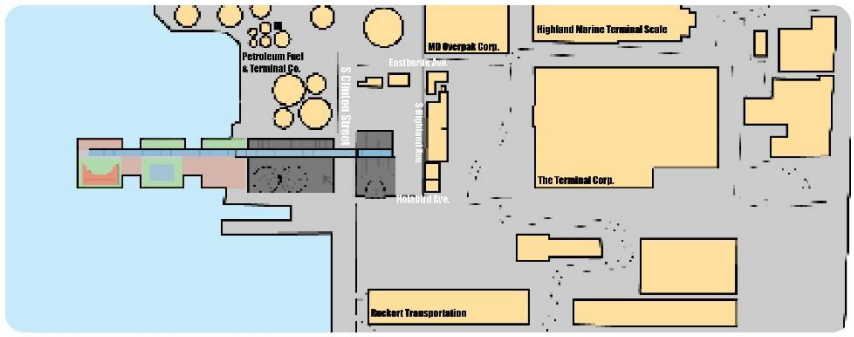


Vertiport Network - Interstate

eVTOL Approach



Vehicle Info/Stats

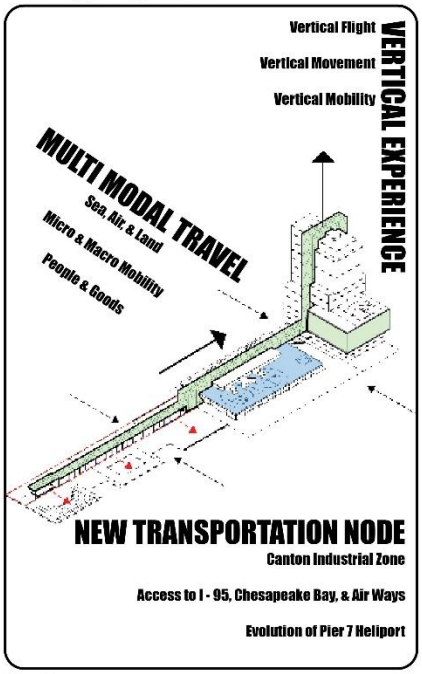


Site Plan

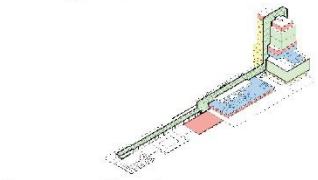
Site Approach

VTOL Night Approach

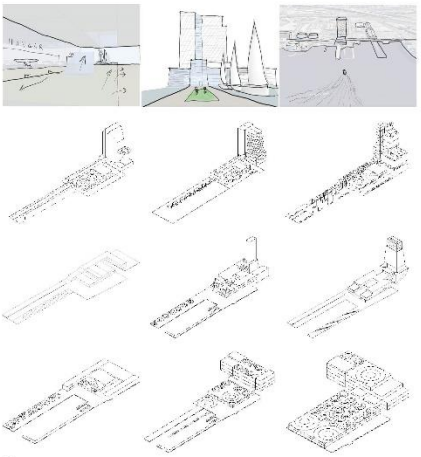
Pier Experience



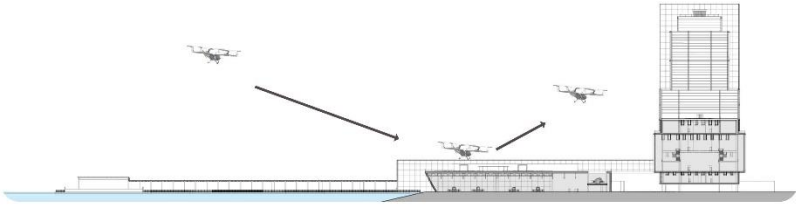
Parti



Program (Axon)



Process



Section A 1/32" = 1'

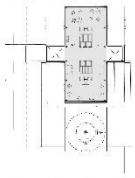
Tower Approach

Hangar Interior

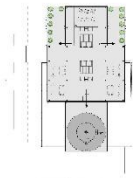
Night Approach

COLLABORATION	Lounges, WeWork, Offices
TECHNOLOGY	eVTOLS, Charging Stations
WELLNESS	"Exterior Experience", Greenery
SUPPORT	Vehicle Maintenance, Cargo Handling

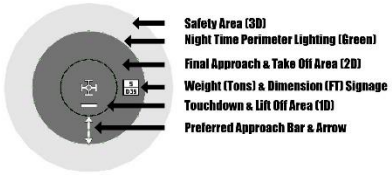
Program



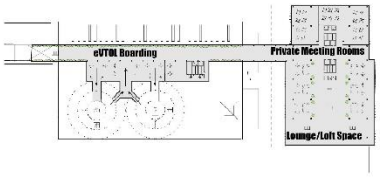
Typical Floor



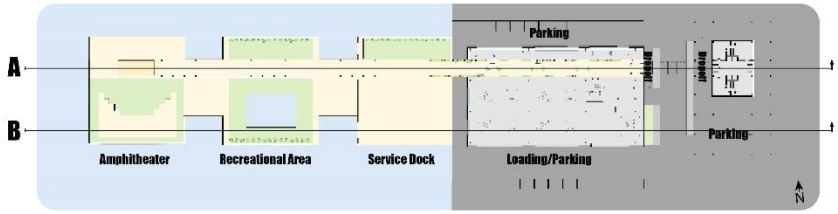
eVTOL Floor



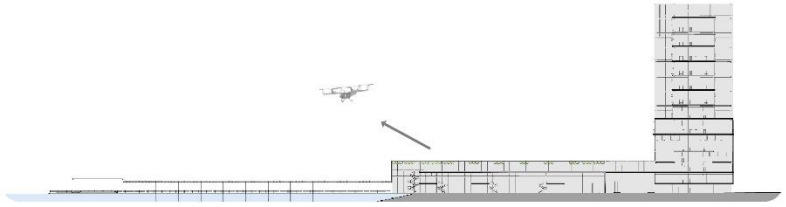
Landing Pads (Detail)



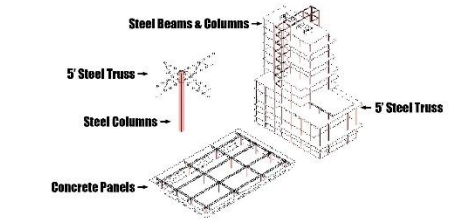
Loft Floor 1/32" = 1'



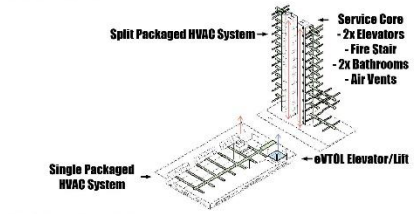
Ground Floor 1/32" = 1'



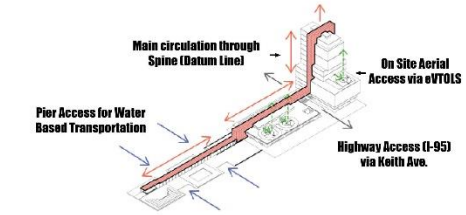
Section B 1/32 = 1'



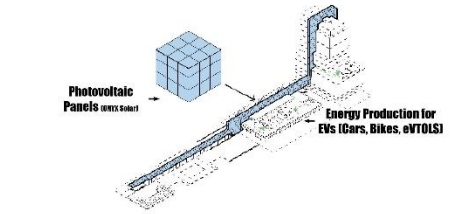
Structure



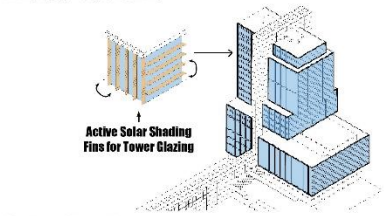
HVAC & MECH.



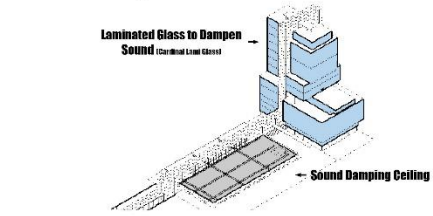
Circulation & Movement



Energy Systems

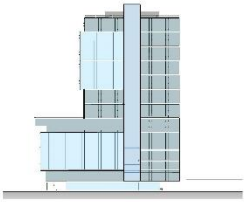


Solar Shading



Sound Control

West Elevation



East Elevation

Top View

WeWork Spaces

Upper VTOL Floor

Loft Space

VTOL Boarding

Spine Experience

Ground Approach

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