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Tanner J. Machala

Mobility Hub Design:  
Conducting Generalizable Urban Design Research

Tanner J. Machala

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Jan Whittington

Rachel Berney

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**Abstract**

Mobility Hub Design: Conducting Generalizable Urban Design Research

Tanner J. Machala

Chair of the Supervisory Committee:  
Jan Whittington  
Department of Urban Design and Planning

Municipal and regional governments are evaluating methods for expanding transportation options. Urban populations continue to grow globally, adding increased stress to already overburdened road networks. Internationally, public transportation agencies have begun experimenting with the mobility hub concept to determine opportunities to respond to the growing social, economic, and environmental issues disproportionately affecting communities. This thesis establishes an inventory of existing data on mobility hubs for application in the King County, WA context. For King County Metro (KCM) -the county transit agency- to address design challenges of mobility hubs, this thesis brings to light the necessary considerations for siting and designing features functionally relevant to mobility hubs by answering the questions: what are the generalizable takeaways of locating mobility hubs at existing transit centers. The analysis began with a literature review defining generalizability in urban design. Following this, literature, workshops, and interviews were used to develop a catalog of site features based on functions. Three matrices were used to compare policies, existing site features, and proposed site features to locate the common,

unique, and adjacent features between facility types. The findings indicate that there are several considerations worth evaluating prior to siting and designing mobility hubs at transit facilities.

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## **DEDICATION**

To my amazing family, Liz, Chris and Emily and our wild dogs Olive and Mila.

## CHAPTER 1. INTRODUCTION

Cities around the world are moving away from the transportation habits of the past 100 years. It is more apparent that our communal use of the automobile to fulfill our personal trips is at the expense of our built environment and community health. Per the National Highway Traffic Safety Administration, 43,000 people were killed in car related accidents in 2022. This is the highest recorded count since 2005, with 2020 through 2021 being the largest year to year increase since recording began in 1975.<sup>1</sup> In addition, the shared environmental cost borne by car dependence is compounding. Water quality is diminished by engine lubricant runoff and tire debris, while our air quality is diminished by tail pipe emissions. The connection between our current transportation habits and our global climate crisis is evident as more people become susceptible to rising sea levels and harsher weather patterns. To stave off a larger climate crisis, governments at all levels are acting to phase out internal combustion vehicles. Including actions by the federal government to phase out internal combustion engine sales by 2035.<sup>2</sup>

Reducing personal car trips and changing current transportation behavior can make our communities safer for people. Local governments are encouraging a behavioral transition by improving existing transportation infrastructure to support an increasing diversity of mobility options. One solution that cities are using to address the shortcomings of transportation systems is the mobility hub. Mobility hubs are nodes along high-frequency fixed-route transit services that

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<sup>1</sup> Michael Brady, "US Traffic Deaths Reach Highest Level since 2005: NHTSA," Smart Cities Dive, accessed May 10, 2023, <https://www.smartcitiesdive.com/news/us-traffic-deaths-highest-level-2005-nhtsa/647893/>.

<sup>2</sup> Brad Plumer, "Nations Must Drop Fossil Fuels, Fast, World Energy Body Warns," *The New York Times*, May 18, 2021, sec. Climate, <https://www.nytimes.com/2021/05/18/climate/climate-change-emissions-IEA.html>.

are compatible with a variety of mobility options. Primarily, mobility hubs are meant to create a safe and convenient transportation environment. This is achievable by providing infrastructure supporting each person's travel needs.

Mobility hubs are a relatively new concept. Current mobility hub strategies published in cities such as Los Angeles CA, San Diego CA, and in Toronto, Canada, have yet to see their systems fully implemented. Given these circumstances, there is little practical knowledge on the siting and designing of mobility hubs for existing fixed route facilities. The consensus between professionals and academics is well designed mobility hubs take into consideration the context of the hub and the larger hierarchical operations of the transit network. This process achieves an understanding of what site features are likely to benefit the user. However, given the finite nature of space, determining which features are most vital to the specific demands of a hub creates a series of design considerations and trade-offs.

One consideration is if mobility hubs can be implemented at existing transit hubs or in neighborhoods without fixed route service. Transit hubs, or facilities currently dedicated to transit operations such as park & rides or transit centers, may have the benefit of being serviced by high-frequency transit services. They tend to be in areas of high demand such as dense neighborhoods or corridors with mixed residential and commercial uses. Additionally, existing facilities do not have the increased real estate costs affiliated with acquiring land for the mobility hub. But most importantly, existing transit facilities like transit centers or park & rides are already designed to be functional for transportation.

The features located at existing transit hubs pose the largest opportunity for facilitating mobility hub implementation. Existing site features such as sidewalks, curb spaces, electrical facilities, and parking spaces can be repurposed or redesigned to meet growing current and future trends in transportation. The growing body of mobility hub literature establishes these benefits along with general considerations for designing mobility hubs. They range from accommodating new modes of transportation to incentivizing mode changes from the automobile. However, identifying the specific functional opportunities of each site feature has yet to be accomplished. Determining the specific functions currently provided at transit facilities provides considerations necessary for siting mobility hubs.

The purpose of this thesis is to provide designers, planners, policymakers, and builders with a methodology for conducting generalizable urban design research at mobility hubs. The approach taken in this thesis to demonstrate generalizable urban design research begins by defining the benefit of generalization in urban design. This is achieved by evaluating the history of urban design and by reviewing the benefit of typologies for organizing information about the built environment. Having established the value of generalization in urban design, this thesis demonstrates how to conduct generalizable urban design research by assessing existing transit hubs in King County, WA. This process yielded a comprehensive list of compatible features that are generally applicable to mobility hubs, and therefore define the features and functions relevant to the concept. Illuminating existing strategies is important for determining what features are generally related to certain functions of mobility hubs. Applying this in practice requires a specific context to determine which features do or do not exist at the current location. This illuminates which features are most likely to provide greater function than what is currently available.

The analysis started by reviewing currently implemented mobility hub design guidelines. The review provided the thesis with an understanding of what is generally applicable at different mobility hubs based on the needs and priorities of that agency. Based on this analysis, a list of site features is created and organized based upon the methods employed by that agency. Four transit hubs in King County, WA were analyzed using matrices developed from the site features. These transit hubs were selected based on differing contextual characteristics and transportation demand. The purpose for incorporating sites of varying characteristics is to gain the largest pool of general takeaways when implementing mobility hubs at existing transit hubs.

Three matrices are used to determine the results of this research. Matrix 1 compares the design guidelines by KCM, the local transit facility operator, against mobility hub design guidelines published by San Diego Associations of Governments (SANDAG). The matrix is populated with fully- or half-shaded circles, indicating either a full or partial match in design and functional purpose. Matrix 1 discerns the priorities of each transit agency and highlights the general compatibilities between current design guidelines implemented in King County and the mobility hub design guidelines implemented elsewhere. Matrix 2 presents how current design guidelines are implemented at each KCM transit hub by determining whether facilities were implemented as intended or if implementation has led to unintended uses by the traveler. Most importantly this will give us an understanding of what is at the site and why it was planned. Finally, Matrix 3 compares the same facilities against SANDAGS design guidelines to determine the features that are most likely to have uses beneficial to mobility hub implementation. The takeaways all of three matrixes will be presented in the results section. These results will then be analyzed against the

literature and professional interviews in the discussion section. Finally, this thesis will end with a conclusion.

## CHAPTER 2. LITERATURE REVIEW

This chapter begins with a review of relevant theories for conducting generalized urban design research. This review will ground the thesis research in urban design theories that determine the value of generalization in the urban environment and how to organize the urban environment. More importantly, it will answer the question of how to conduct generalizable urban design research at mobility hubs. Once the research question is framed in urban design theory, the focus will shift towards defining mobility hubs. This will be accomplished through a review of academic and professionally written documents. Academic resources are beneficial for defining mobility hubs through previously completed observations. Academic resources provide best practices for siting, designing, and operating mobility hubs. Published regional and municipal design documents will highlight the current rules and recommendations employed by transit agencies that are on the vanguard of mobility hub implementation. Synthesizing actively employed design guidelines of other transit agencies will provide the thesis with methodology for selecting and siting mobility hub features. Overall, this portion of the literature review defines the assets of existing transit hubs in King County that are most applicable to King County.

### 2.1 DEFINING GENERALIZABILITY IN URBAN DESIGN

To understand generalizability in urban design it is imperative to define urban design. Urban design is a concept that has evolved over time and lacks a singular definition, but it is focused on the form and function of places. A rule of thumb is understanding urban design is largely dependent upon the goals set for a place. In this case the focus is on design governance. Design governance

refers to the regulations that control the built form of our environment such as street treatments, building massing, and other aesthetic qualities. Design governance provides a distinct role in standardizing the form of the built environment based on the values of a specific community or neighborhood. As observed in England and the U.S., design governance evolved from urban and natural preservation movements determined to preserve natural and built amenities. Design governance has three major outcomes: preserving historic downtowns and residential district character, improving a community's urban fabric at the street level, and establishing a consistent "look".<sup>3</sup> Based on the historical evolution of design governance from preservationist movements, specific policies in design governance generally reflect the character and values of a specific community.<sup>4</sup> Occasionally, the design dialogue is held publicly, allowing for people to address their conflicts in a meaningful and direct manner.<sup>5</sup> In theory, design governance establishes a higher standard of design by requiring architects and designers to be incorporate the public's preference.<sup>6</sup> The encouraged participation of the public requires designers to think deeply about the site context when considering design decisions. Design governance strategies then generalize the values present in a project's context to create a standard form that reflects the community.

Design governance strategies sometimes employ systems of organization through typologies. Typologies are often employed by cities and public agencies to organize, classify, and present groupings of shared objects such as housing typologies. Typologies are made by a series of

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<sup>3</sup> Robert Rotenberg, "Design Standards as Urban Planning: From Technical Specification to Community 'Look' in Northeast Illinois Suburbs," *Economic Anthropology* 2, no. 1 (2015): 145–64, <https://doi.org/10.1002/sea2.12022>.

<sup>4</sup> John Punter and Matthew Carmona, *The Design Dimension of Planning: Theory, Context, and Best Practices for Design Policies* (Taylor & Francis, 1997).

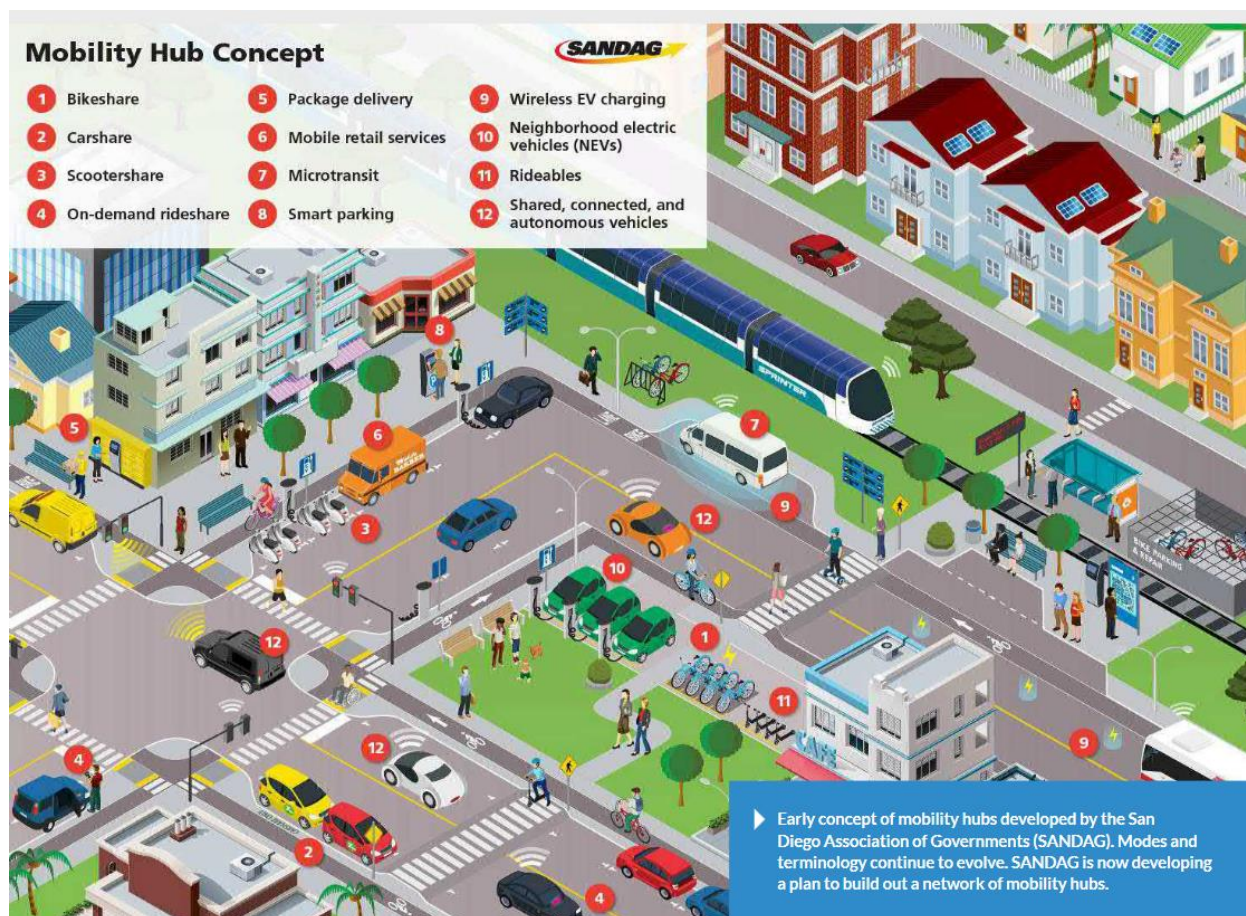
<sup>5</sup> Rotenberg, "Design Standards as Urban Planning."

<sup>6</sup> Punter and Carmona, *The Design Dimension of Planning: Theory, Context, and Best Practices for Design Policies*.

elements reflecting current values of the environment that are averaged to form a general ideal or “type” of design solution.<sup>7</sup> The typological approach is all about design intentions, and the ability to communicate contextual values through these specific intentions for a range of types, e.g., housing types, street types. Typological presentation by nature illustrates generalities yet conveys specific visual and physical ideas about the intended character of a place (Ibid).

## 2.2 DEFINING MOBILITY HUBS

Figure 1: Mobility Hub Concept (Shared Use Mobility Center, 2019, pg. 4 )



The mobility hub is a relatively new concept born from a growing need to improve transportation safety and promote community wellness and health. The mobility hub concept was originally

<sup>7</sup> Diana Painter, *Typology and Urban Design* (University of Sheffield, 1990).

conceived in Germany to overcome parking issues growing within cities. In these first iterations, mobility hubs primarily served as shared-mobility connection points.<sup>8</sup> The mobility hub concept has since evolved significantly from its inception twenty years prior. This is due to the growing diversity of travel patterns, technological innovations, and accommodation of user needs. Today, mobility hubs are areas served by a variety of sustainable transportation options. Mobility hubs have opportunities to integrate new mobility technology to improve both the user experience and transit resiliency.<sup>9</sup> The importance of providing sustainable mobility at centralized locations where travelers have access to a wide variety of public and privately operated transportation options is widely agreed upon.<sup>10</sup> Improved mobility access is beneficial towards discouraging single-occupancy vehicle trips. Enbel-Yan also supports that mobility hubs play a critical role in the regional transportation system. He also raises the significance of mobility hubs' second role; the place making role. Enbel-Yan stated the need for mobility hubs to be interesting and desirable places that encourage a diversity of uses and activities.<sup>11</sup> Saravanan concludes that correlative activities provided on site like repair, eating, shopping and logistical pick-up points are the types of opportunities for creating interesting and activated space.<sup>12</sup>

Choosing the appropriate locations for mobility hub implementation ultimately depends on the specific goals of a transit agency. However, the traits mentioned above connote the environmental

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<sup>8</sup> Thomas Arnold et al., “Mobility Hubs: Review and Future Research Direction,” *Transportation Research Record*, July 30, 2022, 03611981221108977, <https://doi.org/10.1177/03611981221108977>.

<sup>9</sup> Saki Aono, *Identifying Best Practices for Mobility Hubs* (TransLink, 2019).

<sup>10</sup> Doug Arseneault, “Mobility Hubs: Lessons Learned from Early Adopters,” June 30, 2022, <https://doi.org/10.17610/T6N31C>.

<sup>11</sup> Joshua Enbel-Yan and Amanda Leonard, “Mobility Hub Guidelines: Tools for Achieving Successful Station Areas,” *Institute of Transportation Engineers. ITE Journal* 82, no. 1 (January 2012): 42–47.

<sup>12</sup> Mukil Prasath Saravanan, “Modelling Impacts of Mobility Hubs in Residential Areas,” 2022, <https://repository.tudelft.nl/islandora/object/uuid%3Ab5b304bc-dcf1-4e1a-bdcc-2f6732649696>.

contexts most suitable for mobility hub application. Here are contexts that are suitable for mobility hub application:

**Surrounds major transit stations** – Presence of one or more major transit stations enhanced by residential and employment services that are accessible by uptake services at the hub.

**Provides sustainable transportation options** – Services and destinations are easily accessible within a five-minute walk, ride, and drive distance. Mobility hubs encourage active, and shared transportation methods such as micro mobility, bike-share, car-share, and other transit services like paratransit.

**Areas with high residential and employment density** – Dense urban environments with high activity are integral to achieving agency goals to the highest degree. Urban environments provide the most consistent user pools.<sup>13</sup>

Accessibility to high-frequency transit services like light-rail and bus rapid transit (BRT) creates a transparent transportation hierarchy connecting neighborhood residents to a regional network of destinations. The Shared-Use Mobility Center (SUMC) suggests a design strategy that considers the specific type of high-frequency transit types.<sup>14</sup> Research testing the applicability of mobility hubs in Dutch residential neighborhoods observed decreases in overall car and bus trips, but increases in vehicle miles traveled.<sup>15</sup> The reduced bus trips is a symptom of mode shifts favoring active transportation in a multi-modal approach. Increased car trips were in part the result of car share programs located at the mobility hub. However, some researchers underscore that

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<sup>13</sup> Aono, *Identifying Best Practices for Mobility Hubs*.

<sup>14</sup> Shared-Use Mobility Center, “Mobility Hubs” (Shared-Use Mobility Center, 2019).

<sup>15</sup> Saravanan, “Modelling Impacts of Mobility Hubs in Residential Areas.”

neighborhoods that are less served by public transportation may have the largest benefit from the roll out of neighborhood hubs.<sup>16</sup> These neighborhood locations could provide a larger catchment area for local amenities and services. Mobility hubs placed in underserved neighborhoods has also been understood to address issues of transportation equity.<sup>17</sup>

### 2.2.1 *Transportation Functions of Mobility Hubs*

The mobility hub concept has gained traction as a response to the negative externalities caused by a century of auto dependence. Negative health and safety externalities have made planning for future automobile compatibility at mobility hubs a contentious subject. Especially when placing mobility hubs in the context of a dense urban environment. For one reason, designating land for parking can discourage active transportation needs by fostering an auto-dominant environment. Secondly, land which could be used for residential entertainment, or employment purposes which could urban access are instead dedicated to underutilized parking lots.<sup>18</sup> However, existing parking facilities may play an increasingly significant role in implementing cleaner forms of automobile transportation.

Pasklawski determined that park and ride facilities located at the edge of large city downtowns have an increased opportunity of flexibly responding to user needs. Competition to parking demand such as car-share and electrified autonomous vehicles will have an impact on future user demands for automobile storage. Unforeseen disruptions such as the COVID-19 pandemic made

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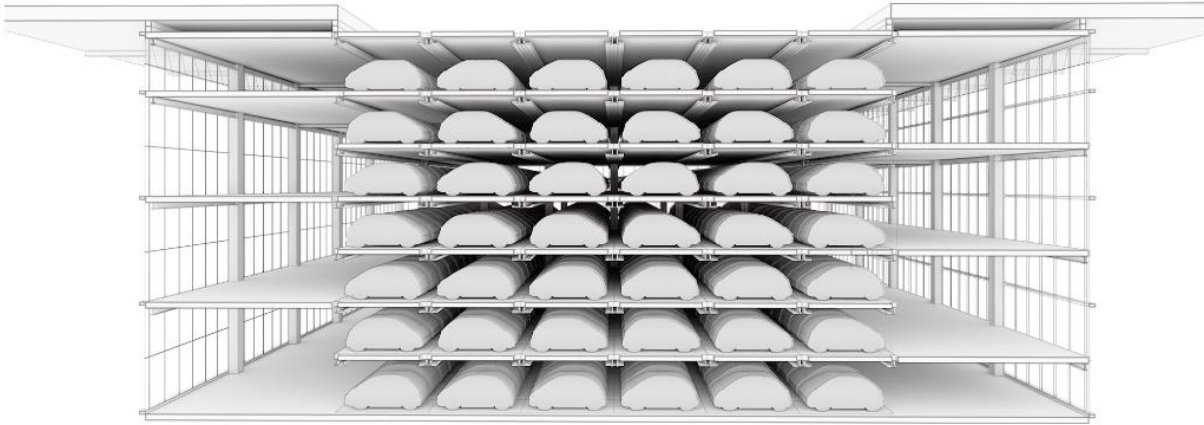
<sup>16</sup> Arseneault, "Mobility Hubs."

<sup>17</sup> Karl Anderson et al., "Incorporating Equity and Resiliency in Municipal Transportation Planning: Case Study of Mobility Hubs in Oakland, California," *Transportation Research Record* 2653, no. 1 (January 1, 2017): 65–74, <https://doi.org/10.3141/2653-08>.

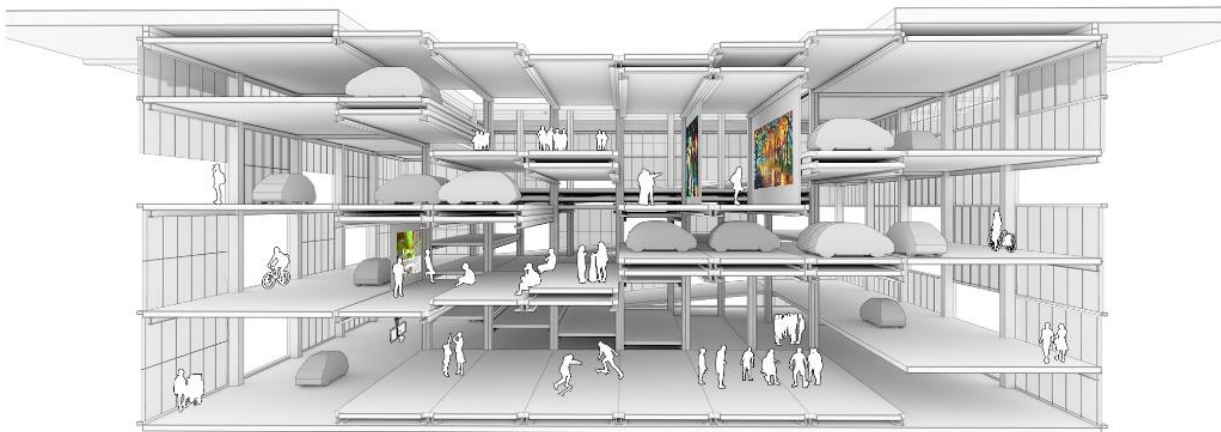
<sup>18</sup> Aono, *Identifying Best Practices for Mobility Hubs*.

evident that typical tendencies are not always guaranteed as hybrid work patterns required during the pandemic have become the new normal. However, professionals and researchers alike are

*Figure 2: Parking Garage Reuse Concept (Chen, 2018, fig. 39, pg. 71)*



*Figure 3: Parking Garage Fitting People and AV Storage ((Chen, 2018, fig. 40, pg. 71)*



aware that parking demand will change. Transportation and planning experts agree that the future of mobility is in shared mobility.<sup>19</sup> Shared mobility ranges in active and motorized mobility types including bike-share, scooter-share, scooter-share, car-share, carpool and vanpool services. The future operations of share-mobility systems are expected to reduce demand by more than half for sedans in the US by 2030 (Ibid). Mobility hubs currently in the planning and design stages at

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<sup>19</sup> Chen.

facilities with parking structures consider future flexibility.<sup>20</sup> Research indicates that these facilities may have multiple programmable spaces, like a basketball court being converted for the use of volleyball.<sup>21</sup>

Additionally, parking facilities with electric utilities present will also have the added benefit of implementing car charging infrastructure at reduced construction costs.<sup>22</sup> Public institutions will play a key role in incentivizing non-combustion engines by developing electric vehicle (EV) friendly infrastructure.<sup>23</sup> Currently there are incentives from public institutions for developing private car-charging facilities, but denser urban settings have the added challenge of providing car charging infrastructure. Increasing EV charger access and visibility can reduce the mental barriers associated with EV ownership and change perceptions of limited supportive infrastructure. Parking will need to be strategically assessed based on regional transportation objectives and local contexts. Strategic parking provisions can improve environmental and social conditions in dense urban areas through the roll out of EV's and car-share infrastructure. In auto-dominated areas, it will be most important to discourage a surplus of parking that would reduce demand by perpetuating auto-access and reducing mobility hub desirability.

The expected decrease in parking demand will be compensated with an increased demand for curb space. In the last decade, the rise of ride-hailing services like Transportation Network Companies

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<sup>20</sup> Jerzy Paslawski and Tomasz Rudnicki, "Flexible Design of Park-and-Ride Facility in the City Center Proximity," n.d.

<sup>21</sup> Chen, "Beyond the Autonomous Vehicle."

<sup>22</sup> Aono, *Identifying Best Practices for Mobility Hubs*.

<sup>23</sup> Dennis Y.C. Leung, W. C. Mok, and Y. L. Lee, "Challenges and Considerations in Migrating towards a Sustainable E-Mobility City," in *2021 9th International Conference on Smart Grid and Clean Energy Technologies (ICSGCE)*, 2021, 62–67, <https://doi.org/10.1109/ICSGCE52779.2021.9621697>.

(TNC's) Uber and Lyft have signaled this shift. As autonomous vehicle (AV) technology continues to advance, the demand for curb space will grow. AVs are expected to be commonplace within this generation, increasing the importance providing supportive infrastructure for the new mobility type.<sup>24</sup> The continuous motion of AV's which will not need dwell during the day will be part of constantly running network of vehicles.<sup>25</sup> Given the shared demand for curb space between TNC's, pick-up/drop-off areas, and future AV accessibility, strategic assessment of curb space will be required. Similar to parking provisions, features oriented to automobiles come at the consequence of walkability and the pedestrian experience. Thus, designing for these uses must require carefully balancing between pedestrian and auto access needs.

Moving beyond personal vehicles, publicly-operated fixed-route rapid transit services are foundational to mobility hub development. Several leading transportation agencies have specified the importance of integrating mobility hubs around core public transit systems.<sup>26</sup> These services range from regional rail systems to high service bus stations and are generally the most affordable option and provide convenient access to a greater proportion of the region.<sup>27</sup> However, these systems too are being upgraded to meet their share of environmental and social responsibility. Implementation of bus charging infrastructure will be space intensive to supply the utilities for charging. In situations where on-route charging services are required, stations already offering layover zones are best oriented towards providing charging facilities to give buses the opportunity to charge during operator break times. Charging services currently available include pantographic,

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<sup>24</sup> *Nico Larco: How Will Autonomous Vehicles Transform Our Cities?* | TED Talk, TedTALKxCollege Park (TedTALK, 2018), [https://www.ted.com/talks/nico\\_larco\\_how\\_will\\_autonomous\\_vehicles\\_transform\\_our\\_cities](https://www.ted.com/talks/nico_larco_how_will_autonomous_vehicles_transform_our_cities).

<sup>25</sup> Chen, "Beyond the Autonomous Vehicle."

<sup>26</sup> Arnold et al., "Mobility Hubs."

<sup>27</sup> Arseneault, "Mobility Hubs."

Gantry, and connected charging. Other concerns for fixed route services include provisions for bus accessibility and wayfinding. Additional accessory features that improve the bus riding experience from the point-of-view of the user such as benches and canopies will be discussed further in placemaking.

Additionally, provisions for on-demand micro-transit should be implemented. These services are dedicated to assisting lower density areas less suited for fixed-route bus operations(Ibid). These smaller vehicles have a capacity of five to twelve riders and offer flexible on-demand services. Generally, these services require less space given their dimensions and route frequency. Features that would benefit this mobility type include dedicated or shared-space for drop-off and pick-ups. These vehicles may also run on electricity or alternative fuels, thus requiring curb or parking space for lay-over charging. Again, this is dependent on route frequency, topography, and other environmental limitations.

Bike facilities are integral to incentivizing active transportation models by improving peoples' attitudes towards the mode choice. Facilities that give protected access and safe parking facilities may help changing people's behavior towards biking.<sup>28</sup> Features that can improve bike accessibility include bike parking (long- and short-term) as well as options for on-demand or membership-based? services. Providing clear access points and dedicated lanes or raised pathways

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<sup>28</sup> Jennifer Dill, Cynthia Mohr, and Liang Ma, "How Can Psychological Theory Help Cities Increase Walking and Bicycling?," *Journal of the American Planning Association* 80, no. 1 (January 2, 2014): 36–51, <https://doi.org/10.1080/01944363.2014.934651>.

can also improve rider experience by prioritizing user safety. Other facilities that can improve bike implementation include bike repair stations, electric charging stations.<sup>29</sup>

## 2.3 CURRENT MOBILITY HUB STRATEGIES

This next section will review mobility hub strategies currently implemented by the cities of Los Angeles, San Diego, and Toronto. Policy documents will be analyzed to determine the specific design strategies used for siting and designing mobility hubs. Key elements to be reviewed include overarching goals of mobility hubs, strategies for locating mobility hubs, and how functions and features are organized.

### 2.3.1 *Los Angeles - Mobility Hubs: A Reader's Guide*

Like Toronto and San Diego, the *Los Angeles Mobility Hubs: a Reader's Guide* is meant to provide guidance and inspiration for city staff, property owners, transit agencies and all possible collaborators for developing mobility hubs to support multi-modal connectivity and access. The guide is organized into 8 topic chapters integrated by supportive amenities. Figure \_\_\_ illustrates the organization of features based on a typological approach, where each amenity is then. LA justifies its use of a typological approach by acknowledging the diversity of mobility hub contexts and specific design recommendations based on different scenarios. The typology splits mobility hubs into three tiers to reflect transit needs and the existing built environment: Neighborhood, Central, and Regional.

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<sup>29</sup> Aono, *Identifying Best Practices for Mobility Hubs*.

Figure 4: Mobility Hub Typologies (Urban Design Studio, pg.7)

Mobility Hub Amenities	Bicycle Connections			Vehicle Connections			Bus Infrastructure		Information-Signage			Support Services				Active Uses		Pedestrian Connections	
	2.1. Bike Share	2.2. Bike Parking	2.3. Bicycling Facilities	3.1. Ride Share/Pick up-Drop off	3.2. Car Share	3.3. EV Charging Stations	4.1. Bus Layover Zone	4.2. Bus Shelters	5.1. Wayfinding	5.2. Real-time Information	5.3. Wi-Fi / Smartphone Connectivity	6.1. Ambassadors	6.2. Waiting Area	6.3. Safety and Security	6.4. Sustainable Approach	7.1. Retail	7.2. Public Space	8.1. To the Mobility Hub	8.2. At the Mobility Hub
(N) Neighborhood	●	●	■	■	○	○	■	○	●	○	○	■	○	○	○	■	■	○	○
(C) Central	●	●	○	●	●	●	○	●	●	●	○	○	●	●	○	●	●	●	●
(R) Regional	●	●	●	●	●	●	●	●	●	●	●	●	○	●	●	●	●	●	●

Legend: Vital: ● Recommended: ○ Optional: ■

**Neighborhood** - smaller ancillary located in low-density neighborhoods offering few basic amenities

**Central** - Typically located in more urban contexts and can encompass one or more stations. They provide additional amenities which are integrated throughout the neighborhood but still within walking distance to the station.

**Regional** - These large stations are generally located in the dense urban areas or at the ends of transit lines connecting to other regional providers. They offer the most amenities along with important infrastructure built into the mobility hub itself. Locations could be as large as one acre.<sup>30</sup>

<sup>30</sup> “Mobility Hubs Reader’s Guide | Urban Design Studio | City of Los Angeles,” accessed April 12, 2023, <http://www.urbandesignla.com/resources/MobilityHubsReadersGuide.php>.



maturity of up-and coming mobility technologies. In a list describing the actions for enabling mobility hub implementation, SANDAG pays specific attention to planning for the future of autonomous vehicles and the investments in infrastructure at mobility hubs and cities to prepare for their roll out. The memo's body consists of guidance for different considerations of the mobility hub. Specific to this thesis, it offers guidance on implementing mobility hubs at existing and new developments. Regarding existing developments, the memo suggests that co-locating hubs at existing transit facilities where transit is most active makes the most sense. The main concern is the collaboration with stakeholders and property owners for the infrastructure and land requirements to build out a network of protected mobility networks. They give the example of working with local shopping centers to provide increased EV infrastructure and parking dedicated to car-sharing programs. SANDAG also views working with new developments as advantageous for mobility hub implementation based on the ability to require public amenity at new developments. Given that most of the forecasted development is to occur within existing high frequency-transit, providing the necessary infrastructure through the hub becomes less contentious.<sup>31</sup>

### 2.3.3 *Toronto - Metrolinx Mobility Hub Guidelines (2011)*

The mobility hub guidelines, as part of the Big Move, are a push to guide the design and implementation of mobility hubs by clearly communicating the mobility hub concept, provide guidance and inspiration for mobility hub plans, become a tool for collaboration between other transit providers, developers, consultants, and other collaborators, and give key decision directions for future planning efforts. The guidelines are organized into three categories: Seamless Mobility,

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<sup>31</sup> San Diego Association of Governments (SANDAG), "Mobility Hub Features Catalog," accessed April 15, 2023, <https://www.sandag.org/projects-and-programs/innovative-mobility/mobility-hubs/mobility-hub-planning-resources>.

Placemaking, and Successful Implementation. While it does not specify the general functions to be considered for mobility hub implementation, it provides recommendations for mobility hubs based on these categories. Topics for seamless transportation indicate the importance of integration of transportation connectivity, pedestrian priority and safety, improved user experience through site design, and strategic parking management. Placemaking topics focus on the whole environment in proximity to the site, specifically the need for a vibrant, mixed-use, and dense context that is attractive to the user. While also considering the ecological footprint through sustainable utility practices. A table is included here indicating the suggested land densities and ridership requirements for specific transit modes. The Successful Implementation category considers other opportunities for reducing the barriers of mobility hub development. The guidelines suggest that these sites be built to be accommodating to future growth and change in user travel habits.<sup>32</sup>

## CHAPTER 3. METHODS

King County Metro, Sound Transit, and Seattle City Light are all dedicated towards developing the mobility hub concept in King County as they are major providers of utilities and infrastructure for the area. So far, this thesis has described a host of factors that are impeding mobility hub implementation. These factors range from physical constraints of existing spaces to cultural norms around transportation. To expedite mobility hub deployment, the following question was conceptualized for examination.

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<sup>32</sup> *Mobility Hub Guidelines / Metrolinx*, 2011, [https://assets.metrolinx.com/image/upload/Documents/Metrolinx/mhgbrochure\\_mzom6p.pdf](https://assets.metrolinx.com/image/upload/Documents/Metrolinx/mhgbrochure_mzom6p.pdf).

**How can generalizable urban design research be conducted?**

The purpose of examining this question is to understand the specific features of the environment that are transferable. In other words, defining which features will still have utility, or be redesigned to meet the new needs of the mobility hubs. Ultimately, determining the specific tangible features related to a larger web of uses will be beneficial towards reducing project costs, project timeliness, and provide increased efficiency for site development based on using existing features.

To develop a response to this question and properly demonstrate the research's utility, the research considered both quantitative and qualitative methods. In the end, the following methods as described in the table below.

*Table 1: Selected Research Methods*

<b>Method</b>	<b>Description</b>	<b>Purpose</b>
Literature Review	Review of applicable subject matter available in academic literature and policy frameworks implemented by public transit agencies	<ul style="list-style-type: none"> <li>• Define best practices</li> <li>• Inventory site features</li> <li>• Determine benefits/limitations</li> <li>• Establish framework for conducting research</li> </ul>
In-depth Interviews with Subject Matter Experts	Loosely-structured interviews with members of lead agencies currently vested in mobility hub development	<ul style="list-style-type: none"> <li>• Develop context specific challenges / opportunities</li> <li>• Identify related programs and documents</li> </ul>
Workshop	Observations made at a workshop with lead agency representatives conducted by the University of Washington	<ul style="list-style-type: none"> <li>• Glean agency and cross-agency priorities</li> <li>• Define timelines for implementation</li> </ul>

		<ul style="list-style-type: none"> <li>• Review, physical, functional, and operational considerations</li> </ul>
Empirical Analysis	A cross comparison evaluating the relationship between the existing, proposed, and theoretical	<ul style="list-style-type: none"> <li>• Identify gaps between existing transit facility guidelines and mobility hub guidelines</li> <li>• Identify gaps in implementation between existing facilities current design guidelines</li> <li>• Identify opportunities for mobility hub implementation at existing facilities</li> </ul>

### 3.1 LITERATURE REVIEW:

When the research began, there were two intended goals for the literature review. Ultimately for my research to be successful my literature review not only needed to be foundational for my content expertise, but also answer the research question originally set. However, given that the focus of this thesis is reducing barriers to implementing mobility hub facilities, this question needed to be presented in a new context. Conducting generalizable urban design research is possible by acknowledging tangible features of site and finding tangible similarities between function and feature. In this case, it is the feature that is being generalized to support an increasing number of mobility needs. This foundation, summarized from the many literature sources, will form the base for other research methods employed in my research.

Additional to answering the research question, the literature review provides insight to the design considerations necessary for mobility hubs. This gave me a firm understanding of best practices, key considerations, and theoretical benefits as identified in the academic literature. From the published journals and books there were specific systems that reoccurred in many of the analysis.

These specific transportation systems and their accompanying design and implementation guidelines underline real-world priorities for siting and designing mobility hubs. This review provided me with a foundational understanding necessary to develop my research question and considering necessary data to support the multi-criteria analysis. SANDAG's *Mobility Hub's Features Catalog* will be the basis for the inventory of site features functionally relevant to mobility hub operation. KCMs *Transit Hubs Typology and Element Toolkit* will be instrumental in generalizing the elements related to transit facilities as communicated to collaborators, developers, designers and the general public.

### 3.2 WORKSHOP

A workshop was convened by representatives of KCM, Sound Transit, and SCL to understand how to renovate existing transit hubs for the future of EV buses. As they are currently invested in a joint fleet electrification project, representatives were motivated to collaborate in three small group exercises facilitated by the UW team. The exercises pressed the representatives to consider functional, physical, and operational elements of mobility hubs by order of priority. These overarching consideration themes each had an individual workspace. The three periods: Short-, mid-, and long-term, went undefined to stimulate conversations between the clients. It was decided that allowing the participants to decide this would be an interesting insight into each agency's general timeline. Elements were presented on sticky notes, while additional sticky notes were made available in case everyone had additional elements to present. Overall, the exercise revealed the priority elements of each agency, while also alluding to element adjacencies by grouping sticky notes.

### 3.3 IN DEPTH INTERVIEWS WITH SUBJECT MATTER EXPERTS

Two interviews were conducted with representatives of the agencies that were present in the first workshop. These semi-formal interviews were conducted virtually over Zoom, and allowed for a supportive dialogue for my research. The main goal was to expand on information gathered from the first workshop. Secondary was determining how realistic was the academic literature and other cities' policy direction. Overall, the two interviews would determine King County's contextual considerations and specific directions for the future of mobility in Seattle. The loose-structure of the interviews allowed for tangential information to become relevant and new opportunities for additional research. Therefore, questions were not exactly similar between the two interviewees. However, the information conveyed was generally similar and relevant to the larger research at hand.

### 3.4 EMPIRICAL ANALYSIS

The literature review, workshop, and interviews have generated a comprehensive inventory of functions and features most common or natural to mobility hubs. This inventory forms the criteria for measuring existing transit facilities for mobility hub implementation. To understand how this inventory of features by functions is applied to each study area, two empirical analyses are conducted. Maps will be used to understand how site context can impact a site's design. Additionally, three matrices are developed to understand commonalities and variations between policy and the built environment.

Maps are used to analyze how transit hubs are designed to fit their urban surroundings. The maps show the location of site features based on the built and natural environment, as well as

environmental factors like land use and transportation infrastructure. Visualizing these features creates an understanding of how people use transportation in the area. If a site is missing features that are required or recommended by guidelines, it may be because of the context of the site.

The maps are made using 2D mapping services provided by Google Earth, ArcGIS, and Travel Time. Google provides the base maps, which are scaled to the size of a 15-minute walk from the study area. These walksheds are generated by Travel Time, an online API that allows users to create transportation-shed maps based on transportation mode and travel time. Additionally, ArcGIS is used to determine local land uses, transportation infrastructure, and high-frequency transit services based on data provided by local and county open data sources.

A 15-minute walkshed is an ideal distance for people to access amenities and services comfortably. This measurement is used increasingly to determine a community's health and well-being because it reduces car dependence and socioeconomic inequity. When people can walk to services they need, it reduces the number of car trips they take, which is better for the environment.<sup>33</sup> The cost of car ownership is often seen as a barrier to accessing jobs and services, so walking is also better for socioeconomic health. Both environmental and socioeconomic health are important for defining the health and well-being of a community. Additionally, these maps will show general land use categories to illustrate the diversity of uses present within the walksheds. Land use diversity is linked to an exciting and economically healthy environment. Mobility hubs work best in areas where there are commercial, residential, and entertainment uses close to the hub, according

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<sup>33</sup> Robert Steuteville Andres Duany, "Defining the 15-Minute City," Text, CNU, February 8, 2021, <https://www.cnu.org/publicsquare/2021/02/08/defining-15-minute-city>.

to literature. The maps will show how close these uses are. Lastly, the analysis will demonstrate the location of transportation infrastructure and services. Infrastructure may improve peoples attitudes towards active transportation types by catering to certain transportation behaviors. If mobility hubs are to be implemented successfully, they must be supported by connected transportation infrastructure the promotes active and shared transportation types.

Matrix 1 provides a policy comparison analyzing the differences and similarities between King County KCMs *Transit Hubs Typology and Element Toolkit* and SANDAG's *Mobility Hub Features Catalog*. Both documents organize site features and services based on common themes and functional purpose. These design guidelines are intended to increase collaboration between regional agencies, transit operators, and private service providers by visually demonstrating the criteria for locating site features at transit facilities. This visual factor reduces the technicality of the document and thus makes it more approachable for businesses, residents, developers, and so on to understand the design priorities of each agency. The goal for Matrix 1 is to demonstrate the differences between mobility hub design and policy from current KCM guidelines. Matrix 1 will highlight common features and differentiate between features and the functional purpose for their implementation. This additional layer, identified by hollow or whole circle, defines the generalizable capacity of specific features as transit facilities are considered for mobility hub implementation. It also provides a macro-level approach to understanding system priorities and adapting policies for mobility hub implementation.

The *Transit Hubs Typology and Element Toolkit* is the current design manual for considering the functional requirements, recommendations, and opportunities for transit facilities in King County.

These features are organized by user need, and categorized across themes of environment, convenience, information, or comfort. All features are summarized in Table 2 below.

*Table 2 Transit Hubs Typology and Element Toolkit Features List*

Theme	Function	Feature
Environment	Accessibility	<ul style="list-style-type: none"> <li>● Step-free Access Information</li> <li>● Audible Tactile Information</li> <li>● Clear, well- defined paths</li> <li>● Iconography and High Contrast Colors</li> </ul>
	Safety	<ul style="list-style-type: none"> <li>● Slide-resistant surfaces</li> <li>● Pedestrian Guardrails</li> <li>● Pedestrian Safety Treatments</li> </ul>
	Personal Security	<ul style="list-style-type: none"> <li>● Lighting</li> <li>● Clear Sight Lines</li> <li>● Emergency Call Boxes</li> <li>● Staff Presence</li> <li>● CCTV</li> <li>● Operator Notification Beacons</li> </ul>
	Protected Environment	<ul style="list-style-type: none"> <li>● Benches and leaning rails</li> <li>● Shelters</li> <li>● Wind Breaks and Sound Barriers</li> <li>● Continuous Weather Protection</li> <li>● Enclosed, Climate Controlled Waiting Areas</li> <li>● Energy Efficiency</li> </ul>
	Environmental Sustainability	<ul style="list-style-type: none"> <li>● Sustainably Sourced and/or Recyclable Material</li> <li>● Sustainable Landscaping</li> <li>● Multi-stream Litter Receptacles</li> <li>● Passenger Pick-up and Drop-off zones</li> </ul>
Convenience	Ease of Movement	<ul style="list-style-type: none"> <li>● Off-board Fare Collection</li> <li>● Carshare Parking Spaces</li> <li>● Electric Vehicles Charging Stations</li> </ul>
	Bicycle Facilities	<ul style="list-style-type: none"> <li>● Bicycle Racks</li> <li>● Enclosed Bicycle Parking</li> <li>● Bicycle and Scooter Share Areas</li> <li>● Bicycle Repair Stands</li> <li>● Bicycle Centers or Bicycle Hubs</li> </ul>
	Clean and Well Maintained	<ul style="list-style-type: none"> <li>● Single Stream Litter Receptacles</li> <li>● Recycling Receptacles</li> <li>● Operator Comfort Stations</li> </ul>
Information	Wayfinding	<ul style="list-style-type: none"> <li>● Bus Stop Signage</li> <li>● Guide Signs</li> <li>● Station or Transit Center Identifiers</li> <li>● Station Maps and Area Maps</li> <li>● Digital Information Kiosks</li> <li>● Staff or Agency Ambassadors</li> </ul>

	Service Information	<ul style="list-style-type: none"> <li>● Static Schedule Signs</li> <li>● Real Time Information Displays</li> <li>● Digital Information Kiosks</li> <li>● Multi-language Signage and announcements</li> </ul>
Comfort	Placemaking	<ul style="list-style-type: none"> <li>● Coordination of the visual design with surrounding areas and communities</li> <li>● Public Art</li> <li>● Landscaping</li> <li>● Landmark Architecture</li> </ul>
	Multi-use Spaces	<ul style="list-style-type: none"> <li>● Public Wi-Fi and Charging Stations</li> <li>● Public Restrooms and Water Fountains</li> <li>● Public Spaces</li> <li>● Mail Drop-off Boxes, Package Pick-up Lockers and Newspaper Boxes</li> </ul>

Similarly, SANDAG's *Mobility Hub Features Catalog* is a design manual currently implemented to express the intentions of mobility hubs to stakeholders and the public. The features are organized between five themes of transit amenities, pedestrian amenities, bike amenities, motorized services and amenities, and support services and amenities. Catalog features are summarized below in Table 3.

Table 3 *Mobility Hub Features Catalog* Features List

Theme	Function	Feature
Transit Amenities	Enhanced Transit Waiting Areas	<ul style="list-style-type: none"> <li>● Seating</li> <li>● Landscaping</li> <li>● Bus Shelter</li> <li>● Trash Receptacles</li> <li>● Complimentary Wi-Fi</li> <li>● Real-time Transit Arrival Alerts</li> <li>● Schedule Information</li> </ul>
	Passenger Loading Areas	<ul style="list-style-type: none"> <li>● Curb spaces</li> </ul>
	Bus Infrastructure	<ul style="list-style-type: none"> <li>● Bus Layover Zone</li> <li>● Dedicated Transit Lanes</li> </ul>
	Real Time Travel Information	<ul style="list-style-type: none"> <li>● Real-travel Information</li> </ul>
Pedestrian Amenities	Walkways	<ul style="list-style-type: none"> <li>● Wide Walkways</li> </ul>

		<ul style="list-style-type: none"> <li>● Landscaping</li> <li>● Pedestrian-Scale Lighting</li> <li>● Enhanced Pacing</li> <li>● Pedestrian Cut Throughs</li> <li>● Street Furniture</li> </ul>
	Crossings	<ul style="list-style-type: none"> <li>● Curb Bulbs</li> <li>● Signal Timing Treatments</li> <li>● Mid-block Crossings</li> <li>● Refuge Islands</li> <li>● Pedestrian Crossing Protections</li> </ul>
Bike Facilities	Bikeways	<ul style="list-style-type: none"> <li>● Class I-IV Bikeways</li> <li>● Median Refuge</li> <li>● Bike Signals</li> <li>● Bike Boxes</li> <li>● Bike Channels</li> <li>● Bike Footrest</li> <li>● Bike and Pedestrian Counters</li> </ul>
	Bike Parking	<ul style="list-style-type: none"> <li>● Bike Racks</li> <li>● Bike Corrals</li> <li>● Bike Lockers</li> <li>● Secure Group Parking</li> </ul>
	Bike Services	<ul style="list-style-type: none"> <li>● Bike Valet</li> <li>● Bike Repair Stands</li> <li>● Bike Charging Station</li> <li>● Bike Washing Station</li> </ul>
	Bikeshare	<ul style="list-style-type: none"> <li>● Bikeshare</li> </ul>
Motorized Services and Amenities	Dedicated Transit Lanes	<ul style="list-style-type: none"> <li>● Bus only lanes</li> <li>● Special signal treatments</li> </ul>
	Rideables (bikes, scooters)	<ul style="list-style-type: none"> <li>● Charging outlets</li> </ul>
	Electric Bike and Scooter Share	<ul style="list-style-type: none"> <li>● Parking locations</li> </ul>
	Carshare	<ul style="list-style-type: none"> <li>● Carshare</li> <li>● Parking locations</li> </ul>
	On-demand Rideshare	<ul style="list-style-type: none"> <li>● Shared / flexible curb space</li> </ul>
	Micro Transit	<ul style="list-style-type: none"> <li>● Shared / flexible curb space</li> </ul>
	Neighborhood Electric Vehicles	<ul style="list-style-type: none"> <li>● EV car charging</li> <li>● Dedicated path</li> </ul>
	Electric Vehicle Charging	<ul style="list-style-type: none"> <li>● Type I, Type II, or DC Charging Facilities</li> </ul>
	Smart Parking	<ul style="list-style-type: none"> <li>● In-street sensors</li> <li>● Smart meters</li> <li>● Realtime information</li> <li>● Parking reservation systems</li> </ul>
Flexible Curb Spaces	<ul style="list-style-type: none"> <li>● Physical separation from traffic</li> <li>● Traffic calming</li> <li>● Landscaping</li> </ul>	

		<ul style="list-style-type: none"> <li>● Special pavement</li> </ul>
Support Services and Amenities	Wayfinding	<ul style="list-style-type: none"> <li>● Static signs/ maps</li> <li>● Interactive maps</li> <li>● Distinct identity</li> </ul>
	Parcel Delivery	<ul style="list-style-type: none"> <li>● Parcel Lockers</li> </ul>
	Mobile Retail Services	<ul style="list-style-type: none"> <li>● Parking Spaces</li> <li>● Public Spaces</li> </ul>
	Universal Transportation Account	<ul style="list-style-type: none"> <li>● Universal transportation account</li> </ul>

Matrix 2 uses the same format applied in Matrix 1 but analyzes at the micro-, or site-, level. This comparison is necessary to understand how the document properties are translated into real world applications. These findings, together with Matrix 3, will provide macro-level recommendations for agencies designing mobility hubs to consider. These recommendations will be further explored in the discussion section. Matrix 2 compares four facilities – Burien Park and Ride, Northgate Transit Center, Renton Transit Center, and Green Lake Park and Ride - against KCMs Toolkit.

Matrix 3 is like Matrix #2 in that it continues the micro-level review of specific facilities against design guidelines. Where matrix #3 differs is that it compares the facilities designated in matrix #2 against SANDAG’s *Mobility Hub Catalog*. It uses the same hollow and full circle indicators to signify a complete or incomplete alignment between the site features and their observed functions against SANDAG’s features and their associated function as defined by the agency. This will determine which features need no alteration, or minor alterations to features, for mobility hub implementation. Simultaneously addresses which features most influence high- quality design.

In total, the three matrices form a demonstration of generalizable urban design research for mobility hub design and implementation. The matrices determine the tangible connections that a

feature may have to different functions, and ultimately provide a route for site design based on a low impact approach to developing mobility hubs at existing transit facilities.

### 3.5 SITE SELECTION

Each site was selected based on shared and unique qualities between different case study locations. Shared qualities between case study sites include automobile access and storage, operation by King County Metro, and that they are serviced by at least one high frequency line. Automobile access was deemed important based on the opportunities mentioned in the literature for parking, curbs, and other car-oriented infrastructure that is present. Given our historical dependence on the automobile, understanding how these facilities may be flexible towards other functions. Operation by King County Metro was deemed an important trait for controlling the overarching design of transportation facilities through shared guidelines and operational priorities. Lastly, presence of high frequency transit lines was an overarching theme defined in the literature for mobility hubs. Beyond similarities, the case study locations host a variety of contextual and transportation demands that create specific outcomes for each site. That being said, the following paragraphs describe the unique qualities that warranted the site's selection:

## Burien Transit Center and Park n Ride:

*Figure 6: Burien Transit Center and Park & Ride*



The Burien Case Study is located centrally in the City of Burien, providing a host of residential, retail, dining, and civic services within walking distance. The transit center is removed from the ROW. The most unique character of the site is the presence of electric car charging ports within the parking structure of the park n ride. Additionally, the transit center has six total bus bays/stops and has two high frequency bus lines (F and H Rapid Rides), bus layover zones, operator breakrooms, 504 parking stalls provided in off-street parking lots and structures. This site was selected based on the bus terminal size and existing electrical capacity.

Renton Transit Center:

*Figure 7: Renton Transit Center*



Renton Transit Center Case Study is also located in downtown Renton located in the right-of-way between Logan Avenue South and Burnett Avenue South. The immediate vicinity includes parks, event center, dining, and residential land uses. The Transit Center has 10 total bus bays/stops, five high frequency bus lines, 150 covered parking spaces, and café. The site was selected due to the urban fabric and number of high-frequency routes and bus bays.

Northgate Station Transit Center and Park n Ride

Northgate is the most recently updated site in the case study list with the light rail's maiden voyage from the Northgate platform taking place in October 2021. Northgate Station Transit Center is the

largest geographically as it expands across several city blocks including space in the Thornton Place mixed-use center and the Northgate Mall. The station is not centrally located in the neighborhood. Northgate station is the only case study location with light rail service. Additionally, it has four bus bays served by three high frequency lines (75, 67, 44) on top of all day routes. There are 443 parking spaces split between five parking lots and nine ADA parking stalls. The site is adjacent to Interstate 5, retail, dining, and residential services. Northgate was selected based on these contextual features and its presence of the light rail line.

*Figure 8: Northgate Transit Center*



## Green Lake Park n Ride

Green Lake Park n Ride is the smallest geographically and located underneath the interstate 5 just west of the Roosevelt light rail station. The stations are located on the right of way along NE 65 the street. The stations are surrounded north and south by the park n ride lots. The area is composed of middle/low density to the east and high-density mixed-use retail/residential to the west. They are connecting to recreational spaces. There are two high frequency lines serving the station. Along with amenities for other active mobility users. Additionally, there are 411 parking spots. The site was selected based on these differing factors and for its smaller size and volume compared to other sites.

*Figure 9: Green Lake Park & Ride*



### 3.6 LIMITATIONS:

To begin, this research was designed to generalize mobility hub siting and design strategies as currently implemented and observed studies. However, there have been several iterations of this research based on the limitations uncovered in the research and writing process. Some limitations include mobility hubs being a relatively new concept, availability of public transit agency design guidelines, and user input.

The mobility hub concept is relatively new in practice especially in the US. Few transit agencies have fully adopted mobility hub programs which adds several challenges, including defining mobility hubs in a US context. While this thesis does not assume that mobility hubs will have the exact qualities of mobility hubs of other northern hemisphere cities, it does expect that the fundamental components of sustainability, transportation equity, and convenience will be echoed in the American context.

Another limitation is the availability of literature concerning mobility hubs is minimal at best. Specifically, the availability of mobility hub design guidelines published by leading cities has made it difficult to determine what are the functional priorities of mobility hubs. Some cities have made their design guidelines transparent through visual organizational mediums such as typologies and summary tables. However, most cities do not have this level of transparency and are less forthright with their design goals. The most clearly established catalogue of mobility hub features is provided by SANDAG in the Mobility Hub Features Catalogue. For this reason, the Mobility Hub Features Catalogue was selected to compare against existing KCM design guidelines. However, unlike KCM design guidelines which specifically state each feature in their Toolkit,

SANDAG implies the features associated with mobility hubs through summaries, images, and bullet points. These implied features are represented within the results.

Finally, the maps created for this thesis are limited to showing environmental contexts, electric vehicle charging points, and walksheds for pedestrians. The maps lack additional pedestrian, bike, transit, and other features/ systems that would improve the results of these maps.

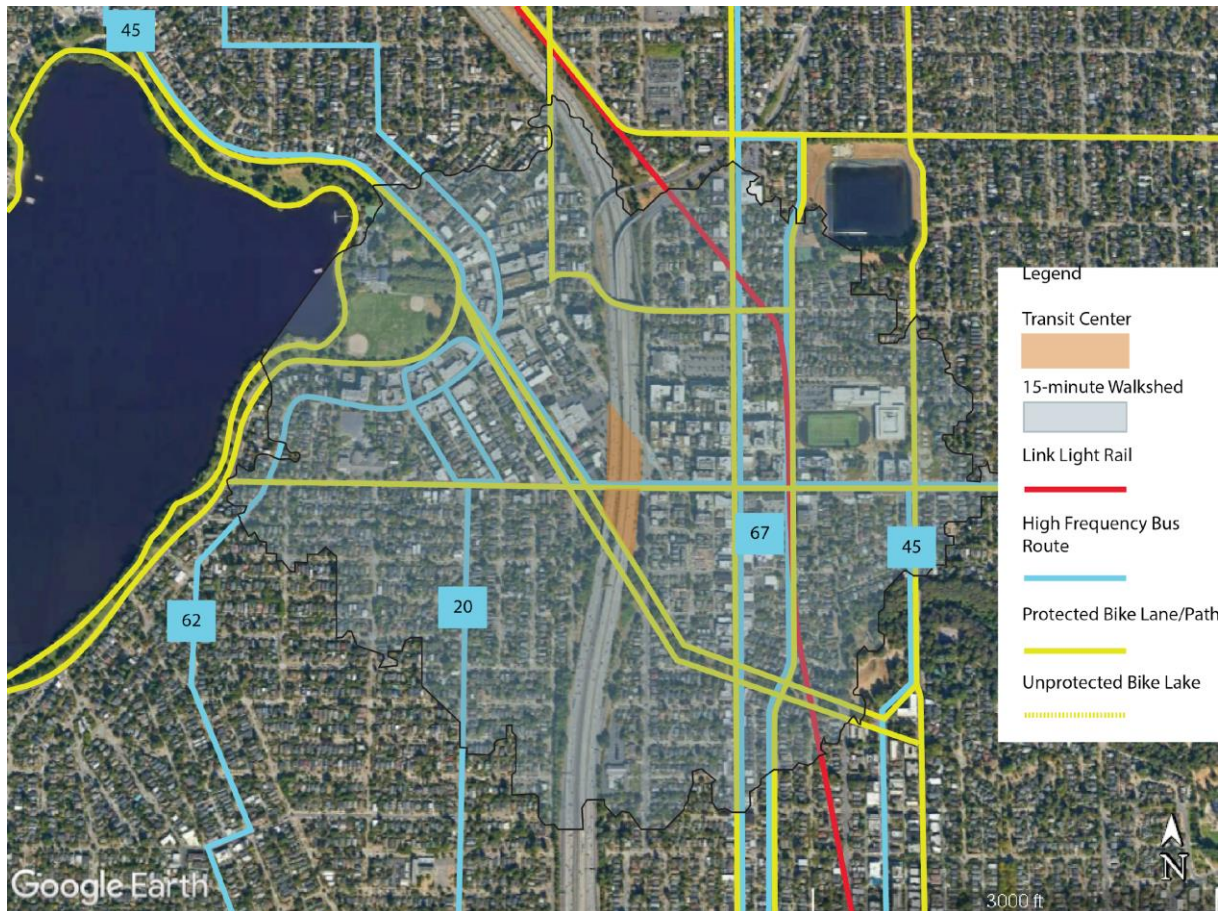
## CHAPTER 4. RESULTS

The purpose of this research is to determine the general site design considerations for implementing mobility hub features at existing KCMs transit facilities. This chapter reveals the findings through a culmination of several methods into three matrix tables. These matrices demonstrate the intersections of existing and proposed features to define the general takeaways for mobility hub implementation.

### 4.1 CONTEXT MAPS

The following maps were made available to understand the neighborhood contexts for each of the four transit hubs.

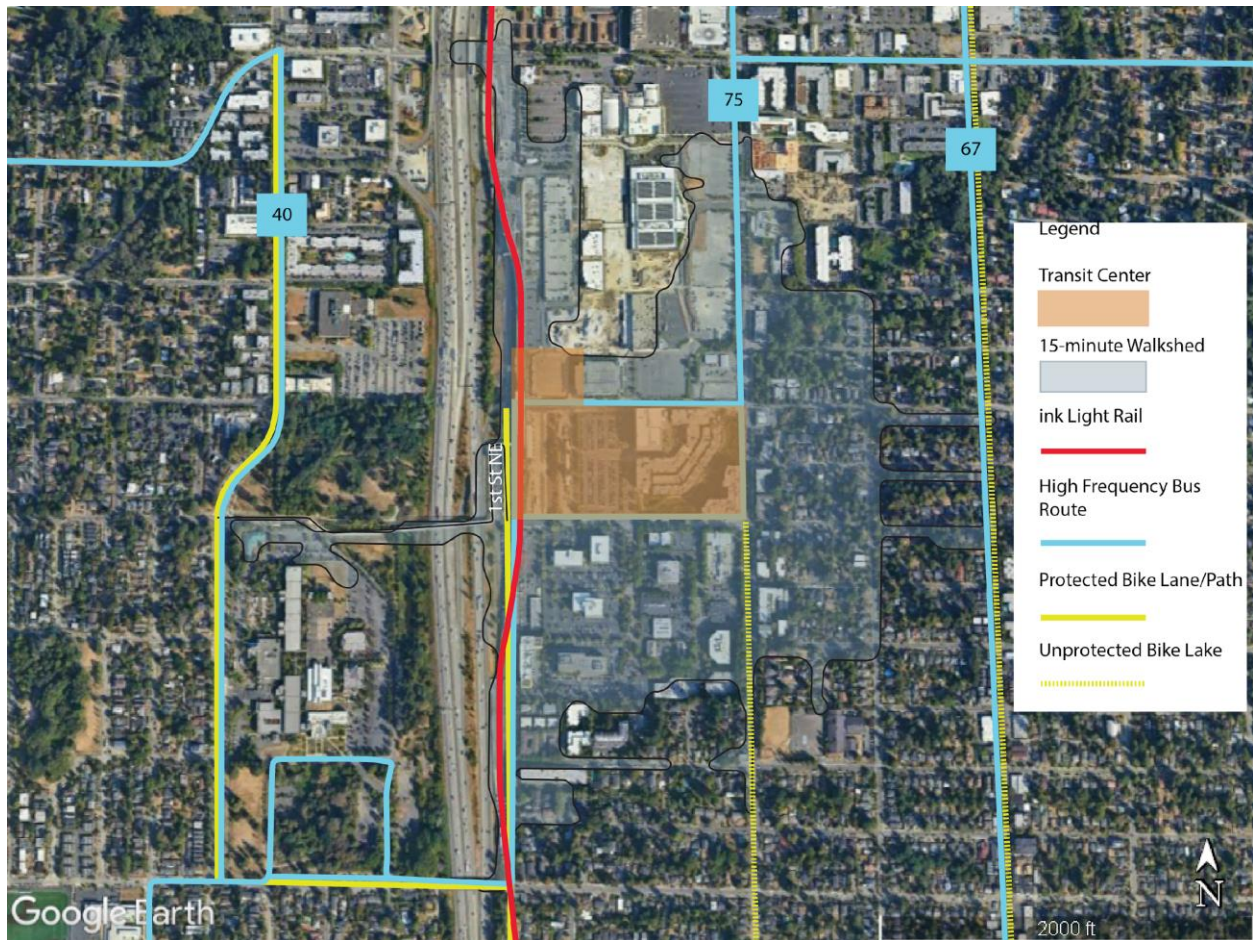
Figure 10: Green Lake Park & Ride Context Map



The Green Lake Park & Ride site is supported by both high-frequency transit and protected active transportation infrastructure. The site is divided along NE 65<sup>TH</sup> street, with parking facilities abutting both sides of the street. Within walking distance of the facility are additional transportation options such as the Link light rail's Roosevelt Station and other high frequency bus routes.

Additionally, the observed 15-minute walkshed provides access to a number of services and amenities. The Roosevelt and Green Lake neighborhoods have dense concentrations of residential and commercial uses. There are grocery stores and retail shopping options. Additionally, there are health clinics, educational facilities, and recreational spaces.

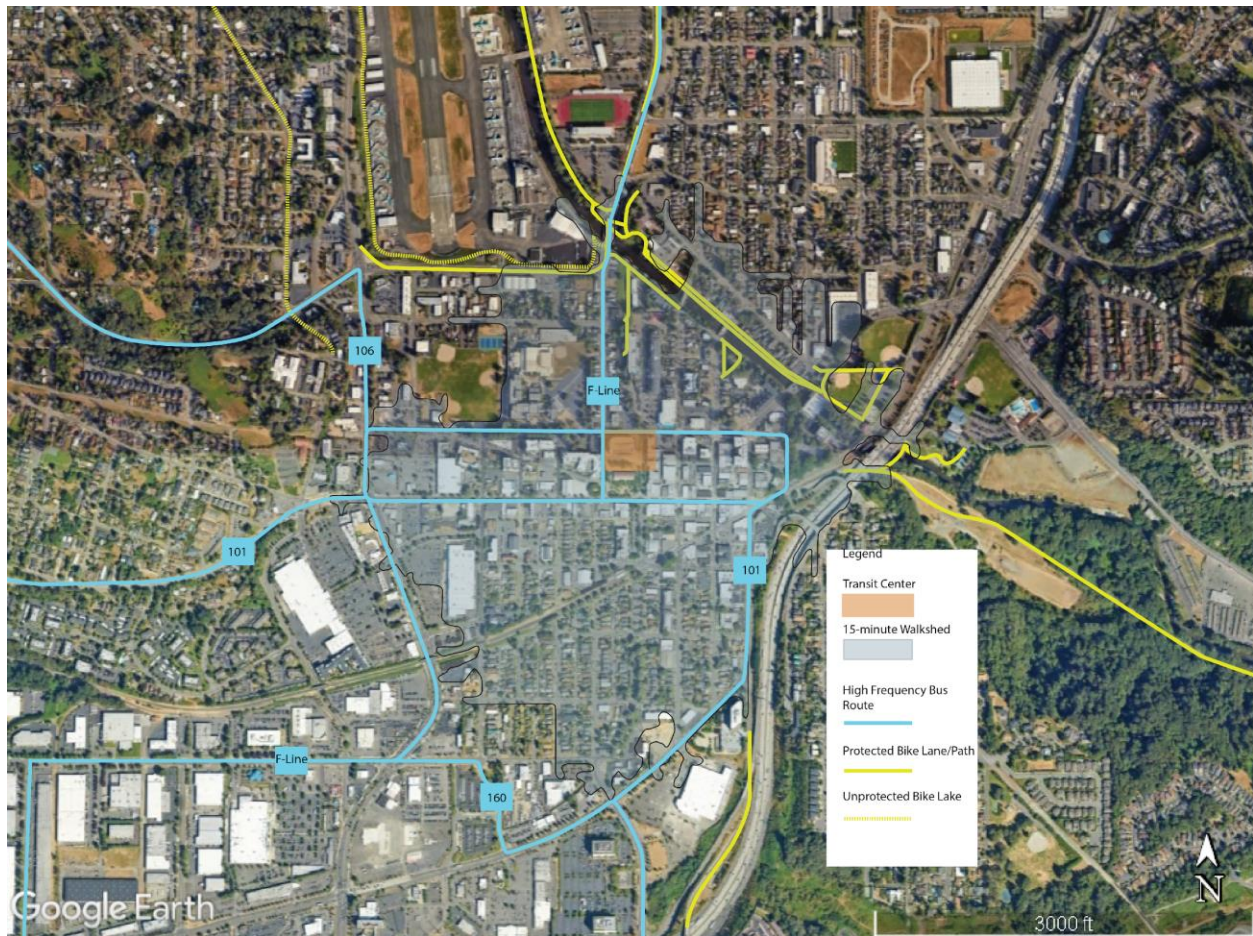
Figure 11: Northgate Transit Center Context Map



The Northgate Transit Center and Park& Ride is directly serviced by the Link light rail, providing access to the greater Seattle area including regional and international transportation facilities. The site is adjacent to I-5 on the west and to parking facilities to the east and northeast. These facilities are both above ground and below ground (under Thornton Place). The site is accessible by protected bike and pedestrian infrastructure such as the John Lewis Memorial Bridge and protected by paths along the west side of 1<sup>st</sup> Ave. NE. The site is also served by a number of high-frequency bus routes.

The 15-minute walkshed mostly consists of commercial retail, entertainment and professional services. The Northgate mall provides some commercial and dining services and is surrounded by large parking lots. There are low density residential properties east of the facility and some higher density uses to the northeast and at Thornton Place. In addition there is the Northgate branch of the Seattle Public Library and North Seattle City College.

Figure 12: Renton Transit Center Context Map



The Renton Transit Center is in downtown Renton, WA. The site includes parking structures on the east and north sides abutting the transit center. The site is serviced by high-frequency bus-routes providing connections to Seattle, Burien, Kent, and Auburn. There is no bicycle infrastructure connecting to the facility. Bike infrastructure can be located along the waterfront of the Cedar River.

The zoning in the immediate vicinity is mixed between commercial retail, dining, and high-density residential uses. Additionally, there are educational services and recreational/community spaces within the walkshed.

Figure 13 Burien Transit Center and Park & Ride Context Map



The Burien Transit Center and Park & Ride is in downtown Burien, WA. The site includes 5 bus terminals, and has car-parking onsite. The site is serviced by two high-frequency bus routes (H-line and F-line). The site is not directly served by bicycle infrastructure which is located south and southwest of the site.

The 15-minute walkshed is composed of low density commercial and residential uses. There are some higher-density residential uses southwest of the facility. The area includes retail, dining, and automotive oriented services. There are grocery stores, pharmacies and other necessary services within walking distance. Additionally, the Burien Library, Highline Highschool, and recreational/community spaces in the vicinity.

## 4.2 MATRIX #1: POLICY COMPARISON

Matrix 1 demonstrates the congruencies between implemented KCM design guidelines and SANDAG's Mobility Hub Features Catalogue. The findings of matrix 1 are summarized below. The full matrix could not be provided due to the number of features identified by both transit agencies. The matrix summarized below shows KCM design guidelines along the y-axis and SANDAG design guidelines along the x-axis. For this exercise, SANDAG'S design guidelines will be referred to as the catalogue and KCMs design guidelines will be referred to as the toolkit. Each cell in the body of the table indicates in order from left to right, total possible matches, slight matches in either design or function, and complete matches in design and policy between the two documents. Therefore, each cell represents summary analysis of several features grouped by theme.

Table 4: Matrix 1

		SANDAG Mobility Hub Features Catalogue Themes				
		Transit Amenities	Pedestrian Amenities	Bicycle Amenities	Motorized Services and Amenities	Support Services
King County Transit Hub and Element Typology Themes	Environmental	<u>1</u> 230 / 44 / 3	<u>2</u> 253 / 51 / 2	<u>3</u> 345 / 25 / 0	<u>4</u> 322 / 20 / 0	<u>5</u> 115 / 9 / 0
	Convenience	<u>6</u> 130 / 3 / 0	<u>7</u> 143 / 2 / 0	<u>8</u> 195 / 13 / 5	<u>9</u> 182 / 11 / 1	<u>10</u> 65 / 3 / 0
	Information	<u>11</u> 100 / 14 / 1	<u>12</u> 110 / 0 / 0	<u>13</u> 150 / 1 / 0	<u>14</u> 140 / 2 / 1	<u>15</u> 50 / 6 / 0
	Comfort	<u>16</u> 100 / 10 / 2	<u>17</u> 110 / 7 / 1	<u>18</u> 150 / 1 / 0	<u>19</u> 140 / 1 / 1	<u>20</u> 50 / 4 / 1

### *Intersection of Environment Theme and Transit Amenities (Cell 1)*

The transit amenity theme of SANDAG Design Guidelines includes features relevant to transit services, specifically those related to enhanced transit waiting areas, passenger loading zones and

real time information.<sup>34</sup> The environment theme of the KCM Toolkit includes features that improve accessibility, safety, personal security, protected environment, and environmental sustainability.<sup>35</sup> The intersection of Transit Amenities and Environmental theme had a total 230 possible matches, with 44 having at least a partial match, and 3 completed matches. Completed matches include real-time transit arrival alerts, benches and leaning rails, and shelters. Of the features relevant to mobility hubs, shelters had the most partial matches with the toolkit, including all features associated with a protected environment (wind/sound barriers, continuous weather protection, enclosed climate controlled waiting rooms, emergency call boxes) and a majority of personal security items (lighting, emergency call boxes, CCTV and operator notification beacons). Of features listed in the toolkit, shelters again have the highest matches (5 partial, 1 direct). Energy Efficiency had the second most matches (four partial).

#### *Intersection of Environment Theme and Pedestrian Amenities (Cell 2)*

Functions related to pedestrian amenity include walkways and crossings that improve safety. The intersection of pedestrian amenities and the environment theme had a total of 253 possible matches, 51 total matches, and 2 complete matches. Slip resistant surfaces and enhanced pavement shared functional matches of creating a safe walking environment during inclement weather. Additionally, street furniture aligned with benches/leaning benches in terms of creating comfort and enjoyment. The pedestrian amenity feature that resonated most with environmental features were wide walkways, specifically with features grouped under accessibility, safety, and personal

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<sup>34</sup> San Diego Association of Governments (SANDAG), “Mobility Hub Features Catalog.”

<sup>35</sup> “Transit Hubs Typology and Elements Toolkit” (King County Metro, April 2022).

security. The environment theme had most matches was pedestrian safety treatments which partially matched with all pedestrian amenity features except street furniture.

#### *Intersection of Environmental Theme and Bicycle Amenities (Cell 3)*

Bicycle features are grouped under three function groups: bikeways, bike parking, and bikeshare. In total, there were 345 possible matches, 25 total matches, and 0 complete matches. Bicycle features did not have as many connections to the environment theme compared to cell 1 and 2. Features related to bike parking shared partial matches to personal security features like lighting, emergency call boxes and clear site lines.

#### *Intersection of Environment Theme and Motorized Services and Amenities (Cell 4)*

Motorized services and amenities have the most related functions of SANDAG amenity themes. This includes dedicated transit lanes, rideables (bikes/ scooters/other rideable EV vehicles) electric bike and scooter share, carshare, on-demand ride hail (TNC), micro transit, neighborhood electric vehicles, electric vehicle charging, smart parking, and flexible curb spaces. In total there were 322 potential matches, 20 total matches, and 0 complete matches. No feature in the motorized services and amenities function had more than 2 partial matches except for carshare which had 3. For the environment theme, clear site lines, and energy efficiency had the greatest partial matches with 6 and 8 matches respectively.

#### *Environment Theme and Support Services (Cell 5)*

Support service amenities include features such as wayfinding, package delivery, mobile retail services, and universal transportation accounts. The intersection with environment theme includes

155 potential matches, 9 partial matches, and 1 complete match between wayfinding and high contrast signage and colors.

*Intersection of Convenience and Pedestrian Amenities (Cell 7)*

Features included in the convenience theme of the KCM Toolkit includes functions that create ease of movement, promote bike riding, and create clean/ well maintained facilities. There were 142 potential matches, 2 total matches and 0 complete matches. There is a noticeable lack in matches between these two themes. Only partial matches were made between street furniture with garbage, recycling and compost bins.

*Intersection of Information and Transit Amenities (Cell 11)*

Cell 11 is the intersection of KCM's information themed function and SANDAG's Transit Amenity theme. Functions that fit under the information umbrella include wayfinding and service information. Of the possible 100 possible matches, there are a total of 14 matches, with 1 being a complete match (Real-time information). Another point of note was the applicability of several service information oriented features of the KCM toolkit that were relevant to real-time information. Additionally, 6 partial matches were made with the bus shelter of the transit amenities them of SANDAG'S Catalogue.

*Intersection of Comfort and Transit Amenities (Cell 16)*

Cell 16 is the intersection of the toolkits comfort theme and the Catalogue's Transit Amenity theme. The Comfort theme is defined by its functions oriented towards creating a sense of place and providing multi-use spaces. Of the 100 possible matches, there were a total of 10 matches

made, with 2 being direct matches. Landscaping and Wi-Fi/public charging were referenced by both the Catalogue and the Toolkit. The landscaping feature of the Catalogue had the most connections with features of creating sense of place. This finding is based on the definition provided by the catalogue on the benefits of landscaping for coordinating the visual design with the surroundings and creating a sense of place.

#### *Intersection of Comfort and Support Services (Cell 20)*

Cell 20 is the intersection of Toolkit's comfort themed features and the Catalogue's Support services themed features. Of the possible 50 matches, there are a total of 4 matches made, with 1 complete being complete matches. Both the Toolkit and the Catalogue included mail drop off or delivery features at the facility. Additionally, the Toolkit's emphasis on coordinating the visual design of the transit hub had partial matches with two features in the catalogues support services theme including package lockers and parking lots. Suggesting that these features can communicate more with existing environment to create a more comfortable environment for the user.

### 4.3 MATRIX #2: EXISTING SITES AND CURRENT DESIGN GUIDELINES

Matrix #2 compares four existing transit hubs in King County to the currently implemented KCM *Transit Hub Typology and Element Toolkit*. The purpose of doing so is to determine what is missing from current facilities based on priorities as noted in the Toolkit.

#### *Environment*

For features related to Accessibility, all sites had step free access provided throughout the site. This was done primarily by curb cuts and mid-block crossings. Northgate and Burien, both being

multi-story facilities, had escalators and/or elevators. The prevalence of tactile information was present on all sites but mixed in degree. Northgate Transit Center and Green Lake Park and Ride were equipped with brail signage and included tactile pads. The tactile pads were positioned near in front of curb cuts or curb \less sidewalks. Tactile signage was identified near other transit supporting features such as real-time information displays Burien and Renton only partially matched with this requirement. In the design toolkit tactile information was defined by having both informational but also environmental tactile features for creating a protected

*Figure 14: Tactile information at Northgate Transit Center*

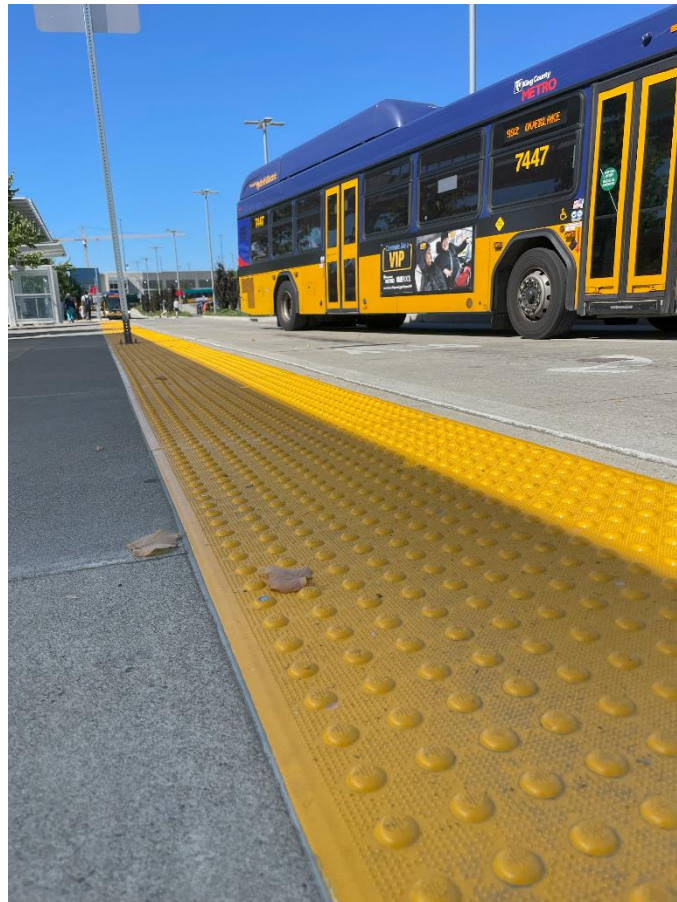


Table 5: Matrix 2

Park and Ride Theme	Related Function	Feature/Principle	Burien Transit Center and Park and Ride	Northgate Transit Center	Renton Transit Center	Green Lake Park and Ride
Environment	Accessibility	Step Free Access	●	●	●	●
		Audible Information		●		○
		Tactile Information	○	●	○	●
		Clear, well-defined paths	●	●		○
		Iconography and high contrast colors	○	○	○	○
	Safety	Slid resistant surfaces	●	●	●	●
		Pedestrian Guardrails	●	●	●	
		Pedestrian safety treatments	○	○	●	○
	Personal Security	Lighting	●	●	●	○
		Clear Sight Lines		○	○	
		Emergency Call Boxes	●	●		
		Staff Presence	○	●		
		CCTV	○	●		
	Protected Environment	Operator Notification Beacons				
		Benches and Leaning Rails	●	●	●	○
		Shelters	●	●	●	●
		Wind breaks and sound barriers	○	○	●	
		Continuous weather protection			●	●
	Environmental Sustainability	Enclosed, climate controlled waiting rooms				
		Energy Efficiency	○	○		
Sustainably Sourced and/or recyclable material						
Sustainable Landscaping		○	●	○		
Convenience	Ease of Movement	Multi-stream litter receptacles		●	●	
		Passenger Pick up and Drop off zones	○	●	○	
		off-board fare collection	●	○	○	
		car-share parking spaces			●	
		electric vehicles charging stations	○		●	
	Bicycle Facilities	Bicycles Racks	●	●	○	
		Enclosed Bicycle Parking	●	●		●
		Bicycle and Scooter Share areas		○		
		Bicycle stairway ramps		●		
		Bicycle repair Stands		●		
Clean and Well-Maintained Facilities	Bicycle centers or bicycle hubs					
	Single Stream litter receptacles	●	●	●	●	
	recycling and compost receptacles		○	○		
Information	Wayfinding	operator comfort stations	●	●	●	
		Bus Stop Signage	●	●	●	●

		Guide Signs		●		●
		Station or transit center identifiers	●	●	●	○
		Station maps and area maps		●	●	●
		Digital Information Kiosks				
		Staff or agency ambassadors				
	Service Information	Static schedule signs	●	●	●	●
		real time information displays	○	●		●
		Digital Information Kiosks				
		Multi-language signage and announcements				
	Comfort	Sense of Place	coordination of the visual design with surrounding areas and communities		●	●
public art			●	●	●	○
landscaping			○	●	●	
Landmark Architecture			●	●		
Multi-Use Spaces		Public Wi-Fi and charging stations				
		public restrooms and water fountains				
		retail uses, ATMS, vending machines			●	○
		public spaces	○		●	
		mail-drop-off boxes, package pick up lockers and newspaper boxes				
		advertising	●	●	●	

● Indicates Full Match

○ Indicates Partial Match

environment. In the case of Burien and Renton, both sites have tactile guards but lack tactile information.

*Figure 16: Real Time Information Displays at Northgate TC*



*Figure 15: Real time Information Displays at Renton TC*



### *Convenience*

A notable result that came from the Ease of Movement function are the inconsistencies in passenger pick up and drop off zones. To begin, Green Lake Park & Ride does not provide a pick-up drop off area on or around the premises. Burien and Renton stations do have pick up/ drop off areas, however they are limited in function. They are specific spots within the parking lot that are directly adjacent to transit services, However, they're functionally limited in the vehicles that it can access these spots. Northgate on the other hand has designated ample curb space east of bus and light rail facilities that allow for increased flexibility of the space. Another point of note was the lack of car-share facilities at these stations. The Toolkit identifies carshare spots as an

opportunity only if parking spots are available. Only one station had carshare compatibility even though all four have parking. However, locating carshare vehicles was difficult. Northgate provides two Gig Car Share and two Zip-car vehicle spots at the farthest east point of the park and ride lot on near the street corner least travelled by pedestrians. During site visits weren't fruitful for locating these carshare options. However, they became apparent through google street view analysis.

Across all sites there was a lack of bike infrastructure and features. All four sites had provided bike lockers but three of four had bike racks (Green Lake did not). Only one site had bike/scooter share mobility types available but did not designate a space for pick-up/drop-off (Northgate). Northgate is also the only facility providing Bike stairway ramps, but this is due to it being the only facility that has transit access above ground level. As far as bicycle repair stands and Bike hubs, Northgate was the only facility that provided these features. Being the most modern of facilities, these features were hidden behind large metal doors requiring an access key to use the tools or bike racks enclosed. It should also be noted that no additional information was provided at the site that delineated who gets access or how access is received.

Lastly, clean and well-maintained facilities function was accomplished to varying degrees. All four had single stream trash cans present but only two had recycling facilities (Northgate and Renton) Composting was not found on any site. Three of four sites included operator comfort rooms including restrooms and vending machines (Burien, Renton, Northgate).

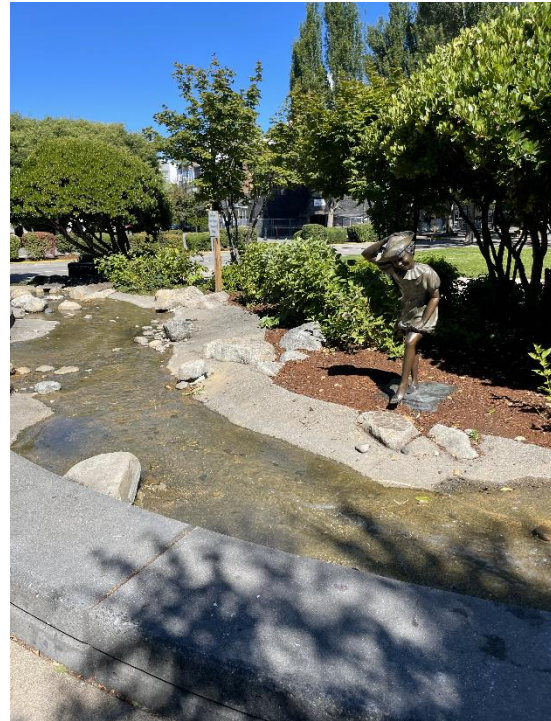
Notable of the information function is that there were few times where there wasn't a direct match between policy guidance and feature function. Bus Stop signage was fully present at every facility along with transit station identifiers and static schedule signs. No station provided information kiosks as illustrated in the plans. Some digital and real-time information was present at Northgate and Renton however this information was limited and not interactive. Northgate was the only station to provide real-time information for its bus fleet and high frequency trip machinery. Burien and Renton both had real time information on site but were limited to the Rapid Ride high frequency bus system. Green Lake did not come equipped with such features.

Of note, comfort was mostly un-included in the planning of these sites. No site included public restrooms which were functioning at the time of observation. It is worth noting that Northgate does have restrooms on the second floor of the facility but were closed for maintenance. Additional port-o-potties were available on the ground floor, however. Additionally, no public Wi-Fi was available at any site nor were mail drop-off boxes, package pick-up lockers or newspaper boxes. Previously planned newspaper boxes have been either destroyed or removed entirely. However, advertising was present at three of the four stops (Burien, Northgate, Renton). Renton was the only site that included retail uses. There is a café present on site providing a range of goodies and snacks to perk up your trip. In terms of public spaces, Renton was the only space functionally designed to hold events and to allow the public to gather. There is an onsite water feature, civic center, and plenty of benches for people to gather and enjoy the downtown facility. Northgate and Burien both

Figure 18: Retail Services onsite



Figure 17: Water Features at Renton TC



have art present on the site but lack the public facilities such as benches and tables to create a more enjoyable public space.

#### 4.4 MATRIX# 3: EXISTING SITE AND MOBILITY HUB DESIGN GUIDELINES

Matrix #3 compares the four sites selected in the methods section to SANDAG's *Mobility Hub*

##### *Transit Amenities*

In the transit amenity rows, there are points of note. To begin, the four facilities. Seating is a prevalent feature at all sites. Other features included in the transit amenities include shelters, trash receptacles schedule information. Curb spaces were available at three of four sites (Burien, Renton, Northgate). Like Matrix 2, no Wi-Fi was available at any site. Two sites provided bus layover zones (Burien and Northgate). Lastly, real time information was provided for one site (Northgate)

and partially provided for two additional sites (Renton and Burien) The reasoning for the partial mark is because real time information was limited to only one bus line.

Table 6: Matrix 3

Mobility Hub Theme	Related Function	Feature/Principle	Burien Transit Center and Park and Ride	Northgate Transit Center and Park and Ride	Renton Transit Center	Green lake Park and Ride
Transit Amenities	Enhanced Transit Waiting Areas	seating	●	●	●	●
		landscaping	○	●		
		Bus Shelter	●	●	●	●
		trash receptacles	●	●	●	●
		Complimentary WIFI				
		schedule information	●	●	●	●
	Passenger Loading Zone	Curb spaces	●	●	●	
	Bus Infrastructure	Bus Layover Zones	●	●		
	Real-Time Travel Information	Real-Time Travel Information	○	○		●
Pedestrian Amenities	Walkways	wide walkways	●	●	●	
		landscaping	●	●	○	
		pedestrian scale lighting	●	●	●	
		enhanced paving	●	●	●	
		pedestrian cut-throughs	●	●	●	○
		Street furniture	○	●	●	
	Crossings	curb bulbs		○	●	
		signal timing treatments			●	●
		mid-block crossings	○	○	●	
		refuge islands				
	crossing protections		○	●		
Bike Interface	Bikeways	bikeways		○		●
		median refuge				
		bike signals				
		bike boxes				●
		bike channels		●		
		bike footrest				
	Bike Parking	bike and pedestrian counters				
		Bike racks	●	●		
		Bike Corrals				
		Bike Lockers	●	●		●
	Secure Group Parking		●			
	Bike Valet					

		Bike repair stand		●		
	Bike Services	Bike Charging Station				
		Bike Washing Station				
	Bikeshare	Bikeshare Station				
Motorized Services & Amenities	Dedicated transit lanes	Dedicated transit lanes				
	Rideable	charging outlets				
	Electric bike & scooter share	parking locations				
	Carshare	Carshare			●	
	On-Demand Rideshare	shared / Flexible curb space	○	●	○	
	Micro Transit	shared / Flexible curb space	●	●	●	
	Neighborhood Electric Vehicles	EV Car Charging	○			
		Dedicated paths				
	Electric Vehicle Charging	Electric Vehicle Charging	○		●	
	Smart Parking	In-street sensors				
		smart meters				
real-time information						
parking reservation systems						
Support Services and Amenities	Wayfinding	Wayfinding	●	●	●	●
	Package Delivery	package lockers				
	Mobile Retail Services	parking lot	●		●	●
	universal transportation account	Universal Travel Accounts	●	●	●	●

### *Pedestrian Amenities*

Wide walkways were mostly provided for at the site, with three of four having wide walkways present at the site (Burien, Northgate, Renton). The three sites each have the recommended 5' paths as SANDAG's catalogue calls out specifically. Green Lake on the other hand does not have separate pedestrian walkways within the site but opts to include marked pedestrian ways on the pavement. Landscaping was also another point of note as 3 of the 4 sites had landscaping present (Burien, Northgate, Renton). Burien had noticeably less landscaping based on the amount of impervious pavement present at the site. However, landscaping along the pedestrian pathway fit the considerations of SANDAD's catalogue. Northgate and Renton landscaping appeared to have more functionality based on their scale. It was clear the landscaping present at Northgate acted as an artificial bioswale filtering stormwater runoff and creating a natural barrier between the street

and the internal bus terminal. Enhanced paving, pedestrian cut-throughs, and pedestrian scale lighting were also traits for 3 of the 4 sites. Each site demonstrated a mix of paving types, lighting styles, and having separate pedestrian shortcuts improving active pedestrian usage at the site. Street Furniture became less matched, only 2 of 4 sites demonstrated a complete match (Northgate and Renton) while Burien demonstrated a partial match. Burien's transit center lacked benches or other seating features. There are places designated for leaning at the transit center benches were removed for safety reasons. Some natural seating is available on large stone benches; however, these are located at Burien's Park and Ride facility away from the bus terminal. Green Lake did have some seating facilities present within their bus shelters.

Safety treatments outside of site facilities was lacking across all four sites. Renton had the most complete matches with the SANDAG's catalogue as it had curb bulbs, signal timing treatments, mid-block crossings, and crossing protections. Northgate only partially met having curb bulbs, mid-block crossings, and crossing protections. However, the partial matches are due to site features only being internally located in the site and not within the larger five-minute walk shed. Burien had two mid-block crosswalks, on the west and north side of the lot, however these mid-block crossings are only due to strip mall parking access and don't fully meet the qualities as explained in the catalogue. Green Lake largely lacked in crossing infrastructure outside of having signal timing infrastructure at busy intersections.

### *Bike Amenities*

Bike amenities were largely absent from the four sites. Understanding that bike infrastructure is expected to fill a five-minute bike-shed map there was little infrastructure supporting bikeways,

parking, or other services. Northgate was most sufficient at providing bicycle-related features bike channels, racks, lockers, secure parking, and a bike repair stand. Between the three other sites only a combined three matches were made, and no partial matches were made.

*Figure 19: Protected Bike Lockers at Burien TC and Park & Ride*



### *Motorized Services and Amenities*

Features supporting motorized services and amenities were also largely missing from the four sites. Most consistent was the presence of micro transit services use of flexible curb space for three of four sites (Burien, Northgate, Renton) while Green Lake lacked flexible space for this service. On-demand ride share or TNC vehicles were partially included at two of four sites, where it was in fact to pick up a user through flexible parking spaces. Northgate is the only site providing land for on demand pick up. Electrical facilities for vehicle charging were absent at most sites. Burien was

the only site with charging capacity for EV vehicles and has the capacity to charge ten cars with level two chargers. However, every charger at the site was damaged and inoperable at the site. Lastly, smart parking features were lacking at all sites that had parking available.

### *Support Services*

Support services notably had zero partial matches. Wayfinding services were available at each site as were universal transit card account compatibility. Mobile retail services were promotable

*Figure 21: Damaged EV Charging Devices*



*Figure 20: Damaged EV Charging Devices*



at three sites that had out-door parking lots (Burien, Northgate, Green Lake. Mobile retail was most likely at Northgate given large portions of land no designated for any particular use.

## CHAPTER 5. DISCUSSION

This section synthesizes the results gathered through the various methods utilized against the wider applicable literature. The findings presented in the research reflect the growing body of knowledge of mobility hub policy and design best practices. However, there are some outliers between the literature and the results for mobility hubs that will be worth discussing further. The discussion begins by focusing on the most influential findings prior to reviewing the general similarities displayed between the two sets of functions and features.

The most pressing concern revealed by matrix #1 is the isolation of planning and designing for transit facilities. As identified in the results section under convenience, no check marks matches were made with pedestrian and bicycling networks. There are features presented in KCMs toolkit that indicate matching physical environment and providing public space, but does not consider the whole network of paths, trails, and roads. The types of interventions present in the transit hub toolkit reflect features isolated to the facility as opposed to the “hub” This could simply come down to differences in defining hub between “transit hub” and “mobility hub”. As noted by Aono in her review of best practices, she acknowledges the variations on mobility hub size and shape; ranging from whole communities, to neighborhoods, to individual parcels where the transit station sits. However, it is still applicable that from the “hub” the network of paths expand out and make connections that are conducive to a wider variety of mobility options beyond the single occupancy vehicle. While providing services at a hub is beneficial to incentivizing user behavior changes, creating a safe and reliable network that is considerate to the mobility types needs will have a much greater impact towards reaching the mobility values articulated in mobility hubs. From this assessment, it is worth recommending that KCM should consider revising its transit hub toolkit or

prepare a mobility hub framework that holistically considers the environment from a standpoint of active transportation networks.

An integrated approach can be accomplished through a wider range of considerations and opinions achievable through community outreach. In its toolkit, KCM includes a brief blurb describing the community engagement process and the necessary steps for quality engagement. Understanding that in its current stage, the mobility hub project has only begun to be conceptualized. However, for successful implementation of a mobility hub with the greater community will require the highest level of collaboration with public and private sector actors. As indicated in the literature, the increasing diversity in roadway utility will require collaboration with developers and property owners along with city agencies in order to align land-use and design controls for seamless travel and service provision.

Matrix 1 also presented the role of parking for future mobility hub application. As described in the literature, there are expansive changes on horizon for the automobile market from AV vehicles that self-drive themselves and do not need parking, to new automobile shared ownership models present in car share programs. These ground shaking changes will have deep impacts on our land-use and transportation habits and highly likely to change our daily lives. However little attention is paid to the parking lot or parking structure. Through interviews, its understood that KCMs priorities are currently about promoting active transportation modes and trying to disincentivizing car trips. This is highlighted in KCMs Long Range Plan *Metro Connects*. However, parking lots provide a hidden variety of opportunities and should be considered prior to removing the facility. As demonstrated in the matrix, parking lots are flexible for all sorts of unintended uses such as

farmers markets, retail events, political protests, and other non-peak hour events. The increased flexibility of parking lots and structures is also represented over time. The literature articulates the need to plan for flexibility and acknowledging the need to design facilities with the future in mind. Since the pandemic a lot of research has been published considering the adaptiveness of parking facilities in urban areas to fulfill a range of new uses. In Seattle's Northgate neighborhood, research was conducted on the parking structure of the North Seattle Community College to see how a hybrid AV docking and studio class layout would look.

As made notable in the results of matrix #2, the Toolkit matches much closer to existing facility feature placement and function than Mobility Hubs does. However, matrix 2 makes some interesting points to noted. For one point, being that these facilities are located in the Northwest and that the planning document is for northwest facilities, there is an absolute lack of continuous weather protection at these sites. Weather protection is largely because of accidental functioning over overhead infrastructure such as Northgate or Green Lake. Overhead transportation facilities such as the highway help block rain elements and reduce wind but unfortunately at the cost of increased sound pollution from the rebounding sounds. Northgate too was able to provide some weather coverage due to the overhead light rail station, however this too was not continuous from various points of the facility. In the summer months, these facilities were incompetent for providing cover from the direct sunlight, causing individuals to hide under sparse covers of shade

in the evening hours. In cases of severe elements such as these it becomes more important to include these considerations into the work.

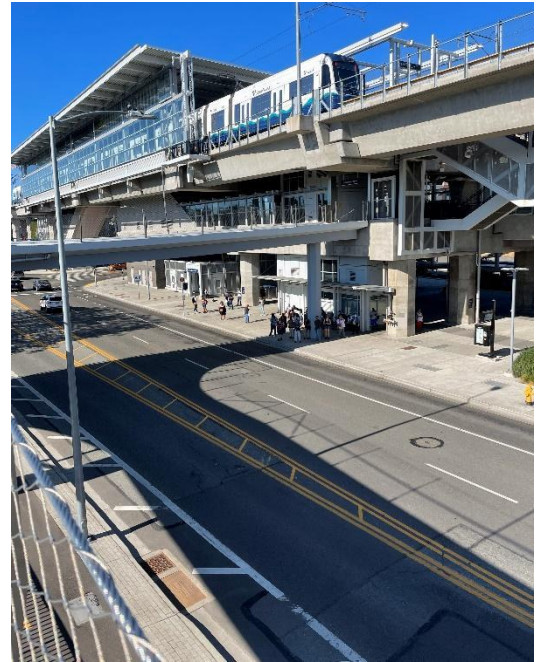
One item made clear in the literature was the importance of design flexibility. Whether it be parking structures and the oncoming AV revolution, or curbspaces having multi-use functions for mobile commerce, deliveries or increased pick up/drop off activity. Matrix 1 indicates this importance by evaluating if this is currently considered in

transit hub design. Matrix 3 additionally indicates if, and to what degree, existing facilities have this feature provided. Per Matrix 3, KCM transit hubs are well equipped to meet the projected demand as these sites have large strips of curbs that could be repurposed.

## CHAPTER 6. CONCLUSION

This thesis was determined to master the mobility hub concept in order to understand the general considerations for co-locating mobility hubs at existing transit facilities. Addressing the sub questions of what is currently planned for at transit centers and what are the expected functions of mobility hubs established the comparative analysis necessary to answer my primary question. The final matrix presented in the results section highlights the quantity of take-aways present based on the existing and the proposed hubs. The framework highlights the necessary considerations for an efficient and cost-effective product made possible by a careful analysis of what future hubs will need and what is present.

Figure 22: People finding shade on hot summer day



There are several items that this thesis was unable to complete in its research and thus creating room to be built up on. Understanding how mobility hubs could be implemented in neighborhoods lacking fixed route services will be important for addressing issues in transit inequity. This thesis only focuses on existing facilities and the benefit towards equity in transportation services. Additionally, this thesis is limited in its comparison to existing mobility hub feature lists provided by other transportation agencies. SANDAG was primarily referred to in this research due to the transparency of their catalogue. Greater emphasis could be placed on European and international mobility hub systems. Doing so may create other observations for comparison that could factor into the features that may improve the seamlessness of mobility hubs.

For professionals, there are several take-aways that have been alluded to. The framework indicates the efficiencies of locating mobility hubs and functionally similar transit facilities. While the existing routes are based on historic commuter trends and therefore are most present in specific corridors, addressing the siting and design of mobility hub features can reduce any additional inefficiencies. Employees of KCM or any agency should consider constructing their own matrices to determine opportunities and illustrate what is planned for and what is missing. Doing so reduces the haze of designing for the unknown by graphically organizing and presenting these findings. Publishing or making available these findings as typologies or other visual mediums will have the added benefit of comprehension with future collaborators.

For researchers, there are several new avenues now made more available. Further addressing differences in context will drive new understandings of the applicability of elements in a more

specific format. While this research can provide a generalized approach to designing mobility hubs, a finer approach will address contextual considerations of a place. Additionally, work will need to be conducted to understand if and what benefits there are to locating hubs at locations not previously activated by transit. SANDAG indicated there being benefits to newly developed hubs in terms of land use and cost. These will need to be tested over time as more mobility hubs are implemented.

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