Walkability Assessment of New Transit Areas, Austin, TX

MyungKyung CHUNG
myungkyung@live.com

Community and Regional Planning
School of Architecture, the University of Texas at Austin

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Walkability Assessment near New Transit Areas, Austin, TX

1. Executive summary

In light of new transit systems of light rail and street car, the City of Austin is facing a new shift of paradigm in the transportation. The city expects that these new multi modal transportation systems will give wider variety of transportation choices to Austinites. The city also anticipates that these newly built systems will improve mobility of the city dwellers, enhance the environment and lead physical/economic growth to the entire city.

The areas and neighborhoods near those stations and transit stops will be developed as Transit Oriented Development (TOD) zones. TOD is a concept pursuing vibrant, sustainable, and livable communities. The physical design concept of TOD plan is to build compact, walkable communities centered around high quality transit systems.

Given the new development of transportation means, this research project begins from a question of how Light Rail Station in Martin Luther King Jr. Street and future Street Car Station in Manor Road, Austin, Texas will change people’s mobility and activity patterns.

The main hypothesis of this project is safer sidewalks and better connections of sidewalks would improve walkability in the area. To testify the hypothesis, first, safety of current pedestrian environment was measured. Current sidewalk data was collected through two days of field observations. Based on certain criteria, the collected sidewalks are ranked from 1 (excellent) to 4 (missing). Speed limit is selected as another significant element influencing pedestrian safety. Second, to measure connectivity, a Network Analysis Tool in ArcGIS was used. The tool was used in two ways: measuring shortest distance between nodes; measuring service areas.

The results from the two analyses – safety measurement and connectivity test – show Austin’s poor pedestrian conditions and poor connectivity between adjacent neighborhoods and newly built stops. To make the argument more solid and feasible, other factors such as elevation of the area, socio-economic perspectives, and other planning issues should be considered in the future. Also in order to see the connectivity in the area, not only other transportation nodes, such as bus stops, bike lanes, park and ride, but also neighborhood character should be carefully studied.

Key words: Walkability, Accessibility, Pedestrian Safety, New Transit Stations, Transit Oriented Development (TOD), Network Analysis, ArcGIS
2. Introduction

Austin has been one of the most auto-dependent cities in the United States. Its spread-out development trends, huge express roads passing through the city, and the lack of public transportation systems have fostered people’s dependency to automobiles for decades. Newly planned commuter rail system and streetcar system, however, are expected to change people’s mobile trends in a different way. The Commuter Rail Line (red line in Map 1.) will run on 32-miles of existing freight tracks between Leander and Downtown Austin; the Streetcar (green line in Map 1.) will run from Mueller Redevelopment Site to Downtown in 10 years (Capital Metro, 2006).

These new systems are seeking for better circulations between multimodal transportations – Commuter rail, streetcar, feeder buses, bicycling, and walking. In order to understand the multimodal transit system, the Transit Oriented Development (TOD) needs to be considered first. TOD is a development concept that combines land use and transit. The goals of TOD are pursuing moderate-high dense, compact design, increment of walkability, mixed-uses. By connecting the concept to the high-quality of public transportation, TOD encourages people to walk, bike and to use public transportations but discourages car trips. Based on the concept, the City of Austin plans medium density of mixed-use in these TOD sites.
Among the large selection of transit stations shown in Map 1, I picked the Martin Luther King Jr. and Manor Rd. for my study site. When Austin’s light train begins its operation and Mueller project gets finished, the area will soon be regarded as one of the core nodes connecting various important nodes of Austin: the road connects UT campus to the west, downtown to the south, Mueller area to the north, and East Austin to Austin Bergstrom International Airport. Also the newly planned commuter rail and street car system are expected to change people’s mobile trends towards less driving and more walking and biking. There is no doubt that this area will be more vibrant and have more demand for travelling. As CapMetro provides, the ridership of bus and streetcar in Austin will be dramatically increased to 7,600 and 11,500 respectively in 2017 and 9,400 and 13,000 in 2030. At the time, we expect the following changes from the new systems in this site: more pedestrians with high density of mixed-uses, more bus circulations to feed two rail stations, commuter line stations in MLK and Manor, and streetcar stop in this site.

For the above reasons, it is necessary to increase accessibility from the adjacent neighborhoods and facilities to the area surrounding the railway station and encourage the use of the commuter rail system. This project measures accessibility in two aspects: safety of pedestrian environment; and street connections by network analysis.

3. Theoretical Background

The relationship between built environment and habitual behavior patterns – including walking – are identified by community design disciplines perspectives, rather than by behavioral scientists’ perspectives (Leslie, Coffee, Frank, Owen, Bauman, and Hugo 2007). However, according to their paper, there is only a limited number of studies that have used environmental variables derived from GIS data (Leslie et al. 2007). GIS provides methods that have the potential to facilitate the development of indices of walkability at the local level in cities or regional areas, not only for the purposes of research, but also to evaluate new environmental and policy initiatives (Leslie et al. 2007). This paper approaches to measure the accessibility in two ways: measuring safety of the current pedestrian environment; and analyzing current street connections using Network Analysis tool. ArcGIS is used to evaluate current street conditions and to conduct network analysis.

Safety of Pedestrian environment

According to Morris and Mayard’s article, certain design features can improve the pedestrian environment (e.g., sidewalks, clearly marked crosswalks, shade trees, benches, and landscaping) […]. In turn, these features can reduce driving by increasing the desirability of walking and biking and, consequently, lead to decreased auto ownership (Morris et al. 2006). Also as the most pedestrian accidents are caused by certain roadway design features, to reduce the unsafe pedestrian environment, Transportation Research Board 2003 suggests 1) to reduce the speed of motor vehicles; 2) to reduce pedestrian risks at street crossing locations by providing sidewalks and walkways separate from motor vehicle traffic; 3) to improve awareness of and visibility
between motor vehicles and pedestrians; and 4) to improve pedestrian and motorist behaviors (Morris et al. 2006).

In this project, current sidewalk conditions and speed limit of the traffic roads are considered as measures of the accessibility. Combined results of the two features – sidewalk conditions and speed limit – are converted into safety rate score, ranging from 1 (most safe) to 4 (least safe), as to provide a simple analysis of the pedestrian environment around the transit stations.

Network Analysis
From a methodological aspect, a number of different methods have been previously examined to analyze accessibility to the built environment. A criticism to many previous studies is that they have tended to simplify the road structure by too much by using Euclidian buffers, or straight-line distances to measure accessibility. The rise in use of geographic information systems (GIS) has led to the feasibility of measuring accessibility using a more realistic network-based distances. A study done in Seoul, Korea, found that access to public parks was decreased by nearly half when using network analysis, as opposed to the traditional Euclidian buffer method (Oh and Jeong, 2007).

Using the Network Analysis Tool in the ArcGIS 9.3, this paper testifies the street network of the study site. Two sub-methods are used: Route Analysis which finds the shortest route using a network dataset; and Calculating Service Area which creates a series of polygons representing the distance from a facility within a specified amount of time or distance.

4. Hypothesis and Research Questions

Hypotheses

Based on the literatures mentioned earlier, this project assumes that pedestrians’ street usage will increase if the street equipments are satisfying. Converting the concept of “satisfying” to “safety” and “connections”, we setup hypotheses and research questions suitable for this research. This project has two hypotheses: 1) Safer pedestrian environments leads to more accessibility to the facilities; and 2) More connections between streets leads to more accessibility to the facilities.

Research questions

Safety:
- What are the risky elements for pedestrian walkability?
- Which elements should be considered in the assessment of safety?
- How to weigh each element?
Connections:
- How to measure street network between new transit areas and their adjacent neighborhoods?
- How to measure service areas?

5. Methodology

Study Area

Map 2. Study Area

WALKABILITY ASSESSMENT
Study Area | Walkable Distance

In selecting the study area, ¼ mile and ½ mile were used as a walking distance commonly accepted for best practices. To determine which neighborhoods could potentially access new transit stations within easy walking distance, Euclidian quarter-mile and half-mile zones (marked as dark blue and lighter blue circular zones in Map 2) are created around the Martin Luther King Jr. (MLK Jr.) station and expected Street car stop on the Manor Road corridor. To focus on the analysis of walking distance, study site was carefully clipped along with street lines completely...
covering the quarter-mile buffer in the area. Airport Blvd, which forms the eastern boundary of the site, was excluded since this 6-lane street was considered as a barrier to pedestrians. As result, the area clipped by Airport to the east, east 12th street to the south, Chestnut to the west, and Cherrywood – E 38th ½ to the north was picked as the study boundary (shown by yellow area in Map2). All network and facilities GIS layers except Land Use and Zoning layers were clipped to these study boundaries.

**Data and Data Sources**

GIS data used in this analysis were obtained from the City of Austin, Capital Metro, U.S. Census Bureau, and CAMPO websites. Most datasets were publicly available on the City of Austin’s GIS Data Sets website. Aerial photo was obtained from Capital Area Council of Governments for reference throughout the study.

**GIS Data**

- **Streets**
  - Streets, Rail Road (City of Austin GIS Website, CAPCOG Website)
  - Sidewalks (collected from field observation)
  - Speed Limits (City of Austin GIS Website)
  - Capital Metro Stop Data (CMTA)
  - Street car Stop Data (Georeferenced from the CapMetro Greenline report)

- **Region/Neighborhoods**
  - Demographics - Race (U.S. Census Bureau TIGER)
  - Land Use 2008 (City of Austin GIS Webstie)
  - Zoning (City of Austin GIS Website)
  - Austin Citylimits (GIS data folder, University of Texas at Austin)

- **Transportation Related**
  - Rail Stations, Routes, Available Services (Digitized information from CapMetro)
  - Capital Metro Bus Stop (CMTA)

- **Demographics**
  - Demographic TIGER/line Shape files (ESRI)
  - Population (Ridership) Projections (CAMPO)

- **Field Data**
  - Sidewalk conditions
  - Pedestrian Crossing condition

Project all data sets into common projection system: NAD83, Texas Central State Plane, Survey (feet).
Analysis Procedures

Step 1: Current Street Conditions

Figure 1. Street conditions of the study site

After the spatial boundaries of the research were decided, data of current street conditions were collected through three times of field observation at the end of October and early November, 2009. Sidewalk conditions and pedestrian crossing marks within the study area were checked. Speed limits different from the downloaded data were also marked.

Sidewalks in poor condition can present more of a barrier to accessibility, than an aid. This research supposes that poor or missing sidewalk discourages people’s walking. So the sidewalk conditions were categorized as the following seven categories: excellent, good, poor, missing, alley, existing crossing, and possible crossing.

Though all network analysis studies reviewed relied exclusively upon vehicular street networks, not all vehicular streets are appropriate for inclusion in an analysis measuring pedestrian access. For example, highways and high speed arterials without sidewalk facilities can be extremely dangerous for pedestrians and should not serve as indicators of true pedestrian access. To determine how to classify the sidewalk conditions in this study, the streets layer was examined in GIS for speed limits and the presence sidewalks. Four hierarchical streets were found: speed limit on 45 miles per hours on major arterials (Airport Blvd and MLK Blvd), speed limit on 40 miles per hours on two minor arterials (Manor rd. and E. 12th street), most of local roads, and alleys (Map 3.). For the purposes of this study, arterials with a speed limit of 35 ~ 45 miles per hour were deemed to be walkable only if a sidewalk was present. Crossing of these arterials was permitted within the network only if a crosswalk was present at the intersection. When a crosswalk was not present but with speed limits of less than 30 miles per hour, streets and intersections were included as ‘crossable.’ in the network, regardless of the presence of a sidewalk or crosswalk, because they were primarily local streets and alleys with low traffic volumes, which, in most cases, are relatively safe for pedestrians, even without the presence sidewalks and crosswalks.

Step 2: Network Analysis
One of the network analysis relied upon the minimum distance measure of accessibility. This method calculates the minimum distance from a designated spot to the facility – in this project, one of the stations. The minimum distance from a certain spot – one testified from a bus stop, the other testified from a multi-family residential area - to the stations was calculated both default (no barriers added) and after (barriers added – based on the actual street conditions).

Another network analysis testifies coverage of the services within 3 minutes, 5 minutes, and 10 minutes walkable distance.

6. Findings

The principal findings are the following series of maps.
Map 3. Demographics - Racial Compositions

WALKABILITY ASSESSMENT

Demographics

POPULATION DENSITY
Population per Acre

0
0.1 - 10
10.1 - 15
15.1 - 20
20.1 - 25

Caucasian (%)
0.1% - 5.3%
5.4% - 19%
19.1% - 34.4%
34.5% - 52.3%
52.4% - 89.1%

African American (%)
0.1% - 20%
20.1% - 40%
40.1% - 60%
60.1% - 80%
80.1% - 100%

Hispanic (%)
0.1% - 16%
16.1% - 32%
32.1% - 48%
48.1% - 64%
64.1% - 80%

Authors: Myung Kyung Chung
Date: November 15, 2009
Source: City of Austin GIS Data Set, Capital Metro
Datum: NAD83, Projected Coordinate System: NAD83 Texas Central State Plane
WALKABILITY ASSESSMENT

Zoning Map

Zoning
- Single-Family Residence
- Multi-Family Residence
- Office
- Commercial
- Community Commercial
- Industrial
- Public District
- TOD
- Study Area
- MetroRail Station
- Future Streetcar Stop
- Bus Stop
- Metro Railroad

Map 5. Zoning Map

Author: Myung Kyung Chung Date: November 15, 2009
Sources: City of Austin GIS Data Set, Capital Metro
Datum: NAD83 Projected Coordinate System: NAD83 Texas Central State Plane
Map 6. Existing Street Condition Map: pedestrian sidewalks and pedestrian crossing

WALKABILITY ASSESSMENT

Current Sidewalk Condition

Sidewalk Condition
- Excellent
- Good
- Poor
- Missing
- Alley
- Existing Crossing
- Possible Crossing
- No Data

Study Area
- MetroRail Station
- Future Streetcar Stop
- Metro Railroad

Author: Myung Kyung Chung
Date: November 15, 2009
Source: City of Austin GIS Data Set, Capital Metro
Datum: NAD83 Projected Coordinate System: NAD83 Texas Central State Plane
WALKABILITY ASSESSMENT

Speed Limit

Map 7. Speed Limit

Sidewalk Condition
- study Area
- 10
- 25
- 35
- 40
- 45
- No Data

Miles

0 0.125 0.25 0.5

Author: Myung Kyung Chung/ Date: November 15, 2009
Sources: City of Austin GIS Data Set, Capital Metro
Datum: NAD83/ Projected Coordinate System: NAD83 Texas Central State Plane
Map 8. Sidewalk Safety Analysis

WALKABILITY ASSESSMENT

Sidewalk Condition II
= (Sidewalk Condition * 0.6) + (Speed Limit * 0.4)

SIDEWALK SAFETY
= (Sidewalk Condition * 0.6) + (Speed Limit * 0.4)

Legend:
- Study Area
- MetroRail Station
- Future Streetcar Stop
- Bus Stop
- Metro Railroad

0 0.125 0.25 0.5 Miles

Author: Myung Kyung Chung
Date: November 15, 2009
Source: City of Austin GIS Data Set, Capital Metro
Datum: NAD83/Projected Coordinate System: NAD83 Texas Central State Plane
Map 9. Proximity to Public Facilities Map: measure the connections between the rail stations and adjacent bus stations (before)

WALKABILITY ASSESSMENT

Network Analysis

Street Connection

Distance from A to B
3452.77 Feet

- Bus Stop
- MetroRail Station
- Future Streetcar Stop
- Metro Railroad
- Study Area
- Routes
- Error
- Located
- Unlocated

0 0.125 0.25 0.5 Miles

Authors: Myung Kyung Chung
Date: November 15, 2009
Source: City of Austin GIS Data Set, Capital Metro
Datum: NAD83/Projected Coordinate System: NAD83 Texas Central State Plane
Map 10. Proximity to Public Facilities Map: measure the connections between the rail stations and adjacent bus stations (after)

WALKABILITY ASSESSMENT

Network Analysis
True Street Shape with Barriers (missing Sidewalk)

Distance from A to B 3881.7 Feet

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Intro GIS CRP386. Fall 2009
Map 11. Network Analysis - Shortest Route from a Multi-family house to the Metro Station (before)

**WALKABILITY ASSESSMENT**

**Network Analysis**
Shortest Route from a Multi-family House to Metro Station (Barriers included)

- **Routes**
- **Error**
- **Located**
- **Unlocated**
- **Bus Stop**
- **MetroRail Station**
- **Future Streetcar Stop**
- **Metro Railroad**
- **Study Area**

**SIDEWALK STATUS**
- Excellent
- Good
- Poor
- Missing
- No Data

**Land Use 2008**
- Single Family
- Mobile Home
- Multi Family
- Commercial
- Office
- Industrial
- Civic
- Park
- Transportation
- Streets or Roads
- Undeveloped

Distance from 1 to 2: 3732.9 Feet

Author: Myung Kyung Chung Date: November 15, 2009
Source: City of Austin GIS Data Set, Capital Metro
Datum: NAD83 Projected Coordinate System: NAD83 Texas Central State Plane
Map 12. Shortest Route from a Multi-family house to Metro Station (after)

WALKABILITY ASSESSMENT

Network Analysis
Shortest Route from a Multi-family House to Metro Station (Barriers Included)

Distance from 1 to 2: 4316.4 Feet
WALKABILITY ASSESSMENT

Network Analysis
Calculation Service Area - Area
(3 min, 5 min, and 10 min Distance from Facilities)
WALKABILITY ASSESSMENT

Network Analysis
Calculation Service Area - Line
(3 min, 5 min, and 10 min Distance from Facilities)
7. Analysis

Map 3 – Map 7
These maps are generated to understand the qualitative aspects of the study site. The study site includes three neighborhoods: Upper Boggy Creek on the north side, Rosewood on the south west, and Chestnut on the south east side. While most of the Caucasian population is living in the Upper Boggy Creek neighborhood, African American population (approximately 77%) is concentrated on the Rosewood neighborhood and Chestnut neighborhood. Most of the Hispanic population is occupying Chestnut area.

Street conditions are varied by the neighborhoods and current land use. Upper Boggy Creek has suburban styles of street connection. That is, local streets are connected to their feeder minor arterials rather than being connected to each other. Also every street in this neighborhood does not have sidewalk. Unlike the Upper Boggy Creek neighborhood, Chestnut neighborhood is medium density residential area with relatively well connected street networks. Moreover its newly developed new urban style residential area along with the Miriam Avenue has excellent street conditions. The street conditions of Rosewood neighborhood is in between the Upper Boggy Creek neighborhood and Chestnut neighborhood. The street conditions of the Rosewood neighborhood, however, were very poor with missing sidewalks.

Map 8: Sidewalk Safety
In order to measure the safety of sidewalks - a key factor of walkability and pedestrian accessibility, I combined ranks of the current street condition and speed limit. Based on the related articles, street conditions were given more weight than speed limit. When the results of current condition rank (with 60% weight) and the speed limit (with 40% weight) are combined together, Manor rd. and a part of MLK blvd were the least safe street to the pedestrians, while the newly developed Miriam avenue has the safest pedestrian environments.

Map 9 – Map 12: Network Analysis (Shortest Distance)
Based on the results from the current sidewalk condition analysis, the shortest distance from a designated spot to the new transit station was calculated using the Network Analysis Tool in the ArcGIS. Map 9 and Map 10 show the shortest distances from a bus stop on the Manor Rd. to the MLK station. The first map is drawn with the assumption that all the streets are connected and accessible. The shortest distance from the node 1 (bus stop) to the MLK station was 3482.77 ft. However, as the Map 10 shows, if we consider more realistic condition by inserting barriers such as missing sidewalk and no crossings, the distance increases to 3881.7 ft resulting in approximately 5-7 minutes more walk. Map 11 and Map 12 provide similar consequences between a multi-family houses on the Upper Boggy Creek neighborhood to the MLK station. The difference between the two routes was 583 ft (approximately 10 minutes distance).

Map 13 – Map 14: Network Analysis (Calculation of Service Area)
These two maps show various consequences depending on different criteria we choose. That is, when people say ‘5 minutes distance,’ the ‘distance’ is calculated with Euclidian way. As the Map 13 shows, when the service area is calculated with the Euclidian method, the service areas (two transit stations) cover most of the neighborhoods within the study area. However, when we consider the street connections as in Map 14, the 3 minutes, 5 minutes, and 10 minutes service areas exclude most of the Upper Creek Neighborhood.

8. Conclusion

This project is to measure the accessibility to new transit stations – MLK Commuter Rail Station and Future Streetcar stop on Manor rd. Two steps of analysis were conducted to realize this measurement: First step was calculating sidewalk safety by combining the current sidewalk conditions and speed limits of the study site. Second step was calculating the walkable distance in the site by considering the current and realistic conditions using network analysis.

While all distance measurement methods seemed fairly consistent in their ability to measure overall changes in access at the neighborhood level, only network analysis was capable of providing changes in measures of accessibility at the household level. Specific changes at the block or household level would be important in using the measures of accessibility to perform a further analysis of equity based on specific demographic characteristics of the resident populations.

This study found that current street conditions impact accessibility to the newly built environment from surrounding areas. Although we assume that the new TOD zone will increase accessibility of surrounding communities significantly, adjacent neighborhood plans also need to be conducted at the same time.

Planners could use this study as an example in planning and approval for future TOD developments. Most of the pedestrian street network is studied based on the container and Euclidian coverage methods. As seen in this study, those methods can be misleading. Having a greater number of facilities does not necessarily mean greater accessibility for those within the neighborhood.

One future work of this study is to encompass more criteria of street conditions. Also when we consider the street network, the connections between other facilities should be considered as well. For example, new streetcar stops apart from two blocks can influence on the network analysis in different ways. For the practical aspects, pedestrians’ actual usages of the streets are worth to be considered as well. The question of what is accessible may change with different target audiences. For example, a similar study may look at the American Disabilities Act (ADA) and use higher standards than the ones used in this study to measure accessibility for disabled persons.
1. References

Eva Lesliea, Neil Coffeeb, Lawrence Franke, Neville Owend, Adrian Baumane, Graeme Hugob,


2. Appendix

Make Index Map and Set Study Sites
Data Used: Travis County, City of Austin Boundary, Street layer, Railroad, Neighborhoods in Manor, Martin Luther King Jr. Station, and Future Street Car Station on the Manor Corridor

a. Index Map
   1. Download county boundaries shapefile from the Capital Area Council of Governments (CAPCOG) website.
   2. Download streets shapefile from the City of Austin GIS Data Set (COA GIS) website.
   3. Download railroad shapefile from the COA GIS website.
   4. Download TIGER file and Census Block 2000 data from ESRI website.
   5. Open ArcCatalog and check if those data are defined and projected correctly.
   6. Change names in easy way in ArcCatalog
   7. Go to the ArcMap, add shapefiles
   8. Right click on the regional counties layer and select data and click export data. Then save and name the new shapefile TravisCounty.
   9. Delete the regional counties layer from the table of contents.
   10. Next, to show the major roads within Travis County, go to the Arc Map tool box and select the Analysis tool, then click on the plus sign by Extract and double click on the Clip tool. In the input select the major roads layer and then select the Travis County shapefile as the clipping feature.

b. Study site map
   11. Insert new frame, copy shapefiles above and paste them into the new frame
   12. Add Census Block data and join this table to the attribute table for the projected block boundary using STFID as the common field.
   13. Right click on the street layer, select Manor Road using select attribute table and click export data. Then save and name the new shapefile Manor.
   14. Zoom in and put Manor Rd on the center of screen
   15. Open ArcCatalog and create new shapefile (point) under data folder and rename it “rail_station”
   16. Right click the new shapefile and import coordinate system
   17. Add rail_station shapefile into ArcMap. Start Editing, click snap to the railroad shapefile and create two stations. Save and stop editing
   18. Using ArcTool Box, create ¼ mile buffers from stations (select dissolve type as ‘all’) and name it ‘station_buffer’
19. Open ArcCatalog and create new shapefile named ‘study_site’ and import coordinate system.

20. In the ArcMap, add study_site and create polygon covering ¼ mile buffer using census_block (to consider street connections).

21. Clip all shapefiles using the ‘study_site’ layer.

22. Delete street, railroad, citylimit, census_block and county layer and keep clipped data and study_site layer only.

**Current Conditions: Built Environment Study**

Data Needed: street_edges, and street data, land use, building footprints, speed limits

c. Prepare Sidewalk Shapefiles
   1. Open Catalog and create new shapefile (point) and rename it as ‘ped_amenity’ and import coordinate system from other existing (projected) layer.
   2. Copy and paste street_edges and rename the latter one as ‘ped_env’.
   3. Open ArcMap and add ‘ped_amenity’. Click start editing and create ‘ped_amenity’ shapefiles collected from field observation. Close editing and open attribute table and add field(s). Click start editing again and fill out fields such as types, quality, and so on.
   4. Add ‘ped_env’ and clip it using ‘study_site’ shapefile.
   5. Edit ped_env shapefile: click modify feature and make one linear line between two intersections as an independent feature (data).
   6. Open attribute table of the new ‘ped_env’. Add fields and fill out pedestrian conditions obtained from the field trip. (Excellent: 1, Good and Alley: 2, Poor: 3, Missing: 4; and no data: 9). Intersections where pedestrian crossing exists, add new feature and type ‘crossing’ in the field. Also calculate length of each feature.

d. Other built environment data: amenities, land use, speed limit, transit stops, and parkings
   7. Add amenity data downloaded from CMATA and clip it using study_site shapefile.
   8. Add land Use (current and future), building footprints shapefiles and clip them using study_site shapefile.
   9. Add street shapefile and clip it using study_site shapefile. Go to symbology and click unique values under categories. Select speed limit under value field and give different colors from 25 to 55.
   10. Copy street shapefile and paste it. Rename it ‘street hierarchy’ and make categories using street type (from alley to Major Arterial).
11. Change land use 2008 colors at the symbology tab (follow the code provided by the city of Austin)
12. Add Transit Stop data and parking data downloaded from CAMPO and clip them

**Assessments: Sidewalk Safety and Network Analysis**

I included two steps of analysis to measure accessibility in this project for suggest efficient use of this study sites by future commuter rail users. Each of the following analyses approaches in a different way to improve the walkability in this area: while sidewalk safety analysis rank current streets based on the conditions and suggest building sidewalk or pedestrian crossings, Network Analysis shows insufficient street connections and suggests new streets.

**Sidewalk Safety Analysis:** evaluate current pedestrian environments and rank them

1. Download the Street_Edge from the City of Austin GIS Data set
2. Open the ArcCatalog and copy the Street_Edge file and create new file named New_street.
3. Add the New_street file to the ArcMap.
4. Using Editor tool, edit the lines as one sidewalk to one block. Each end point meets to the other points.
5. Save and stop the editing.
6. Add field and rank them by the conditions – Excellent: 1, Good: 2, Poor: 3, Missing: 4, Alley: 5, Existing Crossing: 6, Possible Crossing: 7, No Data: 9999.
7. Add another field and calculate the length (ft) using the Calculate Geometry tool
8. Add new field and name it ‘speed limit.’
9. Add another field and rank the speed limit – 10 (Alley): 1, 25: 2, 35: 3, 40: 4, 45: 5, and No data: 9999
10. Using the field calculator, combine the ‘condition rank’ and ‘speed limit rank’
11. At the Properties > Symbology tab > Unique Value, select ‘sidewalk’ as the value field and give different symbols to each category.

e. **Street Network Analysis – Shortest Distance**
1. Create a network dataset at the ArcCatalog
2. Navigate the working folder and create new personal Geodatabase and create feature dataset within the folder.
3. Import New_street, Street, Stations, and Bus stops shapefile to the feature dataset
4. Right click the feature dataset, click New, then click Network Dataset
5. Type ‘GIS_NA’ and click next
6. Click select all to select all the feature classes to add in the network
7. Click connectivity to set up the connectivity model for the network
8. Click under the stations and bus stops and select Override from the dropdown list
9. Click OK to close the Connectivity Group dialog box and click next
10. Since there is no elevation field data for this dataset, therefore click no and click next
11. Open the ArcMap and add the ‘GIS_NA’
12. On the Network Analyst toolbar, click the Network Analyst dropdown menu and click New Route
13. Next, click Stops on the Network Analyst Window and click the Create Network Location tool
14. Click the Bus stop as the node 1 and click the MLK station as the node 2
15. Click the Analysis Layer Properties button next to Route layer on the Network Analyst Window to bring up the Layer Properties dialog for Route
16. In the Layer Properties dialog, click the Analysis Settings tab and select ‘minutes’
17. Choose Everywhere from the Allow U-turns dropdown box
18. Choose True Shape from the Output Shape Type dropdown box
19. After closing the Layer Properties dialog window, click the solve button on the Network Analyst toolbar
20. On the Network Analyst Window, click Barrier (0)
21. On the Network Analyst Toolbar, click the Create Network Location tool
22. Click the missing sidewalk area on the route to place a barrier
23. Click the Solve button on the Network Analyst toolbar.

f. Street Network Analysis – Calculating Service Area
1. On the Network Analyst toolbar, click the Network Analyst dropdown menu and click New Service Area
2. Right-click Facilities (0) on the Network Analyst Window and select Stations and click OK.
3. In the Network Analyst Window, click the Analysis Layer Properties Button to bring up the Layer Properties dialog box
4. Click the Analysis Settings tab
5. Click the Impedance dropdown list and select Walking time (Minutes)
6. Type “3 5 10” in the Default polygon breaks text box
7. Under Direction, click Away from facility
8. Click Nowhere from the Allow U-turns dropdown list
9. Check One-way in the Restrictions list
10. Click Generalized for Polygon Type and click Separate polygons per facility under Multiple Facilities Options.
11. Click Rings for the Overlap type and click apply
12. Click the Line Generation tab and check the box labeled Generate Lines.
13. Click OK to save the settings
14. Click the Solve button on the Network Analyst toolbar