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Final Report

Bike&Place: A New Tool for
Designing Active, Place-Making
Transportation Networks—
An Exploratory Study
(Project # 2016-009)



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ABSTRACT

Bike&Place is a new, open-source tool for designing transportation networks that are conducive to bicycle travel in small towns by the typical actual or potential cyclist and supportive of convivial public places. Thus, Bike&Place is as much about place-making as it is about active transportation planning.

Too often, planners working with small towns do not have a travel demand model. Lacking a model, they have a limited ability to rigorously, quantitatively assess current conditions and proposed changes to a town's transportation network. This study helps overcome that limitation.

This report provides detailed instructions for working with the model and tailoring it to a particular study area. Applications of Bike&Place are well within the capabilities of persons with basic GIS skills, even if they have no experience with travel demand models.

Three small towns in Mississippi were the test beds for developing Bike&Place: New Albany, Pontotoc City, and Houston. This report illustrates the towns' transportation networks and maps the current levels of traffic stress, link by link. A travel demand model is calibrated for one town, Houston, and used to assess the increase in bicycle-based accessibility afforded by hypothetical enhancements to the roadway network reducing traffic stress.

EXECUTIVE SUMMARY

Bike&Place is a new, open-source tool for designing transportation networks that are conducive to bicycle travel in small towns by the typical actual or potential cyclist and supportive of convivial public places. Those networks are both active and animating. Thus, Bike&Place is as much about place-making as it is about active transportation planning.

More specifically, Bike&Place is an easy-to-use agent-based travel demand model developed for the purpose of predicting the increase in bicycle based accessibility that would result from enhancements of a roadway network that reduce the traffic stress which “Interested but Concerned” cyclists would experience while traveling on the network. Coined by Roger Geller (Portland’s Bicycle Coordinator), the term “Interested but Concerned” refers to the adults who would regularly travel via bicycle were transportation infrastructure more supportive and hence exposure to vehicle traffic less frightening.

The “place” in Bike&Place refers to the geographical focus of the enhancements: the roadway links connecting residential neighborhoods (census blocks) and a “heart-and-soul” destination. The latter is a signature place—town square, park, arboretum, river walk, waterfront, greenway, trailhead, farmers’ market, historic business district. As the Orton Family Foundation has shown in many applications of their Community Heart & Soul™ planning process, recognition of the most emotionally significant places provides a powerful and unifying theme for town planning efforts. Heart-and-soul destinations are the places to which (bicycle) access is especially important.

This report describes in simple terms the behavioral theory underpinning the travel demand model and provides detailed step-by-step instructions for working with the model and tailoring it to a particular study area. Reflecting the origins of Bike&Place, the study area is assumed to be a small town for which one has obtained a shapefile having an inventory of the town’s roadway network. Applications of Bike&Place are well within the capabilities of persons with basic GIS skills, even if they have no experience with travel demand models.

Three small towns in Mississippi are this project’s study areas: New Albany, Pontotoc City, and Houston. They were the test beds for developing Bike&Place.

For each study area, this report illustrates the town’s transportation network and maps the current levels of traffic stress, link by link. Additional maps show hypothetical “high interest, low traffic stress” networks, which connect residents to the towns’ heart-and-soul destinations via cyclist-friendly roadways and the Tanglefoot Trail, a recently opened rail-trail.

A Bike&Place travel demand model is calibrated for Houston and used to assess the increase in bicycle-based accessibility afforded by the high interest, low traffic stress network. The benefit measure is the proportion of populated census blocks with bicycle access, reflecting the travel preferences of Interested but Concerned cyclists and potential cyclists.

CHAPTER 1: INTRODUCTION

Bike&Place is a new, open-source tool for designing transportation networks that conduce to bicycle travel by the typical actual or potential cyclist and support convivial public places. Those networks are both active and animating. Thus, Bike&Place is as much about place-making as it is about active transportation planning.

Signature places, such as town squares and historic business districts, play a strategic role in Bike&Place. Lyman Orton, founder of the Orton Family Foundation and co-proprietor of the Vermont Country Store, developed the Community Heart & Soul™ planning process to assist members of the general public with discovering and describing a widely-shared sense of the special characteristics of the neighborhood or town in which they live. “Community Heart & Soul begins with a partnership between local government and residents in a process that casts a wide net of engagement that works to identify and articulate what matters most—emotionally—to residents” (1, p. ii). Bike&Place is centered on heart-and-soul destinations: they are the places to which bicycle access is the most important.

Bike&Place also comprises several analytical components:

- Multimodal travel demand model.
- Work flow for preparing model-ready inventories of roadway (and trail) links, in which the attributes include traffic stress as perceived by “interested but Concerned” cyclists and potential cyclists.
- Protocol for assessing traffic stress.
- Protocol for calibrating the travel demand model’s behavioral parameters.
- Default values for the behavioral parameters, i.e., values that one may use as starting points when applying the travel demand model to places other than the one used in this study.
- Recommended benefit measure for assessing hypothetical or proposed changes to a transportation network: proportion of populated census blocks with bicycle access to the designated heart-and-soul destination.

The primary analytical engine of Bike&Place is the travel demand model. It facilitates network design and enhancement by predicting the increase in bicycle accessibility caused by reductions in traffic stress and/or improvements in connectivity. More specifically, the model predicts the changes in mode shares that may result from reduced traffic stress or better connectivity, as potential cyclists switch from autos to bicycles. When the model’s trip table is configured appropriately, the model also provides insight into the proportion of populated census blocks with bicycle access to the designated heart-and-soul destination.¹

Because the behavioral parameters in the travel demand model are few, the effort required to tailor them to other places would be small: one to two days. This report provides detailed guidance on how to apply Bike&Place to other areas, including detailed instructions on how to prepare a model-ready transportation network using the basic functionality of a commonly used GIS.

¹ The model may also be used to predict decreases in bicycle accessibility caused by network changes that favor automobile travel to the detriment of bicycle travel.

The case-study areas—New Albany, Pontotoc City, and Houston, Mississippi—were chosen for two reasons: familiarity with the towns, but also continuing curiosity, and their small size. First, this project is a follow-on to a study that John Poros, Joe Huegy, and I conducted of a regional planning issue affecting the towns and centering on land use and transportation (2). One aspect of that issue is an economic development initiative involving tourism stimulated by the recently opened mixed-use rail-trail known as the Tanglefoot Trail. The previous study could not include analysis of the role that the trail could play in utilitarian travel, and the current project provides the opportunity to do so.

Second, the case study areas are small towns. The specific attribute of size that is relevant is not population but geographical extent, in particular, the maximum network distance between any two points. For example, in Houston, that value is less than six miles, and it is significant because it facilitates calibration of the travel demand model (see Chapter 3).

Several principles guided development of Bike&Place. First, for the origins and destinations they are intended to serve, bicycle networks should not have any gaps. Second, bicycle networks should expose cyclists to low levels of traffic stress. Third, Bike&Place should use an open-source platform for building travel demand models. Fourth, Bike&Place should be easily adaptable by planners with respectable but modest GIS skills and with little or no expertise in travel demand modeling. Finally, not only should bicycle networks provide functional infrastructure, they should also help activate the public spaces that do—or could—contribute to a neighborhood or town’s conviviality and economic vitality.

The motivation behind Bike&Place also includes the desire to encourage planners and citizen planners to look for a significant characteristic of places that is hidden but nonetheless profound: the adverse effect that high-traffic stress roads have on bicycle travel. Roads are, of course, obvious components of the built environment, and the level of traffic stress that they induce is easily imagined by an attuned observer. Yet the effects are hidden because, to make an economics analogy, they are instances of suppressed demand: high traffic stress increases the disutility of travel via bicycle and hence trips are made via another travel mode, most probably the automobile. To help convey the significance of travel stress, this report includes three-dimensional illustrations of one town’s transportation network: traffic stress induced by roadway links is rendered in the vertical dimension to convey how it severs the town’s heart-and-soul destination from the rest of the town—just as the height of a wall conveys the difficulty of getting to the other side (see Chapter 4).

Although this study is comprehensive, it is nonetheless an exploration. The protocols for assessing traffic stress and for calibrating the parameters can be refined. The travel demand model is applied to only one town. I offer a tentative interpretation of the results of the calibration process, viz., to represent the latent demand for bicycle travel, one must consider preferences to be dynamic and, in particular, endogenous vis-à-vis the transportation network.

TRAFFIC STRESS AND A TYPOLOGY OF ADULT CYCLISTS AND POTENTIAL CYCLISTS

Roger Geller’s four-part typology, developed in 2005, continues to be compelling as a portrayal of actual and potential adult cyclists’ perceptions of bicycling conditions and attitudes toward bicycles as a daily mode of travel; as a field guide to observing transportation infrastructure; and as a guide to strategic planning of bicycle-oriented enhancements to transportation infrastructure (3). The power of the typology is in the evocative labels and vigorous characterizations of the members of each type.

The four types are Strong and Fearless; Enthused and Confident; Interested but Concerned; and No Way, No How. The type that is relevant to the current study is the one connoting latent demand for utilitarian bicycle travel, which would be expressed in actual trips were transportation infrastructure more supportive: Interested but Concerned. The members of the other groups already regularly bicycle for utilitarian purposes (Strong and Fearless, and Enthused and Confident; they have positive expressed demand) or never will do so (No Way No How; they have no latent demand whatsoever).

Geller’s profile of the Interested but Concerned type emphasizes the dominant role of traffic stress in suppressing regular travel via bicycle.

“A much larger demographic, representing the vast majority of Portland’s citizens, are the ‘interested but concerned.’... They like riding a bicycle...and they would like to ride more. But, they are afraid to ride. They don’t like the cars speeding down their streets. They get nervous thinking about what would happen to them on a bicycle when a driver runs a red light, or guns their cars around them, or passes too closely and too fast. Very few of these people regularly ride bicycles...[but they] will not venture out onto the arterials to the major commercial and employment destinations they frequent... They would ride if they felt safer on the roadways—if cars were slower and less frequent, and if there were more quiet streets with few cars and paths without any cars at all.” (3, p. 3)

Evidence for the typology comes from multiple sources using qualitative and quantitative methods of inquiry. Bicycle transportation planners and citizen planners (official advisory committee members and staff with advocacy organizations) in Portland (OR) and elsewhere in the U.S. approve the typology (3, p. 6). Substantial proportions of respondents to annual surveys sponsored by Portland’s SmartTrips program express attitudes suggesting membership in either the Interested but Concerned or No Way, No How groups (and perhaps the Enthused and Confident group) (3, p. 8).²

Dill and McNeil’s survey, conducted in 2011, of over nine hundred adults living in the Portland (OR) region validates use of personal comfort with bicycling near vehicular traffic and interest in cycling as foundations of a typology of actual/potential/unlikely adult cyclists (4). The survey provides empirical support for Geller’s typology and substantiates his subjective assessments of the sizes of membership in each type, in particular the large prevalence of Interested but Concerned actual or potential riders. In the survey, 4% of respondents are Strong and Fearless

² SmartTrips is operated by the Portland Bureau of Transportation and encourages residents to use travel modes other than single-occupant vehicles (<https://www.portlandoregon.gov/transportation/43801>).

(Geller: < 1%); 9% Enthused and Confident (Geller: 7%); 56% Interested but Concerned (Geller: 60%); and 31% No Way, No How (Geller: 33%) (3, p. 3; 4, p. 131).

In 2015, Dill and McNeil surveyed adults living in the 50 largest Metropolitan Statistical Areas in the U.S. to investigate the applicability of Geller’s typology to populations outside the Portland region (5). Although this survey uses operational definitions that are similar but not identical to those definitions used in their Portland survey, the MSA-based survey also found that a small minority of adults are Strong and Fearless or Enthused and Confident (7% and 5%, respectively); a good third of adults are in the No Way, No How type (37%); and a majority of adults are Interested but Concerned (51%) (5, p. 19).

Google’s “bike vision plan” for the area near its headquarters in Mountain View, California, is a recent example of how Geller’s typology informs bicycle transportation planners’ practice (6). “When it comes to encouraging more bicycling trips, most of the ‘Strong & Fearless’ and ‘Enthused and Confident’ riders are already accounted for. If we want to substantially increase the number of people riding bicycles to work, we need to attract the largest pool – the ‘Interested but Concerned’ group” (6, p. 9). The Interested but Concerned type serves rhetorical and analytical purposes. Readers are encouraged to identify with Interested but Concerned cyclists, a rhetorical device that facilitates agreement with the plan. Analytically, those potential riders provide the focus for assessments of existing levels of traffic stress and recommendations for stress-reducing enhancements of the roadway network.

The usefulness of Geller’s typology for bicycle transportation planning has been repeatedly demonstrated in urban settings. The next section asserts its usefulness to small towns and presents a novel application of the typology to travel demand modeling.

OVERVIEW OF THE TRAVEL DEMAND MODEL AND MODEL-READY TRANSPORTATION NETWORK

The primary function of the Bike&Place travel demand model is to measure the bicycle accessibility provided by a study area’s current transportation network and by hypothetical networks in which bicycle conditions have been improved. Accessibility is viewed from the perspective of Interested but Concerned cyclists, the group containing the greatest number of adults with latent demand for bicycle travel.

In effect, the model sends a fixed number of Interested but Concerned persons across a transportation network. Every populated census block in a study area is assigned one Interested but Concerned person. The travelers observe traffic flows and speeds and parked cars (typical conditions) and are aware of any bike lanes and other bicycle facilities on roads and at intersections. The need to travel is given; the travelers gauge the level of traffic stress according to their tolerance and decide whether to travel by auto or by bicycle.

The resulting bicycle mode share is a measure of bicycle accessibility. Because every populated census block has been assigned exactly one traveler, the bicycle mode share is equivalent to the proportion of the study area's populated census blocks with bicycle access to a heart-and-soul destination.

Bike&Place assists with both transportation planning and land use planning, and the tool encourages integration of transportation planning and land use planning. Given the current locations of the heart-and-soul destinations in a particular study area and a map of population density, planners could use the Bike&Place travel demand model to identify the specific roadway links that should be targeted for investments to improve bicycle access for the greatest number of potential cyclists. Conversely, planners could use the Bike&Place travel demand model to help choose the location of a new heart-and-soul destination: the location having the greatest current bicycle accessibility.

The Modeling Platform and Its Behavioral Framework

The travel demand model is implemented in the TRANUS modeling platform, open-source software for creating land use and travel demand models.³ In this application, only the travel demand components of TRANUS are used. The Bike&Place travel demand model is as simple as it can be. No unnecessary component has been included.

The typical travel demand model applying to individual (or household), utilitarian travel comprises four components, and each component entails complex calculations: 1) trip generation; 2) trip distribution; 3) travel mode choice; and 4) traffic assignment. In such models, the trip generation component predicts the number of trips that a person or household makes for a particular purpose, during a period of time such as a day. The trip distribution component predicts the specific locations to which people will travel, given their trip purpose. The travel mode choice component predicts whether someone will travel via auto, walk, bicycle, etc. The traffic assignment component predicts the path—a sequence of roadway segments—that someone will use to travel from his or her origin to his or her destination.

Because the Bike&Place travel demand model only needs to predict mode choice, a model that is much simpler than the typical model is ideal. Instead of employing complex calculations to predict trip generation and trip distribution, Bike&Place employs a trip table in which trips are made from the populated census blocks to the populated census blocks and to a heart-and-soul destination; the number of trips is fixed at one per origin-destination pair. Travel mode choice and traffic assignment processes are included in the Bike&Place travel demand model.

In the TRANUS modeling platform, travel mode choice and traffic assignment are combined in a multimodal path choice framework (7, p. 33). Paths comprise a sequence of link/mode combinations. In general, choice of path is a function of time-related costs, distance-related costs, and transfer costs, which include fares and the value of waiting time. Cost is a disincentive to use a path; a path is preferred to another if the former imposes on a traveler a lower cost.

³ The modeling platform software and manuals may be downloaded from: <http://www.tranus.com/tranus-english/download-install>. Tomás de la Barra is the primary developer (<http://modelistica.com.mx/en/about-us/>).

It is appropriate for the Bike&Place travel demand model to work with a simplified implementation of the multimodal path choice framework. Transfer costs are not relevant because the travel modes in the model do not include public transit.

The only distance-related cost would be the out-of-pocket cost of operating a privately-owned vehicle (“auto”): primarily the cost of gasoline or diesel fuel. The only destinations that would be included in a Bike&Place travel demand model are the heart-and-soul destinations, and hence the purpose of travel would be to consume the services provided at those destinations; examples would include recreation and shopping. It seems unlikely that vehicle operating costs would be an important determinant of travel mode choice for such trips. Consequently, the Bike&Place travel demand model does not explicitly make travel mode choice sensitive to out-of-pocket costs. Instead, out-of-pocket costs are among the influences on mode choice that are effectively included in the auto alternative specific constant (labeled pg_o , see below).

The Bike&Place travel demand modeling framework employs time-related costs as the means to distinguish between travel modes. The time-related costs comprise an actual component and a perceived component. The latter component allows the model to represent the effects of traffic stress on the Interested but Concerned cyclists. Traffic stress makes cyclists feel as though travel takes more time than a watch would report.⁴

The following equation is the Bike&Place travel demand model’s operational definition of the actual and perceived time-related cost.⁵

$$RT_m = tv_m (vv \cdot pt_m \cdot pg_o) \quad (1)$$

RT_m	total perceived cost of travel on a particular network link when traveling via mode o ; the subscript m denotes a link/mode combination.
tv_m	actual travel time (fraction of an hour) on a particular network link when traveling via mode o ; the subscript m denotes a link/mode combination. Actual travel time is the product of link length and speed; speed is fixed for bicycles but variable for autos, depending on the posted speed.
vv	value of travel time (\$/hr).
pt_m	penalizing factor specific to a combination of link type (functional classification) and travel mode.
pg_o	penalizing factor specific to a travel mode o , either auto or bicycle.

⁴ An alternative but equivalent formulation of travel cost is based on distance: traffic stress makes cyclists feel as though travel entails traversing a distance greater than an odometer would report (6, p. 20). The time-based formulation is easier to implement using the TRANUS modeling platform.

⁵ The equation is a simplified version of the time-related costs in the TRANUS modeling platform (7, equation 32, p.34): the latter includes a component for public transit, which is not relevant to the Bike&Place travel demand model.

The Bike&Place travel demand model uses the minimum number of behavioral parameters and network attributes but still represents the fundamental influences on Interested but Concerned cyclists' travel behavior, in particular, choices of travel mode and of route. In this context, "behavioral parameter" connotes either a property of a person's preferences or the person's reactivity to traffic stress. The behavioral parameters are value of travel time (tv); penalizing factor specific to a combination of link type and travel mode (pt_m); and penalizing factor specific to travel mode (pg_o).

"Network attribute" connotes either objective characteristics of the links in a transportation network or subjective characteristics. The objective characteristics are the posted speeds. The subjective characteristics are the traffic stress that Interested but Concerned cyclists would experience. Posted speeds are inputs to the travel demand model, i.e., they are specified in the definitions of link types. Traffic stress levels are also inputs to the travel demand model and are also specified in the link type definitions.

Actual travel time, tv_m , of course, reflects the speed of travel, which is determined by travel mode and, for autos, the posted speed on a particular roadway link. Traffic congestion is minimal if not existent in the case study area, and hence, in the Bike&Place travel demand model, autos always travel at the posted speed. Bicycles always travel at 15,500 meters/hr, which is equivalent to 9.6 miles/hr.

The penalizing factor pt_m represents the reactions to traffic stress that Interested but Concerned cyclists would experience on a particular roadway link or bicycle path. Presumably, bike paths such as the Tanglefoot Trail induce no traffic stress and the corresponding value of pt_m would be one. The values of pt_m are greater than or equal to one for roadway links.

Something akin to a moral imperative may also influence Interested but Concerned cyclists' travel behavior. Dill and McDaniel (4) found that most utilitarian cyclists in the Interested but Concerned group "feel a personal obligation to bicycle instead of driving for everyday travel" (4, p. 136). That result is significant for travel demand modeling because it implies that the preferences underlying travel behavior have a component related to bicycles in general. In the Bike&Place travel demand model, the penalizing factor pg_o represents the considerations that transcend actual travel time and traffic stress.

Links in the Transportation Network and Traffic Stress

Any travel demand model that is unbiased with respect to predicting bicycle travel must operate with a fine-scale transportation network because cyclists are sensitive to such fine-scale attributes of the built environment as vehicular traffic speed and volume on an individual roadway link.

Consequently, the transportation network used in this project includes nearly all roadway links in the case-study area (Houston, Mississippi), and it includes all links in the Tanglefoot Trail. The

road inventory that is the source of the roadway links in the model-ready network is the 2015 vintage of the statewide road centerline shapefile prepared by the Mississippi State Department of Transportation and Mississippi Automated Resource Information System (MARIS).⁶

Bicycle-oriented travel demand models should also use a fine-scale zone structure. In this context, zones refer to the spatial unit of analysis that imparts the geographical locations to trips' origins and destinations. Zones typically are census tracts, census block groups, census blocks, or something in between or even smaller than a census block. Whatever type of zone is the spatial unit of analysis, zone centroids are the points that represent the composite location of all households, businesses, etc. that are present in the zones. Thus the centroids (typically) are the nodes at which trips begin and end. The centroids are connected to the transportation network via "centroid connectors," which can be actual roadway links but also can be artificial links; a centroid may be attached to multiple centroid connectors.

Census blocks are good candidates for zones in bicycle-oriented travel demand models because the corresponding centroid connectors are relatively short compared to, for example, the length of the centroid connectors to which census block groups would give rise. The shorter centroid connectors therefore can best represent the connectivity provided by the actual roadway links for which the centroid connectors are proxies (8, p. 39).

With careful calibration of the penalizing factors, choice of travel mode can be well represented with a dichotomous measure of traffic stress, i.e., traffic stress is either present or absent from any particular link or intersection. A traffic stress level must be assigned to every link and intersection included in the model-ready transportation network. Chapter 2 explains the process of assigning traffic stress levels.

Calibration of the Travel Demand Model's Behavioral Parameters

The goal of the calibration process is to determine the values of the travel demand model's parameters that endow the model with the ability to represent the latent demand for bicycle travel. Traffic stress suppresses bicycle travel by the Interested but Concerned cyclists. Reduced stress creates the conditions in which they would feel comfortable riding, and the cyclists switch travel modes from auto to bicycle. Thus well-calibrated parameters allow the model to simulate the effects of enhancements to the transportation network that reduce traffic stress: reduced auto trips and increased bicycle trips.

The TRANUS modeling platform does not have a calibration module. Calibration must be performed manually via trial-and-error, but trial-and-error is not the same as hit-and-miss. Although calibration cannot be approached mechanically, it can still be systematic, and it is not arduous. Chapter 3 recites step-by-step the process used to calibrate the case study travel demand model. That process is easily applied to other study areas.

⁶ ftp://www.maris.state.ms.us/statewide/mstm/av/MDOT_CO_LRM.zip.

Adapting Bike&Place to Other Study Areas

The parameters are calibrated for Houston, Mississippi. They may need to be modified to adapt the travel demand model to other areas, and the Houston model's parameters provide a starting point.

SUBSEQUENT CHAPTERS

Chapter 2, “Preparing a Model-Ready Transportation Network,” provides a full description of how to prepare a model-ready transportation network, including link-specific levels of traffic stress. Chapter 3, “Transportation Networks Reimagined—High Interest, Low Traffic Stress,” makes specific recommendations for the roadway links that should be enhanced to facilitate bicycle travel from all of the town's residential neighborhoods to each town's heart-and-soul destination. Chapter 4, “Measuring Bicycle Accessibility In Houston Using A Bike&Place Travel Demand Model,” provides a how-to guide for calibrating a TRANUS-based travel demand model's behavioral parameters and applies the model to Houston to measure the increase in bicycle accessibility when the town's transportation network is reimagined.

CHAPTER 2: PREPARING A MODEL-READY TRANSPORTATION NETWORK

This chapter provides very detailed instructions for preparing the files needed by the TRANUS modeling platform to represent a study area’s transportation network. The instructions completely describe the work flow that begins with shapefiles of centerlines and census data and ends with two CSV-formatted files, a “nodes” file and “links” file. The latter have all of the fields and data required by a TRANUS-based travel demand model.

The instructions also describe the evaluation process that I used to rate each roadway and trail link with respect to the level of traffic stress that is likely to be currently experienced by Interested but Concerned cyclists (and potential cyclists). Thus the chapter provides the means for not only preparing model inputs but also communicating the current conditions of bicycle travel using an easily-understood rating system and simple graphics.

To be concrete, the instructions use the example of one of the three case-study towns, New Albany. The instructions also apply—without modification—to the other case-study towns and to other towns and cities in Mississippi.

The instructions should also guide preparation of model-ready transportation networks for towns and cities in states other than Mississippi. The centerline and census data shapefiles for places in other states very probably have fields that are equivalent to the Mississippi shapefiles. Consequently, it is reasonable to expect that the instructions in this chapter would need to be modified only with respect to file names and field names; the geoprocessing procedures are unlikely to need modification.

The GIS platform used for the project is Esri’s ArcGIS 10.4.1 for Desktop. Because the geoprocessing procedures that are used are among the most basic (see this chapter’s first appendix), this chapter’s instructions should also help users of the open-source platform QGIS.

DETAILED INSTRUCTIONS

I. Prepare Basemap: Town, Census Blocks, And Roads

1. Create the map document `Mississippi_BasemapCensus10.mxd`. Set the data frame’s coordinate reference to `mstm`. Add the 2010 statewide shapefile of census designated places downloaded from MARIS (`Cityp10.shp`). Add the 2010 statewide shapefile of census-block-level housing and population data downloaded from MARIS (`Blocks10PopnHou.shp`). Add the statewide road centerline shapefile downloaded from MARIS (`MDOT_CO_LRM.shp`). Add World Imagery Basemap.

2. Using the Select tool, create a shapefile containing a polygon representing New Albany. The Input Features are Cityp10. The Output Feature Class is NewAlbany10.shp. The Expression is "NAMELSAD10" = 'New Albany city'.
3. Using the Select Layer by Location tool, select the roads in New Albany, including the roadway segments that are outside the city but nonetheless link places near the town's boundary to the town. The Input Feature Layer is MDOT_CO_LRM. The Relationship is INTERSECT. The Selecting Features are NewAlbany10. The Search Distance is 50 meters; this parameter corrects for minor inconsistencies in the locations of the town's perimeter and of the roadways. The selection type is NEW_SELECTION. Manually inspect the selected features and, if necessary, add roadway segments (or redo the selection using a larger Search Distance). A later step will remove redundant roadway segments.
4. Export the selected roadways as a new shapefile: NewAlbany_MDOT_CO_LRM_AllRoads.shp. Use the same coordinate system as the data frame. Add the new shapefile to the data frame. Clear the selected features.
5. Put a copy of NewAlbany_MDOT_CO_LRM_AllRoads.shp in a "ForSafekeeping" folder.
6. Using the Select By Location tool, select the census blocks within New Albany. The Input Feature Layer is Blocks10PopnHou. The Relationship is WITHIN. The Selecting Features are NewAlbany10. Use the same coordinate system as the data frame. Export the selected census blocks as NewAlbany_Blocks10PopnHou. Add the exported data to the map as a layer. Clear the selected features.

II. Create Internal Zones Shapefile (Points)

1. Create the map document NewAlbany_TransNodesLinks.mxd. Set the data frame's coordinate reference to mstm. Add NewAlbany_Blocks10PopnHou.shp. Add World Imagery Basemap.
2. Using the Select Layer by Attribute tool, select New Albany's populated census blocks. The Layer Name or Table View is NewAlbany_Blocks10PopnHou. The selection type is NEW_SELECTION. The Expression is "P0010001" > 0. Next, if not already selected, manually add the census block containing the town's heart-and-soul destination, the northern terminus of the Tanglefoot Trail.
3. Using the Feature to Point tool, create a shapefile comprising the centroids of the selected census blocks. The Input Features are NewAlbany_Blocks10PopnHou. The Output Feature Class is NewAlbany_TransInternalZone_Points. Before proceeding, clear selected features.
4. Use the Add XY Coordinates tool add the X- and Y-coordinates of the centroids corresponding to the populated census blocks and the census block containing the Tanglefoot Trail's northern terminus. The Input Features are NewAlbany_TransInternalZone_Points. The coordinates are defined with respect to the mstm projected coordinate system. POINT_X has the X-coordinates, and POINT_Y has the Y-coordinates.
5. Put a copy of NewAlbany_TransInternalZone_Points.shp in a "ForSafekeeping" folder.

III. Simplify Roads, Split Roadway Links at Intersections with Tanglefoot Trail and Split Trail Links at Intersections with Roadway Links

1. Add NewAlbany_MDOT_CO_LRM_AllRoads.shp to NewAlbany_TransNodesLinks.mxd.
2. Add NewAlbany_TanglefootTrail.shp. That shapefile contains the portion of the trail that lies within the town. The parent of the shapefile is TanglefootTrail_mstm.shp, which is based on the KML file of the trail downloaded from the website of the GM&O Rails-to-Trails Recreation District.
3. Visually inspect NewAlbany_MDOT_CO_LRM_AllRoads and delete “channels”—if not needed to provide connectivity (such as to and from freeways)—and loops and U-shaped roads that a simplified network—straightened and without shape nodes—would represent with links that overlay other links. Editing will alter NewAlbany_MDOT_CO_LRM_AllRoads. Export the edited shapefile as NewAlbany_RoadsSimplified_1, and add it to the data frame.
4. Put a copy of NewAlbany_RoadsSimplified_1.shp in a “ForSafekeeping” folder.
5. NewAlbany_RoadsSimplified_1.shp must be edited to include the Tanglefoot Trail. First, the roadway links that intersect the trail at-grade need to be split at the intersections, and the trail links that intersect roads at-grade also need to be split at the intersections, to allow the trail to be connected to the roadway network. Second, the trail needs to be added to the simplified roads shapefile: only the segments that are relevant to in-town travel; some of the trail’s links may need to be split to allow deletion of the redundant portions. Before editing, ensuring Snapping is active.
 - a. Manually edit NewAlbany_RoadsSimplified_1 by splitting the roadway links that intersect at-grade the Tanglefoot Trail: select a target link and apply the Split Tool.
 - b. Manually edit NewAlbany_TanglefootTrail by splitting the trail links that intersect roads at-grade: select a target link and apply the Split Tool.
 - c. Before proceeding, inspect all roadway and trail links that were split, and revise as needed to ensure that intersections are in the correct locations and lengths of split links are correct. To correct length: open the relevant attribute table; select the target link; right click on Distance; and use the Calculate Geometry function.
 - d. Add the Tanglefoot Trail to NewAlbany_RoadsSimplified_1. Include only the portion of the trail bounded by Owen Road (southern terminus) and by MS Highway 178 (northern terminus). Use the Append Tool. The Input Dataset is NewAlbany_TanglefootTrail. The Target Dataset is NewAlbany_RoadsSimplified_1. The Schema Type is No TEST. The default Field Map options are appropriate.
 - e. After adding the trail, select the trail links and use the Calculate Field tool to set ROAD_NAME to Tanglefoot Trail.

IV. Create First Draft of TRANUS Nodes Shapefile

1. Apply the Feature Vertices to Points tool to NewAlbany_RoadsSimplified_1 to create a shapefile containing only the start points (first vertices) of each feature. The Input Features are NewAlbany_RoadsSimplified_1. The Output Feature Class is NewAlbany_RoadsSimplified_1_StartPoints_1. Set Point Type to START.
2. Apply the Feature Vertices to Points tool to NewAlbany_RoadsSimplified_1 to create a shapefile containing only the end points (last vertices) of each feature. The Input Features are NewAlbany_RoadsSimplified_1. The Output Feature Class is NewAlbany_RoadsSimplified_1_EndPoints_1. Set Point Type to END.
3. Use the Merge tool to create a shapefile of start points and end points. The Input Datasets are NewAlbany_RoadsSimplified_1_StartPoints_1 and NewAlbany_RoadsSimplified_1_EndPoints_1. The Output Dataset is NewAlbany_RoadsNodes_1. The default Field Map options are appropriate.
4. Apply the Delete Identical tool to NewAlbany_RoadsNodes_1 to delete the redundant points. The Input Dataset is NewAlbany_RoadsNodes_1. Set Fields(s) to SHAPE.
5. Use the Add XY Coordinates tool add the X- and Y-coordinates of the (unique) roadway nodes to NewAlbany_RoadsNodes_1. The Input Features are NewAlbany_RoadsNodes_1. The coordinates are defined with respect to the mstm projected coordinate system. POINT_X has the X-coordinates, and POINT_Y has the Y-coordinates.

V. Create Second Draft of TRANUS Nodes Shapefile and First Draft of TRANUS Links Shapefile

1. Create a shapefile containing dangle points, some of which will later be designated internal zones (others will be deleted). Use the Feature Vertices to Points tool. The Input Features are NewAlbany_RoadsSimplified_1. The Output Feature Class is NewAlbany_RoadsSimplified_1_DanglePoints_1. Set the Point Type to DANGLE. Symbolize the dangle points with a circle, size 10 points and fill 40% gray.
 2. Create a “Near” table of the roadway nodes that are nearest the census block centroids. The table will facilitate creation of the centroid connectors and deletion of the redundant dangle points. Use the Generate Near Table tool. The Input Features are NewAlbany_TransInternalZone_Points. The Near Features are NewAlbany_RoadsNodes_1. Name the Output Table na_centroids_nearest_road_node. Select the “Location” option. Select the “find only closest feature” option.
 3. Use the XY to Line tool to draw centroid connectors (artificial roadways) connecting the census block centroids and the nearest roadway nodes. The Input Table is na_centroids_nearest_road_node. Name the Output Feature Class: NewAlbany_Lines_Centroids_NearestRoadwayNodes. The Start X Field is FROM_X. The

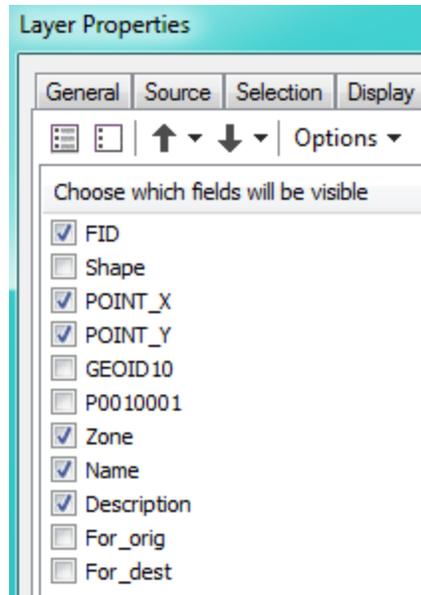
Start Y Field is FROM_Y. The End X Field is NEAR_X. The End Y Field is NEAR_Y. Set Spatial Reference to mstm.

4. Export NewAlbany_RoadsNodes_1 as NewAlbany_TranusNodes_1.shp and add the latter to the data frame. Use the data frame's coordinate system.
5. Edit NewAlbany_TranusNodes_1 by deleting all redundant dangle points, i.e., the dangle points that do not terminate the centroid connectors. Network links terminating at dangle points would cause connectivity errors in the travel demand model.
 - a. Editing is easiest when only these layers are visible and listed in the table of contents in this order: NewAlbany_TranusNodes_1; NewAlbany_TranusInternalZone_Points; NewAlbany_RoadsSimplified_1_DanglePoints_1; NewAlbany_Lines_Centroids_NearestRoadwayNodes; and NewAlbany_RoadsSimplified_1.
 - b. Use the Select Layer By Location Tool. The Input Feature Layer is NewAlbany_RoadsSimplified_1_DanglePoints_1. The Relationship is INTERSECT. The Selecting Features are "NewAlbany_Lines_Centroids_NearestRoadwayNodes selection". The Selection Type is NEW_SELECTION. Apply the Invert Spatial Relationship option. Create a layer from the selected features.
 - c. At this point, all of the dangle points that do not terminate the centroid connectors are selected. The next step is to use the selected dangle points to select the nodes that need to be deleted. Use the Select Layer by Location Tool. The Input Feature Layer is NewAlbany_TranusNodes_1. The Relationship is INTERSECT. The Selecting Features are "NewAlbany_RoadsSimplified_1_DanglePoints_1 selection". The Selection Type is NEW_SELECTION.
 - d. Open the attribute table of NewAlbany_RoadsSimplified_1_DanglePoints_1 and Clear Selection (to prevent deletion of the selected dangle points, which are still useful).
 - e. Edit NewAlbany_Tranus_Nodes_1. Delete the selected features, and save the edits.
6. Create the second draft of the TRANUS nodes shapefile by merging the shapefile of TRANUS internal zones and the shapefile of roadway nodes. Use the Merge tool. The Input Datasets are NewAlbany_TranusNodes_1 and NewAlbany_TranusInternalZone_Points. The Output Dataset is NewAlbany_TranusNodes_2. Use the Field Map option to exclude unneeded fields from the output dataset. Remove all fields except: POINT_X; POINT_Y; GEOID10; and P0010001.
7. As the redundant roadway nodes are deleted, some roadway links have become redundant, and they need to be deleted.
 - a. Use the Select Layer By Location Tool. The Input Feature Layer is NewAlbany_RoadsSimplified_1. The Relationship is INTERSECT. The Selecting Features are "NewAlbany_RoadsSimplified_1_DanglePoints_1 selection". The Selection Type is NEW_SELECTION.

- b. Edit NewAlbany_RoadsSimplified_1. Delete the selected features, and save the edits.
8. Inspect NewAlbany_TranusNodes_2 for non-centroid nodes that have become dangle points, and inspect NewAlbany_Roads_Simplified_1 for redundant links. Delete any new non-centroid dangle points and redundant links. Repeat as needed to delete non-centroid dangle points and redundant links.
9. Export NewAlbany_RoadsSimplified_1 as NewAlbany_RoadsSimplified_2 and add it to the data frame, using the data frame's coordinate system.
10. Create the first draft of the TRANUS links shapefile by merging the shapefile of centroid connectors and the shapefile of the actual roads and Tanglefoot Trail. Use the Merge tool. The Input Datasets are NewAlbany_RoadsSimplified_2 and NewAlbany_Lines_Centroids_NearestRoadwayNodes. The Output Dataset is NewAlbany_TranusLinks_1. The default Field Map options are appropriate.

VI. Finish the TRANUS Nodes Shapefile and Export Selected Fields From Its Attribute Table

1. Use the Add Field tool to add the following fields to NewAlbany_Tranus_Nodes_2, in this order: “Zone” (Field Type = LONG); “Name” (Field Type = TEXT and Field Length = 30) and “Descrip” (Field Type = TEXT and Field Length = 30). Open the shapefile's attribute table and add the alias “Description” to the “Descrip” field.
2. In the TRANUS modeling platform, nodes are either internal zones, external zones, or roadway/trail nodes which are neither internal zones nor external zones. External zones represent gateways that allow trips to enter or leave a study area. New Albany's model-ready network will have only internal zones and roadway/trail nodes. The field in the TRANUS nodes shapefile that classifies nodes is “Zone:” 0 (zero) for nodes and 1 for the internal zones. Use the Calculate Field tool to populate Zone. Use the Python code labeled “Zone” which appears in Appendix 2. (Depending on the study area, if the heart-and-soul destination is not in a populated census block, the value of Zone would need to be set manually to 1.)
3. Use the Calculate Field tool to populate Name. Use the Python code labeled “Name” which appears in Appendix 2.
4. Manually edit NewAlbanyTranusNodes_2 to set Description (Descrip) to “Tanglefoot Trail N terminus” for the feature having FID = 634.
5. To create an attractive layout, use the following symbology for NewAlbany_TranusNodes2.
 - a. Nodes: 60% gray square, 6 points.
 - b. Internal zones: dark navy square, 8 points.
6. Open the Layer Properties of NewAlbany_TranusNodes_2. Activate the Fields tab, and hide fields as shown in the following screenshot.



7. Open the attribute table of NewAlbany_TranusNodes_2, and use Table/Export to save “NewAlbany_TranusNodes_2_00A.nodes”. Save as type Text File, and delete the “txt” extension that ArcMap automatically adds; the file will then be saved in the CSV format. Do not add the new table to the current map. Using Windows, copy the file and rename the copy NewAlbany_TranusNodes_2_00A.nodes. (The “00A” portion of the file names will prove useful later on, when importing the latter file into a new TRANUS model document.)
8. NewAlbany_TranusNodes_2_00A.nodes is ready to be imported into a new TRANUS model document.

VII. Create Second Draft of the TRANUS Links Shapefile

At this point, the first draft of the TRANUS links shapefile, NewAlbany_TranusLinks_1, is incomplete because it does not have all of the fields that the TRANUS modeling platform requires of link files. These fields must be added, in this order: Origin; Destination; Direction; Link_Type; Distance; Capacity; Name; and Description. Each feature’s FID will be used as its TRANUS link identifier. Origin and Destination must be populated with TRANUS node identifiers. Those two fields cannot be added or populated immediately because several preparatory tasks must be undertaken first.

1. Export NewAlbany_TranusLinks_1 as NewAlbany_TranusLinks_2.shp, using the data frame’s coordinate system. Add the layer to the data frame. This step ensures that an intact copy of NewAlbany_TranusLinks_1 is retained.

2. Using the Add Fields tool, add For_orig (Field Type = LONG) and For_dest (Field Type = LONG) to NewAlbany_Tranus_Nodes_2. Those fields will replicate each node's FID. The purpose of adding those fields is to facilitate adding the origin and destination TRANUS node IDs to NewAlbany_TranusLinks_2. Using the Add Attribute Index tool, index the added fields.
3. Using the Calculate Fields tool, populate For_orig and For_dest in NewAlbany_Tranus_Nodes_2.
 - a. For_orig = FID.
 - b. For_dest = FID.
4. Use the Add Geometry Attributes tool to add the following fields to NewAlbany_TranusLinks_2: LENGTH; LENGTH_GEODESIC and LINE_START_MID_END. Set Coordinate System to mstm. Use the Add Attribute Index tool to index START_X, START_Y, END_X, END_Y.
5. Using the Join Field tool, add a field representing the roadway/trail link origins (TRANUS zone IDs) to NewAlbany_TranusLinks_2. The Input Table is NewAlbany_TranusLinks_2. The Input Join Field is Start_X. The join table is NewAlbany_Tranus_Nodes2. The output join field is POINT_X. The join field is For_orig.
6. Using the Join Field tool, add a field representing the roadway/trail link destinations (TRANUS zone IDs) to NewAlbany_TranusLinks_2. The Input Table is NewAlbany_TranusLinks_2. The Input Join Field is End_X. The join table is NewAlbany_Tranus_Nodes2. The output join field is POINT_X. The join field is For_dest.
7. Use the Add Field tool to add these fields to NewAlbany_TranusLinks_2, in this order: Direction (Field Type = LONG); Link_Type (Field Type = LONG); Distance (Field Type = FLOAT); Capacity (Field Type = LONG); Name (Field Type = TEXT, Length = 30); and Descrip (Field Type = TEXT, Length = 30). Open the shapefile's attribute table and add the alias "Description" to the "Descrip" field.
8. Use the Calculate Field tool to populate Direction in NewAlbany_TranusLinks_2. Use the Python code labeled "Direction" which appears in Appendix 2.
9. New Albany has several non-freeway roadway links that are one-way. The value of Direction needs to be set to 1 for: Court Avenue; the couplet comprising Robbins Drive and Marilyn Drive; a portion of King Street; Pine Street; a portion of Carter Avenue; and an unnamed alley intersecting West Bankhead Street (MS Highway 178), Main Street, and Pine Street.
10. Use the Calculate Field tool to populate Name in NewAlbany_TranusLinks_2. Use the Python code labeled "Name—Links" which appears in Appendix 2.
11. Use the Calculate Field tool to set Capacity = -1 (infinite) in NewAlbany_TranusLinks_2. Infinite capacity is appropriate because traffic congestion is not noticeable in New Albany.
12. Use the Calculate Field tool to populate Distance in NewAlbany_TranusLinks_2. Distance is link length measured in meters. For all links except centroid connectors, Distance is set to the geodesic distance calculated when the Add Geometry tool was used previously. The length of

all centroid connectors is set to the de minimis value, 0.01 meters. Use the Python code labeled “Distance” which appears in Appendix 2.

VIII. Assign Default Values of Posted Speeds to All Roadway Links and Assign Default Values of Traffic Stress to All Roadway and Trail Links

The posted speed must be assigned to every roadway link. Representing current conditions, a value of traffic stress—high or low—must also be assigned to every roadway link and to every link that is part of the Tanglefoot Trail. Those tasks require a substantial effort because hundreds of links must be described and evaluated with respect to traffic stress. A phased approach makes the tasks more manageable.

Many roadway links have either low or high posted speeds and, presumably, correspondingly low or high traffic stress. Posted speed may at least initially be inferred from functional classification. The purpose of this major step is to assign default values for posted speed and traffic stress based on a roadway link’s assigned functional classification. The default values are manually revised in the next major step, step number IX, based on fieldwork and observations made with Google Earth. The use of default values minimizes manual revision.

1. Use the Calculate Field tool to populate Link_Type in NewAlbany_TranusLinks_2 with the default values. The field represents the classification of links according to the traffic stress likely to be perceived by Interested but Concerned cyclists. Thus Link_Type is a categorical variable. Use the Python code labeled “Link_Type” which appears in Appendix 2. (Do not use zero (0) as a link type identifier.)
2. Use the Calculate Field tool to populate Descrip (alias Description) in NewAlbany_TranusLinks_2, which provides a label for each link type (LINK_TYPE). Use the Python code labeled “Descrip—Links” which appears in Appendix 2.
3. ArcGlobe can render scenes in three dimensions when a layer contains Z-coordinates, which represent height. For polylines such as links in a transportation network, rendering in 3D extrudes the links to an arbitrary height, thus giving the appearance of walls. Height will connote perceived traffic stress: differences in height suggest lower or higher traffic stress. Use the Add Field tool to add “Height” to NewAlbany_TranusLinks_2 to support 3D rendering. The Input Table is NewAlbany_TranusLinks_2. The Field Name is Height. The Field Type is FLOAT.
4. Use the Calculate Field tool to populate Height in NewAlbany_TranusLinks_2 with initial values, i.e., values that correspond to the initial or default assignment of link types. The values of the Height field determine the heights (in meters) of the extruded polylines.

Because the centroid connectors are artificial, they are not extruded (Height = 0). Use the Python code labeled “Height” which appears in Appendix 2.

5. Export NewAlbany_TransLinks_2 as NewAlbany_TransLinks_3, using the data frame’s coordinate system. Add the layer to the data frame. This step ensures that an intact copy of NewAlbany_TransLinks_2 is retained.
6. Visually inspect the results of the efforts made thus far and manually revise NewAlbany_TransLinks_3 to ensure connectivity, realistic alignments of the centroid connectors, and simplicity.
 - a. Delete the roadway links that are “channels” (Link_Type = 3). Channels are very short one-way links that facilitate right or left turns from one road to another. For the purpose of estimating changes in bicycle-based accessibility, they are unnecessary for a model-ready transportation network.
 - b. Ensure that the direction of travel on one-way links is correct. To make it easier to verify the direction of travel on any one-way links and to differentiate start nodes from end nodes, symbolize the links with the “Arrow at End” symbol.
 - c. Revise any centroid connectors that are attached to nodes delimiting an interstate highway link, ramp, or a Tanglefoot Trail link. The noncentroid nodes should delimit links that are local roads or are otherwise not access-restricted.

IX. Refine Posted Speeds and Traffic Stress Levels, Finish the TRANUS Links “Current Conditions” Shapefile, and Export Table Containing Selected Fields From Its Attribute Table

I used two different methods to determine posted speed and to assess current levels of traffic stress: windshield/walking surveys and virtual site visits conducted with Google Earth Street View. Excluding freeways, I actually or virtually surveyed every roadway segment in New Albany, Pontotoc, and Houston. Of course, the Tanglefoot Trail is assumed to be uniformly low traffic stress.

To develop a servicable operational definition of high- or low-traffic stress, I worked backwards from an operational definition of Interested but Concerned cyclists. Thus I inferred the roadway characteristics that would induce high or low traffic stress.

Dill and McNeil’s categorization of cyclists gives significance to the proximate land-use context and to bike lanes.⁷ To gather the information on which categorization would be based, they posed the following scenarios to the adults included in their survey. Respondents were asked to express level of comfort (on a four point scale) with each scenario.

“1. A path or trail separate from the street;

⁷ Jennifer Dill and Nathan McNeil (2013), Four Types of Cyclists? Examination of Typology for Better Understanding of Bicycling Behavior and Potential, Transportation Research Record: Journal of the Transportation Research Board, No. 2387, pp. 129-138, DOI 10.3141/2387-15.

“2. A two-lane neighborhood, commercial-shopping street with traffic speeds of 25 to 30 mi [miles] per hour, on-street car parking, and no bike lane: What if a striped bike lane was added?

“3. A major urban or suburban street with four lanes, on-street parking, traffic speeds of 30 to 35 mi per hour, and no bike lane:

“—What if a striped bike lane was added?

“—What if it also had a wide bike lane separated from traffic by a raised curb or parked cars? and

“4. A major street with two lanes in each direction, a center divider, on-street parking, traffic speeds of 35 to 40 mi per hour, and no bike lane:

“—What if a striped bike lane was added?

“—What if it also had a wide bike lane separated from traffic by a raised curb or parked cars.”⁸

In Dill and McNeil’s classification, the interested but concerned cyclists (including potential cyclists): “did not feel ‘very comfortable’ on nonresidential streets, with or without bike lanes, but did not feel ‘very uncomfortable’ on paths and trails.”⁹

Consequently, I used these guidelines to evaluate traffic stress.

- Residential streets: low stress, unless certain conditions exist. High stress when: posted speeds are 35 miles per hour or greater; road segment belongs to a corridor providing direct access to multiple major, high speed roads (such as a road in a low-density residential neighborhood on a town’s periphery and the neighborhood is bounded by roads with 45 miles per hour posted speeds); road segment belongs to a corridor connecting traditional business district and one or more state highways (which connect the town to other towns). “Corridor” connotes high traffic volume.
- Nonresidential streets, including state-designated highways providing regional connectivity: high stress.

The traffic stress induced by intersections deters Interested but Concerned cyclists from traveling through those intersections and selecting routes that traverse the roadway links forming the intersection legs. The TRANUS modeling platform requires an indirect approach to representing the negative effects of high-stress intersections: any roadway link attached to a high-stress roadway link is treated as a high-stress link. Thus, a high level of traffic stress propagates from links to intersections and thence to additional links (excluding the Tanglefoot Trail), even if the latter are otherwise low stress.

⁸ *Ibid.*, p. 131.

⁹ *Ibid.*

1. Export NewAlbany_TranusLinks_3 as NewAlbany_TranusLinks_3_CurrentConditions_1, using the data frame's coordinate system. Add the layer to the data frame. This step ensures that an intact copy of NewAlbany_TranusLinks_3 is retained.
2. Based on the observations made during the site visit, revise Link_Type in NewAlbany_TranusLinks_3_CurrentConditions_1.
3. Use the Calculate Field tool to revise Descrip in NewAlbany_TranusLinks_3_CurrentConditions_1, which provides a label for each link type (LINK_TYPE). Use the Python code labeled “Descrip—Links” which appears in Appendix 2.
4. Use the Calculate Field tool to revise Height in NewAlbany_TranusLinks_3_CurrentConditions_1. Use the Python code labeled “Height” which appears in Appendix 2.
5. Export NewAlbany_TranusLinks_3_CurrentConditions_1 as NewAlbany_TranusLinks_3_CurrentConditions_2, using the data frame's coordinate system. Add the layer to the data frame. This step ensures that an intact copy of NewAlbany_TranusLinks_3_CurrentConditions_1 is retained.
7. Using NewAlbany_TranusLinks_3_CurrentConditions_2, select the “major” roads other than Interstate Highway 22 and the ramps—all of which are high traffic stress—and use the selection to in turn select the low-stress roadway links that intersect the major roads. To perform the first selection, use the Select Layer By Attribute tool and Major Roads Query Expression which appears in Appendix 2. The second selection should not include centroid connectors, ramps, interstate highway links, Tanglefoot Trail links, or roadway links already designated as high traffic stress links. To Increase the selected links' (second selection) traffic stress levels, use the Calculate Field tool to increase Link_Type by one, i.e., add 1 to Link_Type.
8. Using the Calculate Field tool, revise Descrip (Description) and Height in NewAlbany_TranusLinks_3_CurrentConditions_2.
9. Open the Layer Properties of NewAlbany_TranusLinks_3_CurrentConditions_2. Activate the Fields tab, and hide all fields except: FID; For_orig; For_dest; Direction; Link_Type; Distance; Capacity; Name; and Descrip.
10. Open the attribute table of NewAlbany_TranusLinks_3_CurrentConditions_2, and use Table/Export to save “NewAlbany_TranusLinks_3_00A.links”. Save as type Text File, and delete the “txt” extension that ArcMap automatically adds; the file will then be saved in the CSV format. Do not add the new table to the current map. The “00A” in the file name connotes the “current conditions” scenario.
11. Open NewAlbany_TranusLinks_3_00A.links.csv in Excel and, if needed, rearrange the columns to ensure proper order, as required by the TRANUS modeling platform: FID; For_orig; For_dest; Direction; Link_Type; Distance; Capacity; Name; and Descrip. Export the file, retaining the CSV format. Name it NewAlbany_TranusLinks_3_00A.links.
12. NewAlbany_TranusLinks_3_00A.links is ready to be imported into a TRANUS model document.

X. Import Network Files Into TRANUS, Set Any Turn Restrictions, and Test for Connectivity

The work flow described above creates the two network files that TRANUS-based models require: one for nodes and another for links (the latter containing roadway and Tanglefoot Trail segments). The work flow comprises nearly all steps needed to create a valid transportation network, but some additional processing using the TRANUS modeling platform is helpful, if not essential.

First, of course, the network files must be imported into a new TRANUS model document. Any link-to-link turn restrictions must then be set using the “Turns” function. The last step (perhaps the next to last) in creating a model-ready network is using the built-in connectivity test (part of the path-generating module “PASOS”) to verify connectivity between all potential origins and all potential destinations. The connectivity test also finds errors and omissions in specifications of the link types. If there are problems, the most likely cause is a dangling roadway link, i.e., a cul-de-sac terminating at a node that is not a centroid, which was accidentally overlooked in major step V. The solution is to delete the link.

Limitations

The work flow described in this chapter generates a transportation network that is rich in content: link-level traffic stress and all attributes needed for travel demand modeling (using the TRANUS modeling platform). Nonetheless, a fair overall assessment of the work flow must acknowledge several limitations: the traffic stress induced by intersections is represented as attributes not of the intersections themselves but of the roadway links attached to the intersections, thus possibly overstating the prevalence of high traffic stress; some roadway links have two different posted speeds and/or traffic stress levels, but the roadway links, which are defined by MDOT, were not split to reflect changes in either posted speed or traffic stress level; and assessments of traffic stress reflects one observer’s judgment. The limitations are entirely due to the project’s time and financial constraints. The travel demand modeling platform, GIS platform, and work flow can accommodate increased spatial resolution of the intersection and roadway link attributes as well as assessments of traffic stress conducted by a team of observers.

APPENDIX 1: ARCMAP GEOPROCESSING TOOLS USED TO PREPARE THE MODEL-READY TRANSPORTATION NETWORKS

Add Attribute Index (Data Management Toolbox, Indexes Toolset)

“Adds an attribute index to an existing table, feature class, shapefile, coverage, or attributed relationship class.

“Attribute indexes are used by ArcGIS to quickly locate records that match an attribute query.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/add-attribute-index.htm>

Add Field (Data Management Toolbox, Fields Toolset)

“Adds a new field to a table or the table of a feature class, feature layer, and/or rasters with attribute tables.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/add-field.htm>

Add Geometry Attributes (Data Management Toolbox, Features Toolset)

“Adds new attribute fields to the input features representing the spatial or geometric characteristics and location of each feature, such as length or area and x-, y-, z-, and m-coordinates.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/add-geometry-attributes.htm>

Add XY Coordinates (Data Management Toolbox, Features Toolset)

“Adds the fields POINT_X and POINT_Y to the point input features and calculates their values.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/add-xy-coordinates.htm>

Append (Data Management Toolbox, General Toolset)

“Appends multiple input datasets into an existing target dataset. Input datasets can be point, line, or polygon feature classes, tables, rasters, raster catalogs, annotation feature classes, or dimensions feature classes.

“To combine input datasets into a new output dataset, use the Merge tool.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/append.htm>

Calculate Field (Data Management Toolbox, Fields Toolset)

“Calculates the values of a field for a feature class, feature layer, or raster.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/calculate-field.htm>

Delete Identical (Data Management Toolbox, General Toolset)

“Deletes records in a feature class or table which have identical values in a list of fields. If the field Shape is selected, feature geometries are compared. The Find Identical tool can be used to report which records are considered identical without deleting the identical records.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/delete-identical.htm>

Feature to Point (Data Management Toolbox, Features Toolset)

“Creates a feature class containing points generated from the representative locations of input features.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/feature-to-point.htm>

Feature Vertices to Points (Data Management Toolbox, Features Toolset)

“Creates a feature class containing points generated from specified vertices or locations of the input features.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/feature-vertices-to-points.htm>

Generate Near Table (Analysis Toolbox, Proximity Toolset)

“Calculates distances and other proximity information between features in one or more feature class or layer. Unlike the Near tool, which modifies the input, Generate Near Table writes results to a new stand-alone table and supports finding more than one near feature.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/analysis-toolbox/generate-near-table.htm>

Join Field (Data Management Toolbox, Joins Toolset)

“Joins the contents of a table to another table based on a common attribute field. The input table is updated to contain the fields from the join table. You can select which fields from the join table will be added to the input table.

“The records in the Input Table are matched to the records in the Join Table based on the values of Input Join Field and the Output Join Field. Optionally, only desired fields can be selected from the Join Table and appended to the Input Table during the join.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/join-field.htm>

Merge (Data Management Toolbox, General Toolset)

“Combines multiple input datasets of the same data type into a single, new output dataset. This tool can combine point, line, or polygon feature classes or tables. Use the [Append](#) tool to combine input datasets with an existing dataset.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/merge.htm>

Select (Analysis Toolbox, Extract Toolset)

“Extracts features from an input feature class or input feature layer, typically using a select or Structured Query Language (SQL) expression and stores them in an output feature class.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/analysis-toolbox/select.htm>

Select Layer By Attribute (Data Management Toolbox, Layers and Table Views Toolset)

“Adds, updates, or removes a selection on a layer or table view based on an attribute query.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/select-layer-by-attribute.htm>

XY to Line (Data Management Toolbox, Features Toolset)

“Creates a new feature class containing geodetic line features constructed based on the values in a start x-coordinate field, start y-coordinate field, end x-coordinate field, and end y-coordinate field of a table.”

<http://desktop.arcgis.com/en/arcmap/10.4/tools/data-management-toolbox/xy-to-line.htm>

APPENDIX 2: PYTHON CODE AND SQL QUERY EXPRESSION

Zone (TRANUS Nodes Shapefile)

Pre-Logic Script Code:

```
def Reclass(p):  
    if p = 0:  
        return 0  
    if p > 0:  
        return 1
```

Expression:

```
Reclass(!P0010001!)
```

Name (TRANUS Nodes Shapefile)

Pre-Logic Script Code:

```
def Reclass(z,g):  
    if z == 0:  
        return ''  
    if z > 0:  
        return g
```

Expression:

```
Reclass(!Zone!, !GEOID10!)
```

Direction (TRANUS Links Shapefile)

Pre-Logic Script Code:

```
def Reclass(rc):  
    if rc == ' ':  
        return 2  
    if rc == 'CHANNEL':  
        return 1  
    if rc == 'LOCAL':  
        return 2  
    if rc == 'MS':  
        return 2
```

```
if rc == 'RAMP':  
    return 1  
if rc == 'US':  
    return 2  
if rc == 'FC':  
    return 2  
if rc == 'IH':  
    return 1
```

Expression:

```
Reclass(!ROUTE_CLAS!)
```

Name—Links (TRANUS Links Shapefile)

Pre-Logic Script Code:

```
def Reclass(rn):  
    if rn <> ' ':  
        return rn  
    if rn == ' ':  
        return 'centroid connector'
```

Expression:

```
Reclass(!ROAD_NAME!)
```

Distance (TRANUS Links Shapefile)

Pre-Logic Script Code:

```
def Reclass(n,lg):  
    if n <> 'centroid connector':  
        return lg  
    if n=='centroid connector':  
        return .01
```

Expression:

```
Reclass(!NAME!, !LENGTH_GEO!)
```

Link_Type (TRANUS Links Shapefile)

Pre-Logic Script Code:

```
def Reclass(n,rc):
    if n == 'centroid connector':
        return 1
    if rc == 'RAMP':
        return 2
    if rc == 'CHANNEL':
        return 3
    if rc == 'LOCAL':
        return 20
    if rc == 'FC':
        return 20
    if rc == 'MS':
        return 43
    if rc == 'IH':
        return 61
    if rc == 'US':
        return 61
    if n == 'Tanglefoot Trail':
        return 70
```

Expression:

```
Reclass(!NAME!,!ROUTE_CLAS!)
```

Descrip—Links (TRANUS Links Shapefile)

Pre-Logic Script Code:

```
def Reclass(lt):
    if lt==1:
        return 'centroid connector'
    if lt==2:
        return 'ramp'
    if lt==3:
        return 'channel'
    if lt==14:
        return '15mph low traffic stress'
```

```
if lt==15:  
    return '15mph high traffic stress'  
if lt==18:  
    return '20mph low traffic stress'  
if lt==19:  
    return '20mph high traffic stress'  
if lt==20:  
    return '25mph low traffic stress'  
if lt==21:  
    return '25mph high traffic stress'  
if lt==30:  
    return '30mph low traffic stress'  
if lt==31:  
    return '30mph high traffic stress'  
if lt==32:  
    return '35mph low traffic stress'  
if lt==33:  
    return '35mph high traffic stress'  
if lt==40:  
    return '40mph low traffic stress'  
if lt==41:  
    return '40mph high traffic stress'  
if lt==43:  
    return '45mph high traffic stress'  
if lt==51:  
    return '50mph high traffic stress'  
if lt==53:  
    return '55mph high traffic stress'  
if lt==61:  
    return '60mph interstate highway'  
if lt==70:  
    return 'Tanglefoot Trail'
```

Expression:

```
Reclass(!Link_Type!)
```

Height (TRANUS Links Shapefile)

Pre-Logic Script Code:

```
def Reclass(lt):  
    if lt==1:  
        return 0  
    if lt==2:  
        return 30  
    if lt==3:  
        return 30  
    if lt==14:  
        return 10  
    if lt==15:  
        return 30  
    if lt==18:  
        return 10  
    if lt==19:  
        return 30  
    if lt==20:  
        return 10  
    if lt==21:  
        return 30  
    if lt==30:  
        return 10  
    if lt==31:  
        return 30  
    if lt==32:  
        return 10  
    if lt==33:  
        return 30  
    if lt==40:  
        return 10  
    if lt==41:  
        return 30  
    if lt==43:  
        return 30  
    if lt==51:  
        return 30  
    if lt==53:  
        return 30  
    if lt==61:  
        return 30  
    if lt==70:  
        return 10
```

Expression:

Reclass (!Link_Type!)

Major Roads Query Expression (TRANUS Links Shapefile)

```
"Name" LIKE 'GLENFIELD ROAD' OR "Name" LIKE 'MS HIGHWAY 178' OR  
"Name" LIKE 'GLENDALE ROAD' OR "Name" LIKE 'MS HIGHWAY 30' OR  
"Name" LIKE 'BRATTON ROAD' OR "Name" LIKE 'COUNTY ROAD 51' OR  
"Name" LIKE 'COUNTY ROAD 86' OR "Name" LIKE 'S CENTRAL AVE%' OR  
"Name" LIKE 'CARTER AVE' OR "Name" LIKE 'MS HIGHWAY 15' OR  
"Name" LIKE 'MS HIGHWAY 348' OR "Name" LIKE 'Munsford Dr' OR  
"Name" LIKE 'MOSS HILL DRIVE' OR "Name" LIKE 'HIGHLAND STREET'
```

CHAPTER 3: TRANSPORTATION NETWORKS REIMAGINED— HIGH INTEREST, LOW TRAFFIC STRESS

Place-making and bicycle-oriented active transportation are the twin goals of the design exercises summarized below. The exercises, one for each case-study town, reimagine the transportation networks as high interest and low traffic stress. Selected high traffic stress roadway links are transformed with the intention of more effectively connecting residences (but perhaps not all residential neighborhoods) and a town’s heart-and-soul location with a transportation network facilitating bicycle trips. The heart-and-soul locations are: the northern terminus of the Tanglefoot Trail in New Albany’s historic downtown; Pontotoc Town Square in Pontotoc City; and Courthouse Square in Houston.

The design exercises adhered to one constraint on the process of reimagining the networks. Links having a posted speed of 40 miles per hour or greater, all of which are currently designated high traffic stress, continue to be high traffic stress links in the reimagined networks.

For each town, this chapter has two maps. The first map portrays current conditions, and the second map portrays the high interest, low traffic stress network. A red circle helps with finding the heart-and-soul location, which is near the circle’s center. Note that changes to the network are not limited to the roadway links that the circle encompasses.

Houston’s reimagined network is more deeply examined in the next chapter. A Bike&Place travel demand model is applied to quantify the increase in bicycle accessibility.

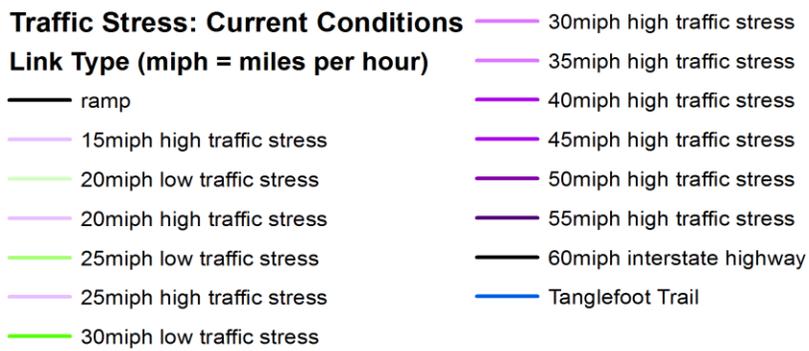
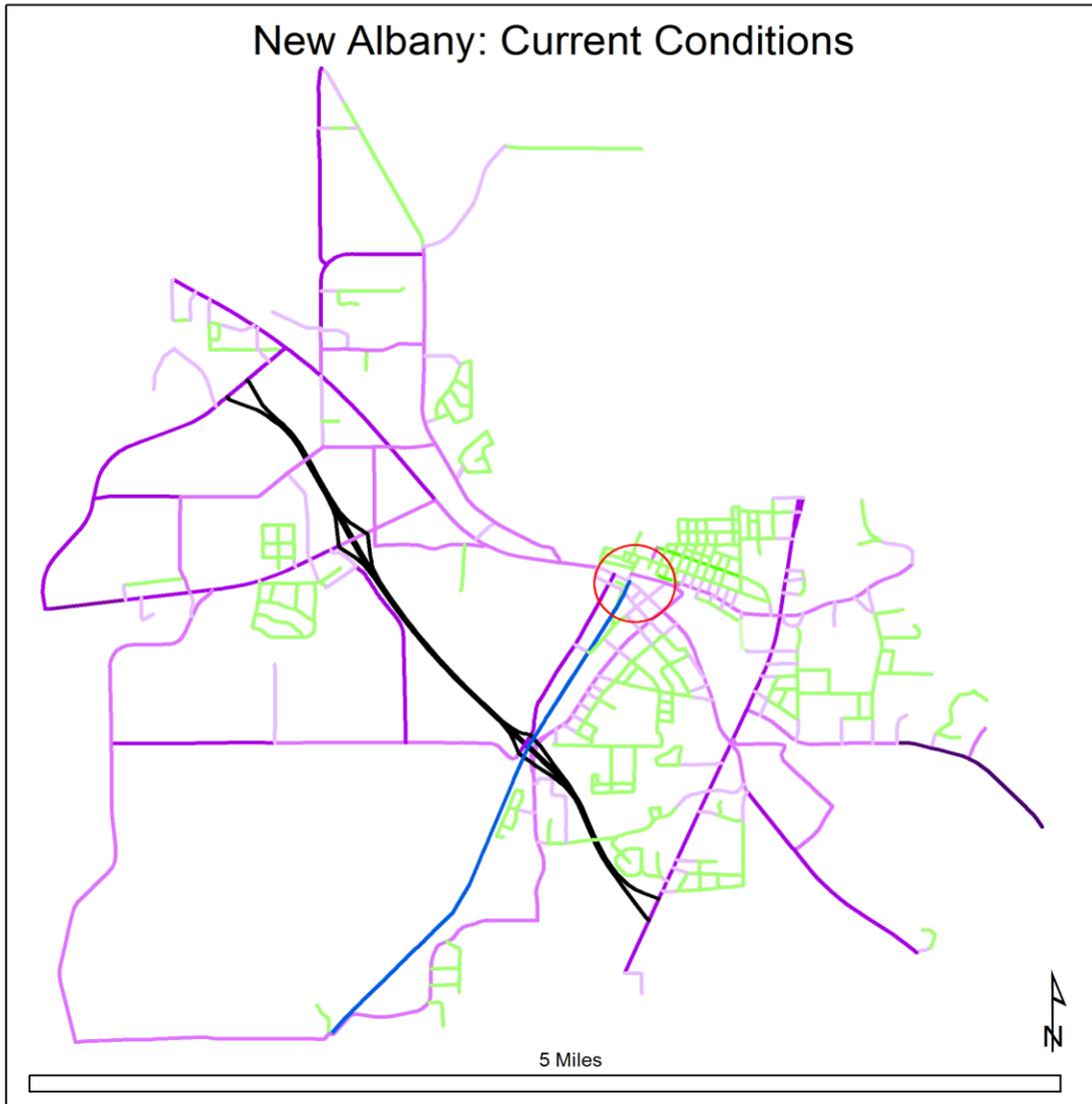
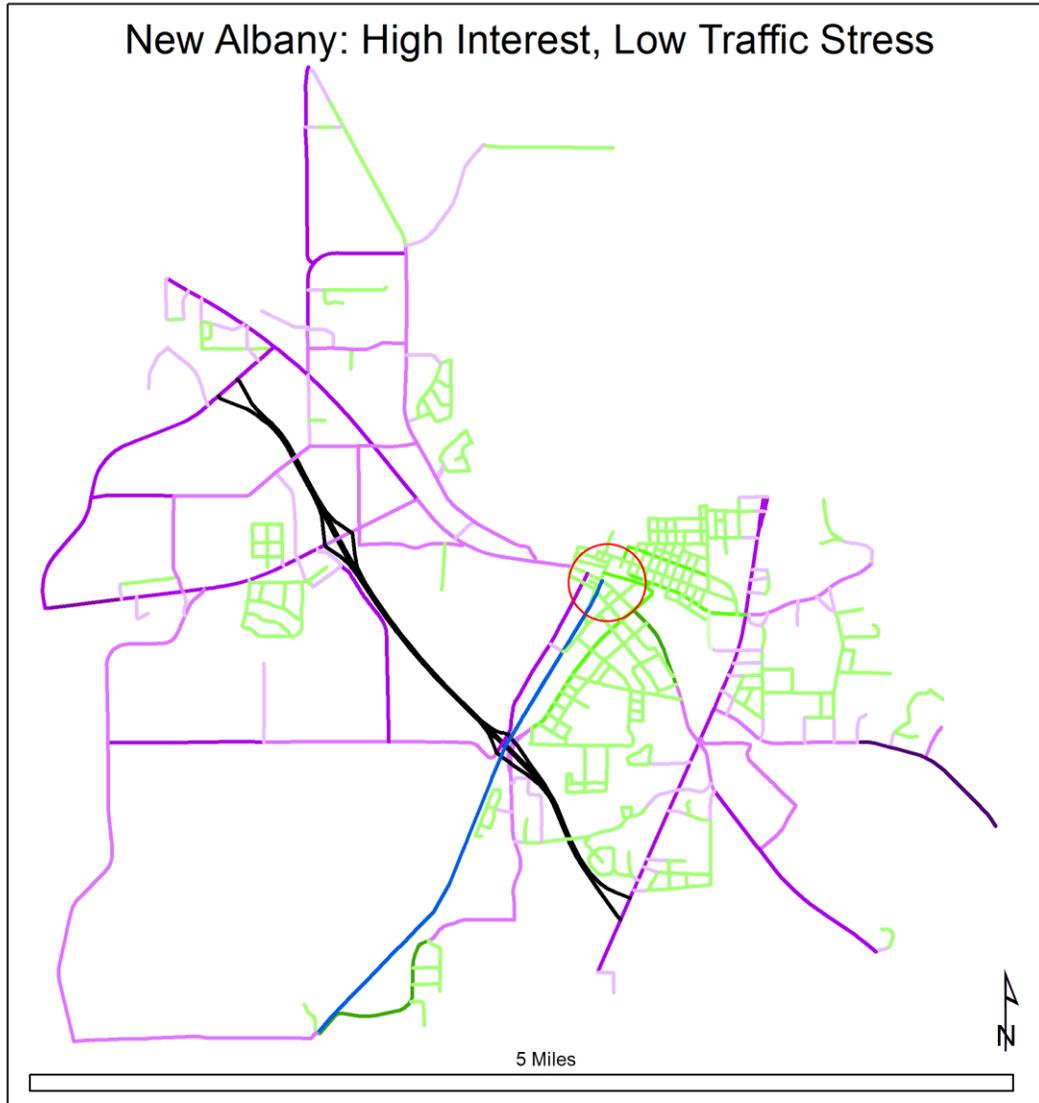


Figure 3-1. New Albany: Current Conditions.



- | Link Type (miph = miles per hour) | |
|--|------------------------------|
| — ramp | — 35miph low traffic stress |
| — 15miph high traffic stress | — 35miph high traffic stress |
| — 20miph low traffic stress | — 40miph high traffic stress |
| — 20miph high traffic stress | — 45miph high traffic stress |
| — 25miph low traffic stress | — 50miph high traffic stress |
| — 25miph high traffic stress | — 55miph high traffic stress |
| — 30miph low traffic stress | — 60miph interstate highway |
| — 30miph high traffic stress | — Tanglefoot Trail |

Figure 3-2. New Albany: High Interest, Low Traffic Stress.

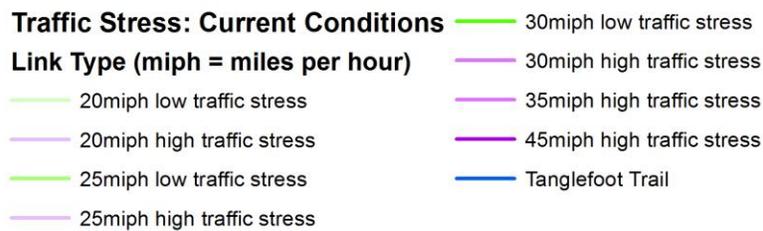
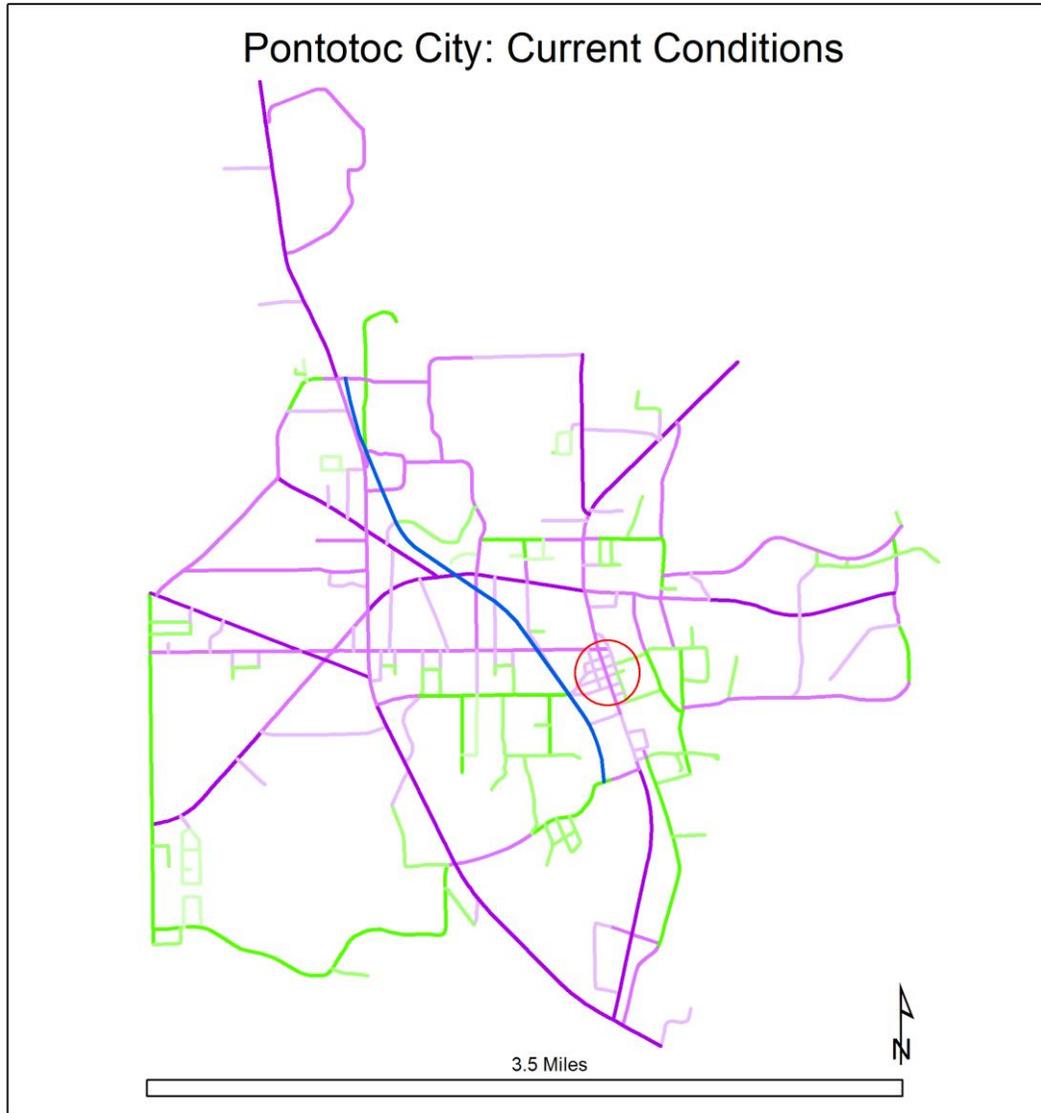


Figure 3-3. Pontotoc City: Current Conditions.

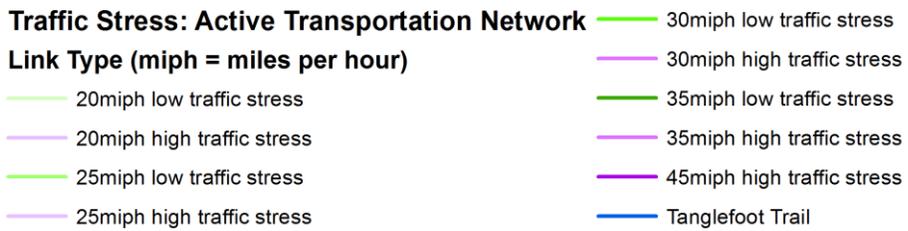
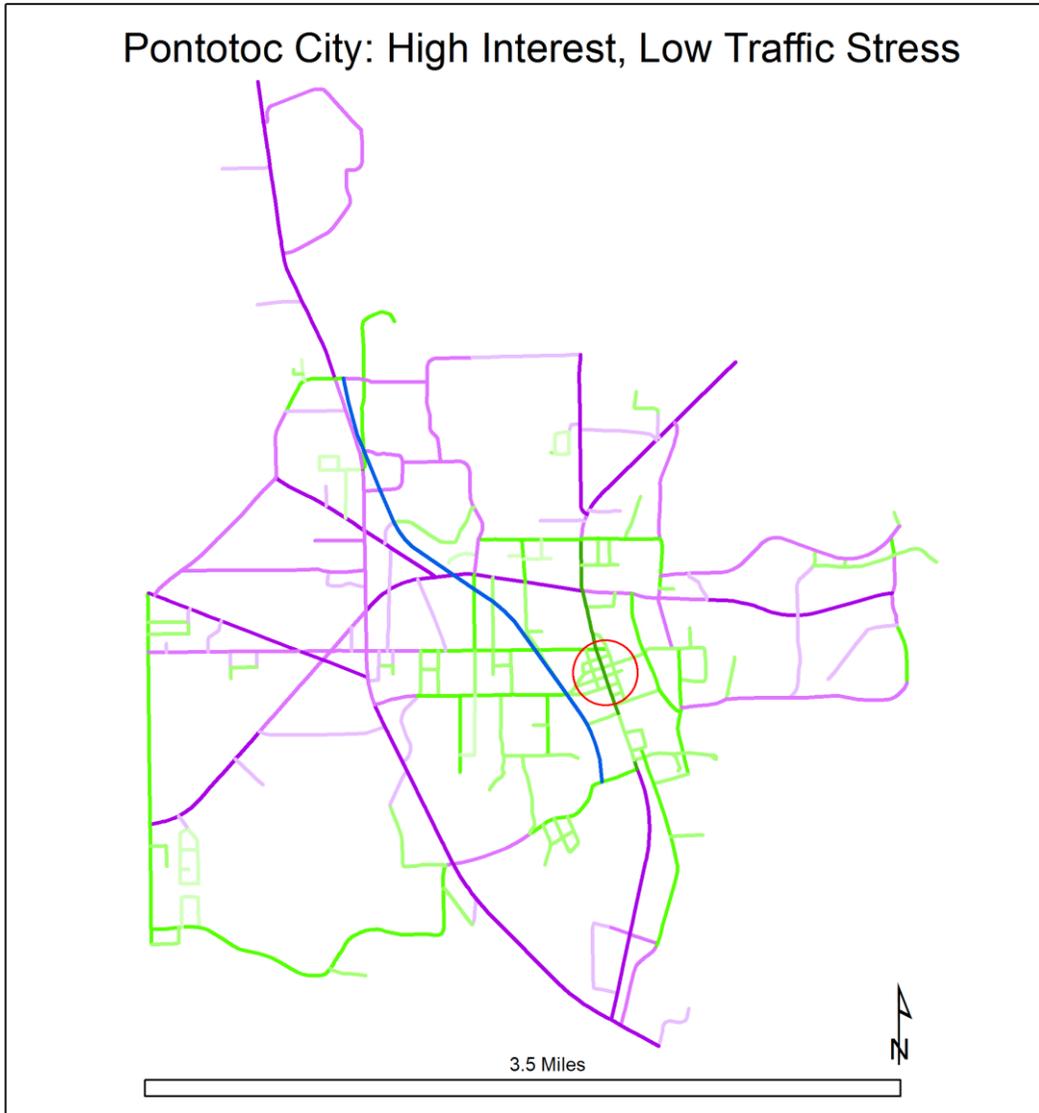


Figure 3-4. Pontotoc City: High Interest, Low Traffic Stress.

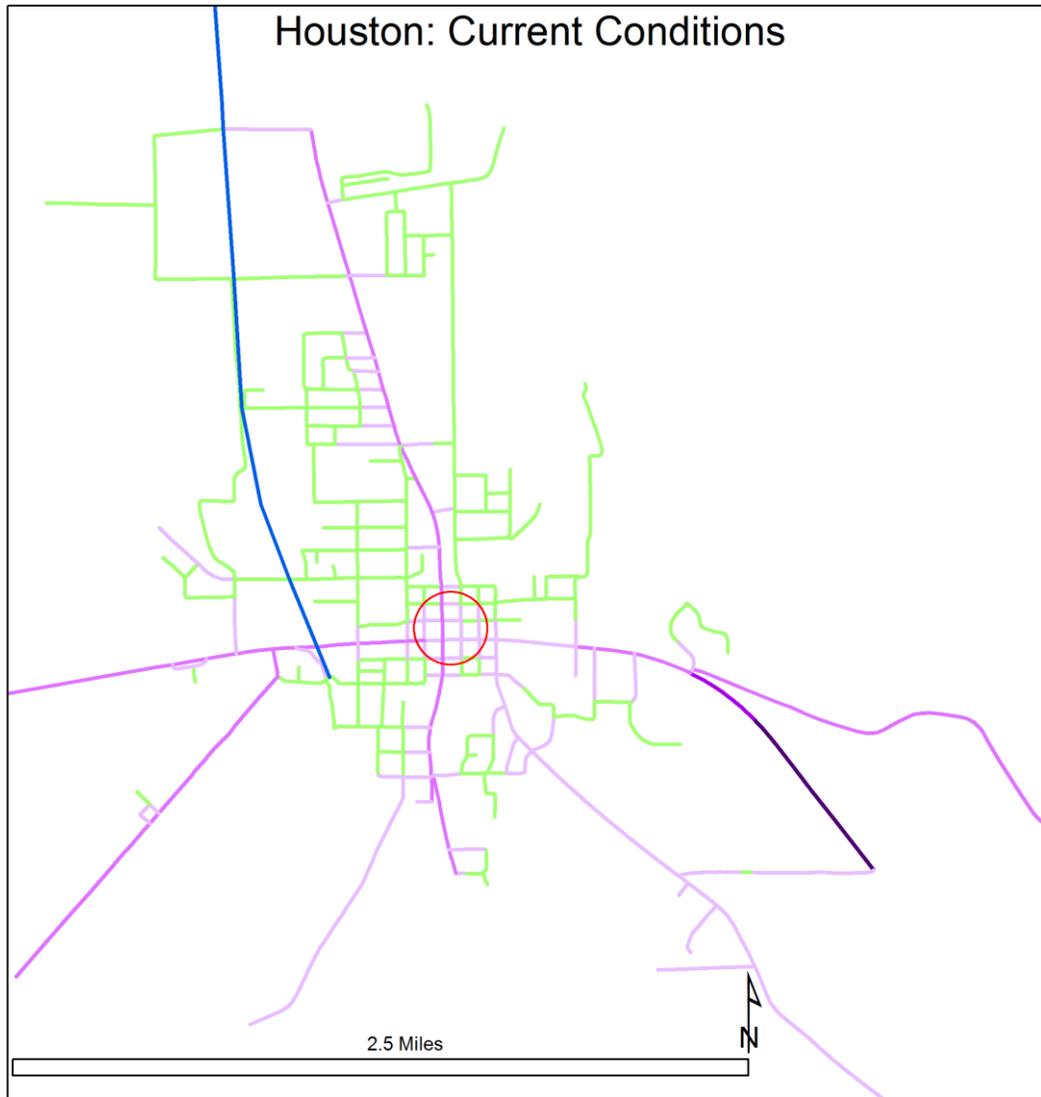


Figure 3-5. Houston: Current Conditions.

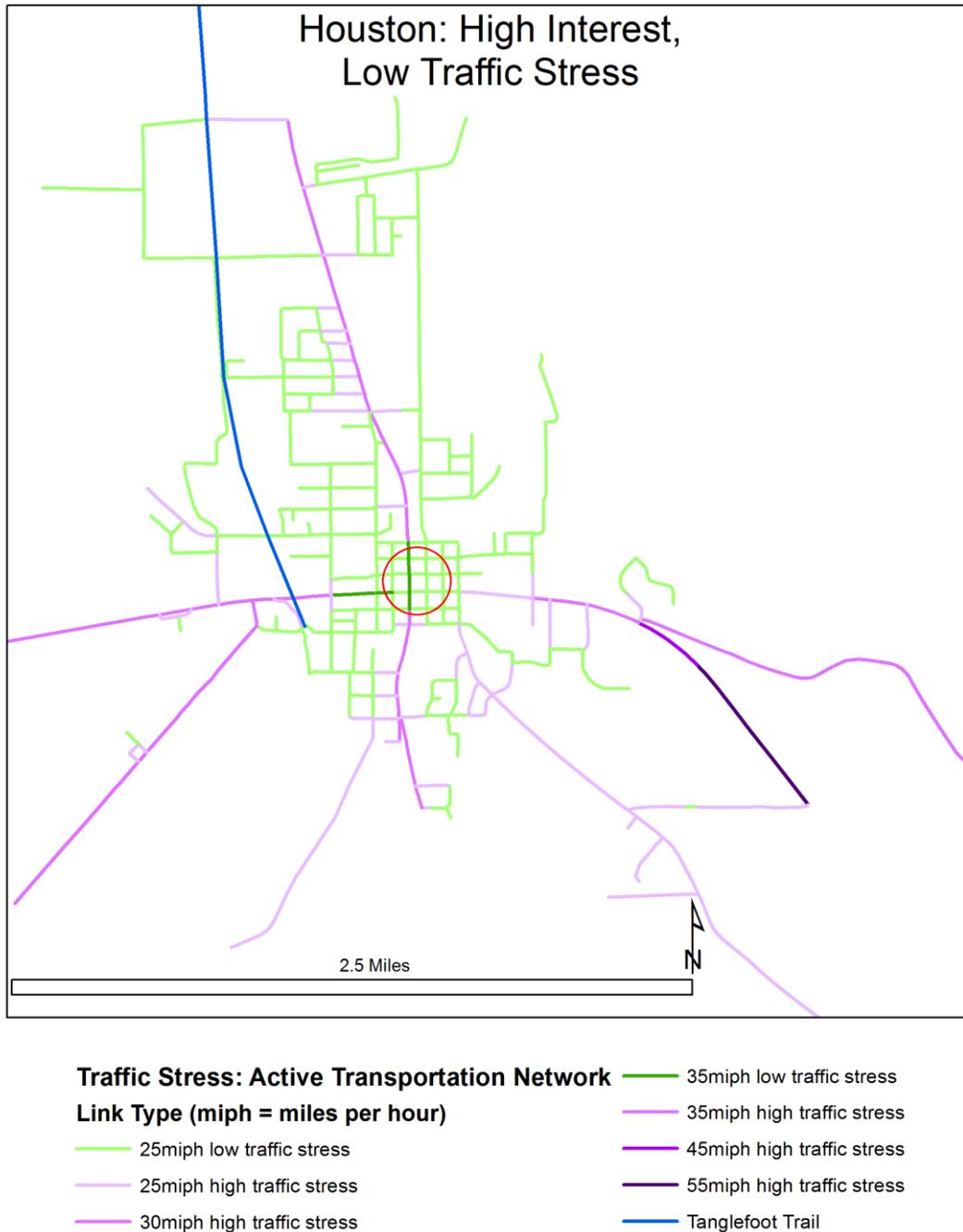


Figure 3-6. Houston: High Interest, Low Traffic Stress.

CHAPTER 4: MEASURING BICYCLE ACCESSIBILITY IN HOUSTON USING A BIKE&PLACE TRAVEL DEMAND MODEL

Houston’s travel demand model is an agent-based model with inelastic trip generation and one class of travelers: Interested but Concerned cyclists (and potential cyclists). They choose how they will travel from their homes to Courthouse Square, the heart-and-soul destination, and to other destinations.

Cyclists choose travel mode, either auto or bicycle, and route. They have a general preference for travel via bicycle, but travel mode choice is also influenced by travel time and by traffic stress.

Their sensitivity to traffic stress is keen, reflecting an observation made by Mekuria, Furth, and Nixon in an investigation of bicycle-based accessibility in San José, California. “[The] ‘weakest link’ principle governs when aggregating over links that form a possible route. That is, the stress of a route is determined by its most stressful link, and not by the sum or average of the stress on its constituent links. If people will not use links whose stress exceeds their tolerance, several low-stress links cannot compensate for one high-stress link” (8, p. 7).

Because the modeling platform does not include a module that automatically calibrates the behavioral parameters, a trial-and-error process is required, making calibration the most difficult part of building a model. The process used to calibrate Houston’s parameters is recounted in great detail and step-by-step in the next section, to ensure transparency about this project, and, hopefully, to reduce the time that other Bike&Place users would need to calibrate their own models.

Houston is an especially convenient test case for developing a travel demand model because of small numbers of populated census blocks and roadway links. The model executes in less than two seconds. Consequently, one may anticipate without dread a calibration process involving many experiments.

CALIBRATING THE BEHAVIORAL TRAVEL DEMAND PARAMETERS

The overall goal of calibration is to represent the latent demand for bicycle travel, using the fewest behavioral parameters. These behavioral parameters are used:¹⁰

- Value of Travel Time: set to one (vv in equation (1) in Chapter 1)
- Modal Constant (pg_o in equation (1) in Chapter 1)
 - Auto
 - Bicycle
- Path ASC
 - Auto
 - Bicycle
- Penalty (pt_m in equation (1) in Chapter 1)
 - Auto
 - Bicycle

Value of Travel Time is set to one because the travel demand model includes only one class of travelers and one trip purpose, i.e., local trips from home. Thus the model includes none of the heterogeneity with respect to traveler or trip purpose which would otherwise justify multiple values for Value of Travel Time.

Path ASC is an “additive penalty to the operator [travel mode]” which is “additional to the modal constant [pg_o]” (9, p. 46). The parameter is not otherwise documented, but it has substantial influence over travel mode choice.

A Penalty (pt_m) must be determined for each combination of link type and of travel mode (operator). Penalties are set to one for these link types, for both auto and bicycle: centroid connector, low traffic stress, and Tanglefoot Trail. For the high traffic stress link types, penalties are set to one for auto, and they are determined by trial-and-error for bicycle.

Calibration is a two-stage process. The first stage works with a counterfactual transportation network in which almost all roadway links realistically accommodating bicycles induce low traffic stress; the exceptions are the high speed links, which have a posted speed of at least 45 miles per hour. Calibration is accomplished when the travel demand model generates a reasonable maximum number of bicycle trips. Houston is a small, compact town: the greatest network distance between populated census blocks (centroids) is less than six miles.

Consequently, given a bicycle-friendly transportation network, all or almost all trips could be made via bicycle, and a reasonable maximum bicycle mode share would be nearly 100%.

The results of the first stage are passed on to the second stage, which uses the current-conditions transportation network. High traffic stress currently is characteristic of many roadway links. The calibration process is informed by the weakest link principle and hence the goal of the second stage is to minimize bicycle trips on the high traffic stress links, in particular those links in the vicinity of Courthouse Square, which thus functions as an indicator zone providing guidance. Calibration is accomplished when the vast majority of trips are made via auto, including the short

¹⁰ Several additional technical parameters are set to the value one, the default value (7, pp. 37-42): Path Overlapping Factor; Maximum Number of Paths; Path Choice Elasticity; and Path Choice Logit Scaling.

trips made to Courthouse Square which would expose cyclists to high traffic stress on two or more links.

Both calibration exercises use the same trip table. The origins and destinations are the populated census blocks and Courthouse Square. The table contains only interzonal trips (made via either auto or bicycle), of which there are 18,632.

The following narratives of the calibration process recount the setup and results of every experiment. The behavioral parameters of interest were changed in small increments. Extreme values helped reveal plausible ranges of the parameters. Values well within the interior of a range were varied in especially small increments in an attempt to precisely identify satisfactory, if not optimal, values. The color-highlighted experiments yielded the parameters' final values.

Stage One (Counterfactual Low Traffic Stress Network), Step-by-Step Summary

1. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 18632
 - ii. Bike boardings 0
2. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 10
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
3. Experiment

- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 9
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
4. Experiment
- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 8
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
5. Experiment
- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 7
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
6. Experiment
- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1

- c. Path ASC (by operator)
 - i. Auto 6
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
7. Experiment
- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 5
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
8. Experiment
- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 4
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
9. Experiment
- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 3
 - ii. Bike 0
 - d. Penalties (link type, by operator)

- i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
- 10. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 2
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
- 11. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 1
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
- 12. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.9
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0

- ii. Bike boardings 18632
- 13. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.8
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 0
 - ii. Bike boardings 18632
- 14. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 56
 - ii. Bike boardings 18576
- 15. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.2
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 1228
 - ii. Bike boardings 17404
- 16. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants

- i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.1
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 8406
 - ii. Bike boardings 10226
- 17. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.09
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 9582
 - ii. Bike boardings 9050
- 18. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.08
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 10792
 - ii. Bike boardings 7840
- 19. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.07

- ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 12028
 - ii. Bike boardings 6604
- 20. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.06
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 13290
 - ii. Bike boardings 5342
- 21. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.05
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 14636
 - ii. Bike boardings 3996
- 22. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.04
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1

- e. Results
 - i. Auto boardings 15826
 - ii. Bike boardings 2806
- 23. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.03
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 16920
 - ii. Bike boardings 1712
- 24. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.02
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 17840
 - ii. Bike boardings 792
- 25. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.01
 - ii. Bike 0
 - d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
 - e. Results
 - i. Auto boardings 18398
 - ii. Bike boardings 234
- 26. Experiment

- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
- b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
- c. Path ASC (by operator)
 - i. Auto 0.005
 - ii. Bike 0
- d. Penalties (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 1
- e. Results
 - i. Auto boardings 18558
 - ii. Bike boardings 74

Stage Two (Current Conditions Network), Step-by-Step Summary

Note that the final stage one values of the Modal Constants and Path ASC (see experiment 14 above) are used in experiment D below. The final values emerging from the second stage of the calibration process differ from the final stage one values.

A. Experiment

- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
- b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
- c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
- d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 2
- e. Results
 - i. Auto boardings 2634
 - ii. Bike boardings 15998

B. Experiment

- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
- b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
- c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
- d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1

- ii. Bike: all are 3
 - e. Results
 - i. Auto boardings 4716
 - ii. Bike boardings 13916
 - C. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 4
 - e. Results
 - i. Auto boardings 5784
 - ii. Bike boardings 12848
 - D. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 5
 - e. Results
 - i. Auto boardings 6614
 - ii. Bike boardings 12018
 - E. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 6
 - e. Results
 - i. Auto boardings 7286
 - ii. Bike boardings 11346

F. Experiment

- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
- b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
- c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
- d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 7
- e. Results
 - i. Auto boardings 7940
 - ii. Bike boardings 10692

G. Experiment

- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
- b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
- c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
- d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 8
- e. Results
 - i. Auto boardings 8486
 - ii. Bike boardings 10146

H. Experiment

- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
- b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
- c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
- d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 9
- e. Results
 - i. Auto boardings 9030
 - ii. Bike boardings 9602

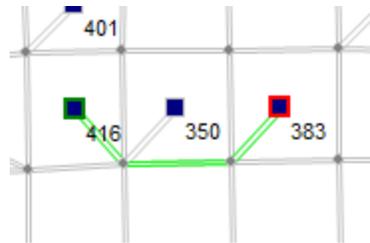
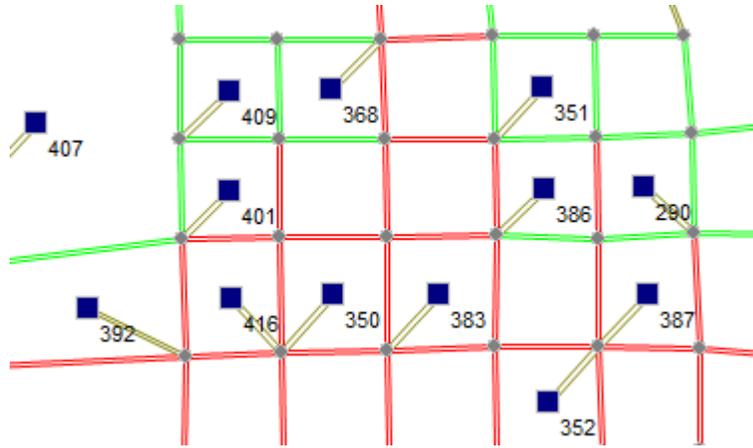
I. Experiment

- a. Trip matrix has interzonal trips from all internal zones to every other internal zone
- b. Modal Constants
 - i. Auto 1

- ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 15 (note discontinuous increase compared to experiment 8)
 - e. Results
 - i. Auto boardings 11044
 - ii. Bike boardings 7588
- J. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.3
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 20
 - e. Results
 - i. Auto boardings 12130
 - ii. Bike boardings 6502
- K. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.2
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 2
 - e. Results
 - i. Auto boardings 5874
 - ii. Bike boardings 12758
- L. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.2
 - ii. Bike 0

- d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 3
- e. Results
 - i. Auto boardings 7622
 - ii. Bike boardings 11010
- M. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.2
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 4
 - e. Results
 - i. Auto boardings 8754
 - ii. Bike boardings 9878
- N. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.2
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 5
 - e. Results
 - i. Auto boardings 9836
 - ii. Bike boardings 8796
- O. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.15
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 5
 - e. Results

- i. Auto boardings 12368
 - ii. Bike boardings 6264
- P. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 1
 - c. Path ASC (by operator)
 - i. Auto 0.1
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 5
 - e. Results
 - i. Auto boardings 15010
 - ii. Bike boardings 3622
- Q. Experiment
 - a. Trip matrix has interzonal trips from all internal zones to every other internal zone
 - b. Modal Constants
 - i. Auto 1
 - ii. Bike 2
 - c. Path ASC (by operator)
 - i. Auto 0.1
 - ii. Bike 0
 - d. Penalties for high stress link types (link type, by operator)
 - i. Auto: all are 1
 - ii. Bike: all are 5
 - e. Results
 - i. Auto boardings 17706
 - ii. Bike boardings 926
 - iii. The first figure below shows the "indicator" zone (Courthouse Square, # 383) and nearby internal zones and links (green = low stress and red = high stress in the current conditions). All of the other figures show preferred paths (green = bike and purple = car). The preferred paths entail travel by car except when the number of links, including centroid connectors, equals three, i.e., only one actual roadway link.





Final Results

The table below displays the behavioral parameters' final values. The experiments confirm the significance of both the parameters that apply to the travel mode per se and the parameters that represent sensitivity to link-level traffic stress. When used with the counterfactual low traffic stress network, the travel demand model using the final stage 2 parameters generates 15,946 auto trips and 2,686 bicycle trips; the travel demand model using the final stage 1 parameters generated 56 auto trips and 18,576 bicycle trips. Two sets of behavioral parameters—final stage 1 parameters and final stage 2 parameters—are required to represent latent demand for bicycle travel.

Table 4-1. Houston Travel Demand Model: Behavioral Parameters’ Final Values

Calibration Stage 1		Calibration Stage 2	
Low Traffic Stress Network		Current Conditions Network	
Parameter	Value	Parameter	Value
Value of Travel Time	1	Value of Travel Time	1
Modal Constant: Auto	1	Modal Constant: Auto	1
Modal Constant: Bicycle	1	Modal Constant: Bicycle	2
Path ASC: Auto	0.3	Path ASC: Auto	0.1
Path ASC: Bicycle	0	Path ASC: Bicycle	0
Penalty: Centroid Connectors, Low Traffic Stress Roadway, & Tanglefoot Trail, Auto	1	Penalty: Centroid Connectors, Low Traffic Stress Roadway, & Tanglefoot Trail, Auto	1
Penalty: Centroid Connectors, Low Traffic Stress Roadway, & Tanglefoot Trail, Bicycle	1	Penalty: Centroid Connectors, Low Traffic Stress Roadway, & Tanglefoot Trail, Bicycle	1
Penalty: High Traffic Stress Roadway, Auto	1	Penalty: High Traffic Stress Roadway, Auto	1
Penalty: High Traffic Stress Roadway, Bicycle	NA	Penalty: High Traffic Stress Roadway, Bicycle	5

ASSESSMENT OF A HYPOTHETICAL HIGH INTEREST, LOW TRAFFIC STRESS NETWORK

The two perspective renderings below illustrate the current-conditions network and a hypothetical active transportation network: the “high interest, low traffic stress” network. The Tanglefoot Trail appears in the foreground and is rendered as a blue line. The vertical dimension helps convey the barrier effect of high traffic stress, which is prevalent near the heart-and-soul

destination, Courthouse Square (located in the historic business district indicated by streets forming a regular grid).

Compared to current conditions, the high interest, low traffic stress network features many fewer high traffic stress links—especially near the heart-and-soul destination, Courthouse Square. High traffic stress links do remain on Houston’s periphery.

The populated census blocks generate 136 trips ending at Courthouse Square. With the current conditions network, and the travel demand parameters that have been optimized for that network (stage two parameters), only two of those trips are made via bicycle. Therefore less than 2% of the populated census blocks have bicycle access to Courthouse Square.

With the high interest, low traffic stress network, and the travel demand parameters that have been optimized for the low traffic stress network (stage one parameters), 113 of the 136 trips to Courthouse Square are made via bicycle. Bicycle access to Courthouse Square increases to 83% of the populated census blocks.

The latter results may be too optimistic. When the high interest, low traffic stress network is assessed with a travel demand model using the “current conditions” parameters (stage two parameters), 36 Courthouse Square trips are made via bicycle: less than 27% of the total.

The more modest increase in bicycle accessibility perhaps reflects the immediate effects of enhancing the transportation infrastructure to reduce traffic stress. The greater increase in bicycle accessibility might be best interpreted as the long term effects, suggesting the increase in bicycle mode share that could occur as preferences evolve in parallel with the transportation infrastructure.

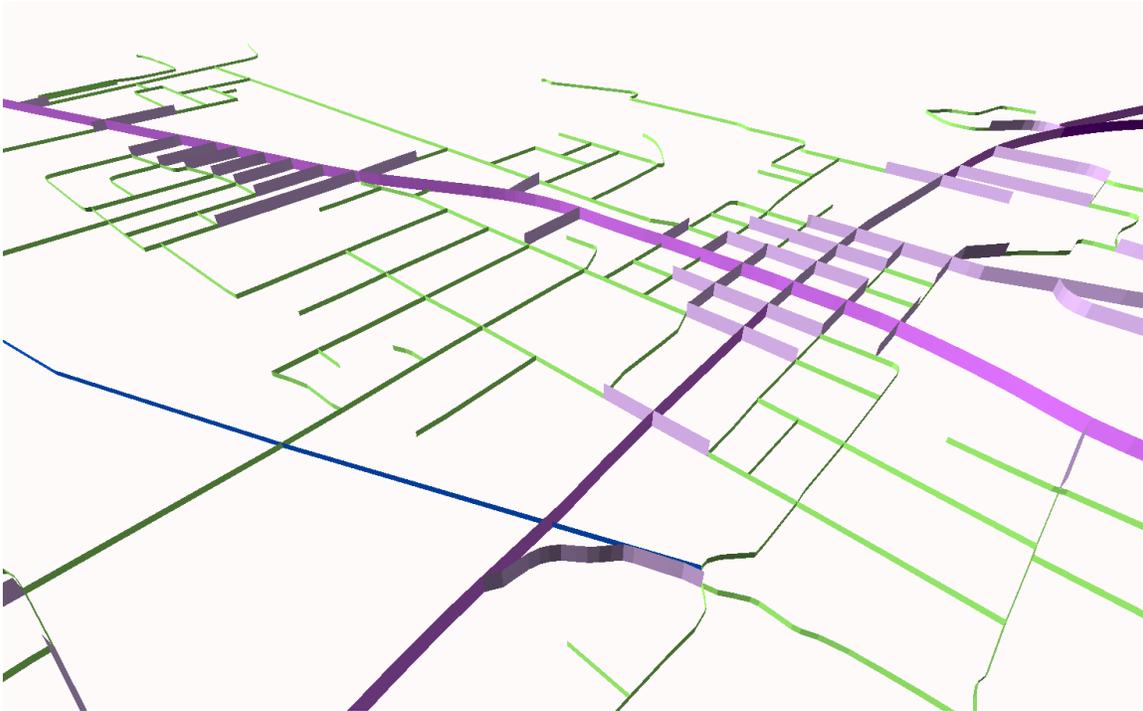


Figure 4-7. Houston's Current Conditions: Extensive High Traffic Stress (3D Rendering)

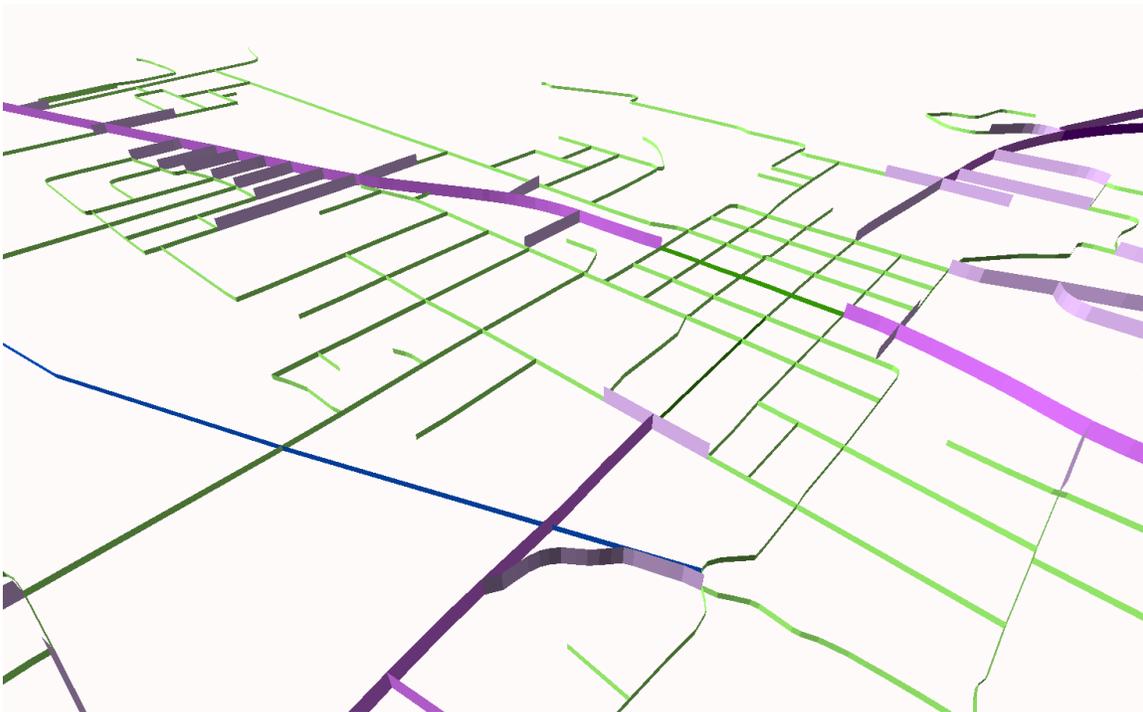


Figure 4-8. Proposed Active Transportation Network for Houston: High Interest, Low Traffic Stress (3D Rendering)

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