CREATION OF A 2012 MULTI-PURPOSE MASTER NETWORK FOR THE PASO DEL NORTE REGION: CIUDAD JUAREZ (MEXICO), EL PASO (TEXAS), AND LAS CRUCES (NEW MEXICO)

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EXECUTIVE SUMMARY

The use of software to develop network based models within the research area of transportation is becoming more and more of a standard practice. In order to be a reliable tool, such programs are in a continuous update but still problems and difficulties arise. Speaking specifically for this project, the model developed for the Paso Del Norte Region, which comprises the border cities of El Paso (Texas), Las Cruces (New Mexico), and Ciudad Juárez (Mexico), does not properly address all the parameters involved. Some of the problems faced by the transportation researchers with the existing model include but are not limited to missing links, incorrect attributes, incorrect names, and lack of a projection/coordinate system just to name a few. Such setbacks lead to a significant amount of time and effort spent by the Center for International Intelligent Transportation Research (CIITR) researchers to update and make the necessary corrections, delaying the already scheduled work. This project developed a 2012 Paso Del Norte regional master network that would efficiently integrate all three cities free of attribute problems and at the same time to be compatible when importing and exporting data with several transportation platforms.

This research was achieved by conducting a systematic process consisting of the following two phases:

- First Phase: Usage of Geographic Information System (GIS) software to aid in the refinement of the transportation networks for Ciudad Juárez and Las Cruces. The CIITR researchers performed a thorough inspection of the parameters for the above networks relying on their personal knowledge of the two cities and the use of Google® Maps street view to determine if they were correct.
- Second Phase: Performing a similar process as in the first phase in order to improve the El Paso network and integrate it with the other two into a reliable master network for subsequent interconnections with all platforms (transportation software) utilized by CIITR researchers. Additionally, in this phase a review of all the Transportation Analysis Zones (TAZs) geometry and attributes from the three regions were reviewed and had them at hand for creation of a regional Origin-Destination Matrix.

Difficulties faced when developing the regional master network included the standardization of attributes in a region covering cultural, social, political, and even language differences (which included a total of 560,000 checked attributes), the final revision process, and collecting all the necessary information consisting of:

- El Paso: 6,101 links, and 681 TAZs.
- Las Cruces: 2,968 links and 380 TAZs
- Ciudad Juárez: 6,422 links and around 850 Areas Geoestadística Básica (AGEBs), which are the equivalent of TAZs in the United States.

The final findings for the second phase resulted in the creation of a regional master network that has no interconnection attribute problems and that can be used by various entities within the Paso Del Norte Region such as transportation planning authorities, GIS departments, and others interested in urban road network analysis concerning the characteristics of the region. In

addition, the beneficiaries of this project can import the network obtained into transportation software such as Paramics, TransCAD, Transmodeler, VISSIM, VISUM, Synchro, Dynus-T, and TRANUS.

CHAPTER 1: INTRODUCTION

Recent research projects for CIITR have involved the use of network based transportation software. All of these platforms have employed the use of the same existing Paso del Norte regional base network and have required a significant amount of time and effort from researchers to update and make corrections to this network. Specifically, CIITR has imported this network into Paramics, TransCAD, Transmodeler, VISSIM, VISUM, Synchro, Dynus-T, and TRANUS; this process is also repeated for different levels of analysis (macro, micro, and mesoscopic). This practice produces a duplication of efforts by updating the same network several times. El Paso and Las Cruces Metropolitan Planning Organizations (MPOs) as well as Instituto Municipal de Investigación y Planeación (IMIP) in Ciudad Juárez have individual travel demand models (TDMs) that terminate at their jurisdiction limits. In addition, the Las Cruces model is in a different model format (VISUM) than the El Paso model.

There are various problems related to network based modeling at CIITR. Problems in the existing base network include missing links, incorrect attributes, incorrect names, lack of projection/coordinate system, etc. Local coordinates in some of the transportation software has made those platforms limited in their import and export functionalities, especially if a modeler needs a global coordinate system or georeferenced points and lines on maps. Often, aerial photographs and satellite images cannot be fully integrated in the background of the transportation network due to missing geographical projection information or a global coordinate system as a main attribute.

1.1 BACKGROUND

CIITR has been using different transportation networks in the Paso Del Norte region since 2006. Usually regional researchers and transportation experts use an official version for individual road networks in the region for their transportation analysis. However, though in reality the transportation in these regions is highly integrated, the El Paso and Las Cruces MPOs as well as IMIP in Ciudad Juárez have individual TDMs that terminate at their jurisdiction limits, which adds more difficulty to the process (due to the existing geographical connectivity, but the isolated and unrealistic regional network configuration). In addition, the Las Cruces model is in a different model format than the El Paso and Ciudad Juárez models. Additionally, all current individual transportation networks in this region (El Paso, Las Cruces, and Ciudad Juárez) have issues with key attributes in their networks such as missing links, incorrect attributes, incorrect names, lack of projection/coordinate system, etc. These issues force transportation experts (including researchers at CIITR) to invest a significant amount of effort updating and making corrections. Specifically, CIITR utilizes at least six different transportation softwares for network analysis, including but not limited to TDMs, corridor synchronization, transit demand models, dynamic and static assignments, and driver behavior. Researchers must also take into account that this process is repeated for different levels of analysis (macro, micro, and mesoscopic). This practice produces a duplication of efforts by updating the same network several times. Figure 1, Figure 2, and Figure 3 show the representation of each one of the individual networks and their corresponding structure and configuration including links and TAZs.

TAZs are also a key element in transportation analysis and specifically for transportation planning. TAZs are constructed by census block information and they provide socioeconomic data that are imperative in the majority of transportation modeling analyses. For a typical TAZ, the common attributes are population, number of households, household size, area type (in terms of land use), average income, the number of automobiles per household, employment by sector, among others (see Appendix). With the socioeconomic data from TAZs and the use of statistical models, modelers can have a better understanding of where trips are produced and attracted among different zones. Again, these zones can be changed or altered as mentioned earlier. All three individual networks have their corresponding TAZs that are commonly populated by the local MPOs or any other official agency that collected reliable local socioeconomic data.

The El Paso road network (Figure 1) contains 6,101 links and 681 TAZs. Notice how the external TAZs are represented with small triangles. Some of these triangles will be eventually substituted by neighbor TAZs that correspond to the adjacent cities once the whole regional network is integrated. Originally, both road networks in the region had different coordinate systems or georeferenced points and lines on maps. In the case of Ciudad Juárez, the coordinate system was not defined and there was a missing geographical projection as well, making it difficult for users to display satellite images or aerial photographs in the background.

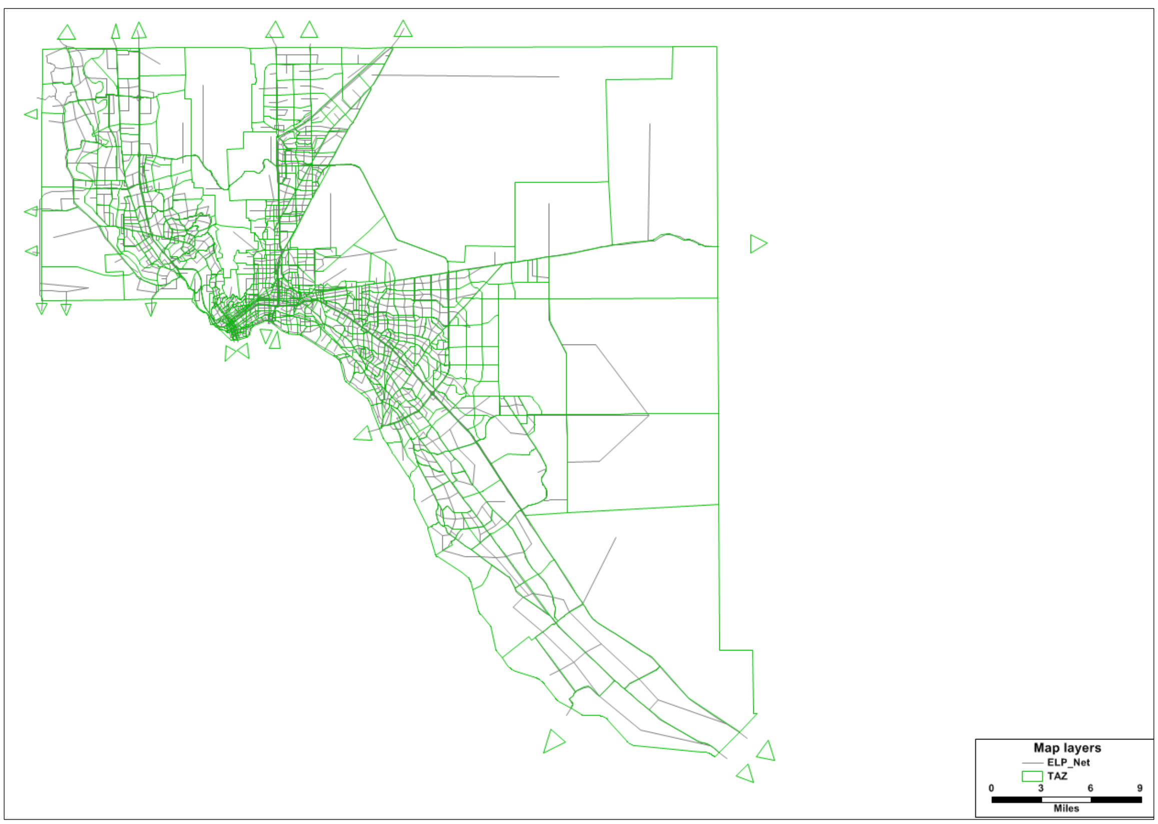

Figure 1. El Paso Official Road Network and Transportation Analysis Zones.

Las Cruces network (Figure 2) contains 2,968 links and 380 TAZs. This road network was originally distributed by the local MPO in a non-GIS format. There were additional extra steps made for this network to be displayed into the GIS software. The importing and exporting processes, however, did not represent a difficulty for the CIITR researchers since several researchers were familiar with the original software used by the Las Cruces MPO.

Figure 2. Las Cruces Road Network (Non-GIS Platform).

In the Mexican side, the Ciudad Juárez road network (Figure 3) has 6,422 links and around 850 AGEBs, which are the equivalent of TAZs in the United States. Despite the similarity of AGEBs and TAZs, the official socioeconomic data that both contain may vary. CIITR researchers worked with Mexican authorities[1] to estimate the equivalent parameters (attributes) commonly used in the United States.

[1] Instituto Nacional de Estadística y Geografía http://www.inegi.org.mx/

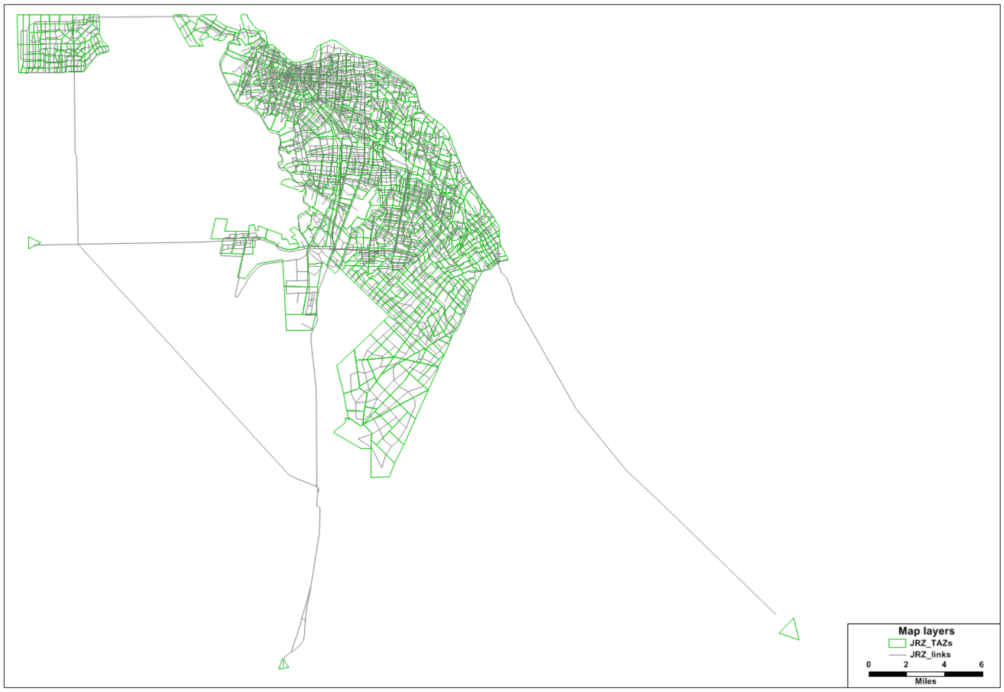

Figure 3. Ciudad Juárez Road Network and Transportation Analysis Zones.

1.2 OBJECTIVE

This project developed a 2012 Paso Del Norte regional master network that integrates all three regions, that is free of attribute problems, and can be used with several transportation platforms. The first phase of the project refined the Ciudad Juárez and Las Cruces transportation networks based on GIS software. A second phase covers the El Paso network and the integration of these three networks into a reliable master network for subsequent interconnection with all platforms (transportation software) utilized by CIITR. The main beneficiaries of this project include El Paso del Norte Region authorities, regional and local transportation planning authorities, regional GIS departments and research centers, and any other party that is interested in urban road network analysis concerning this three-state, binational, and bi-cultural region.

1.3 REPORT OUTLINE

The work plan consisted of five major tasks concluding in the following chapters:

- **Chapter 1. Introduction.** In addition to stating the background and objective of this project, this chapter describes the structure of the report and the study area.
- **Chapter 2. Data Collection.** This chapter details the process of obtaining data for each of the three road networks. In El Paso and Las Cruces, the contact entity where the El Paso and Las Cruces MPOs of each city and in Ciudad Juárez IMIP. Besides the MPOs, several webpages were identified as potential data sources to follow a data selection process.
- **Chapter 3. Data Organization and Management Plan.** This chapter provides a description of the steps taken to store and analyze the raw data and to extract data to be

transformed into GIS data, as well as defining a projection and coordinate system adequate for use in the Paso Del Norte Region.
Chapter 4. Development of the Master Network (First Phase). This chapter presents the work done in the first phase of the creation of the master network from the data revision and action plan that divided the network into three sections for the revision process, integration of the networks, and standardizing network attributes, to the importing of the final network into TransCAD for verification of any missing data to assure no connectivity errors.

- **Chapter 5. Final Remarks.** This chapter presents a summary the challenges faced, findings, and the recommended steps for continuing onto a third stage of this research project.

1.4 AREA OF STUDY

In addition to all the previously described issues, there is a key factor that affects this compatibility among road networks. For instance, factors such as standard geospatial reference where individual transportation networks in the region have different origin sources that are commonly coming from their corresponding MPOs planners. In the case of the El Paso Del Norte Region (Figure 4), there are two main different entities involved in the United States (the cities of El Paso and Las Cruces) and one more entity in Mexico (Ciudad Juárez).

According to the geographical description by The Paso Del Norte Group (*1*), this region is located at the virtual midpoint of the 1,500 mile border shared by the United States and Mexico. The bi-national metropolitan area is located 1,700 miles southwest of Washington, D.C., and 970 miles northwest of Mexico City. Almost 100 million US residents (33 percent of the US population) and 91 million Mexican residents (79.3 percent of Mexico's population) live within a 1,000 mile radius (1,600 km).

Figure 4. Paso Del Norte Region Geographical Proximity to Urban Centers.

The two most important cities in this region are El Paso which is currently the 19th largest city in the United States by population[2] (Ranking 68th among the most populated metropolitan areas in the United States), and Ciudad Juárez, which is the fifth most populated city in Mexico[3] with an estimated population of 1.7 million people. Since 1990, the bi-national three-state region has grown by more than 52 percent.

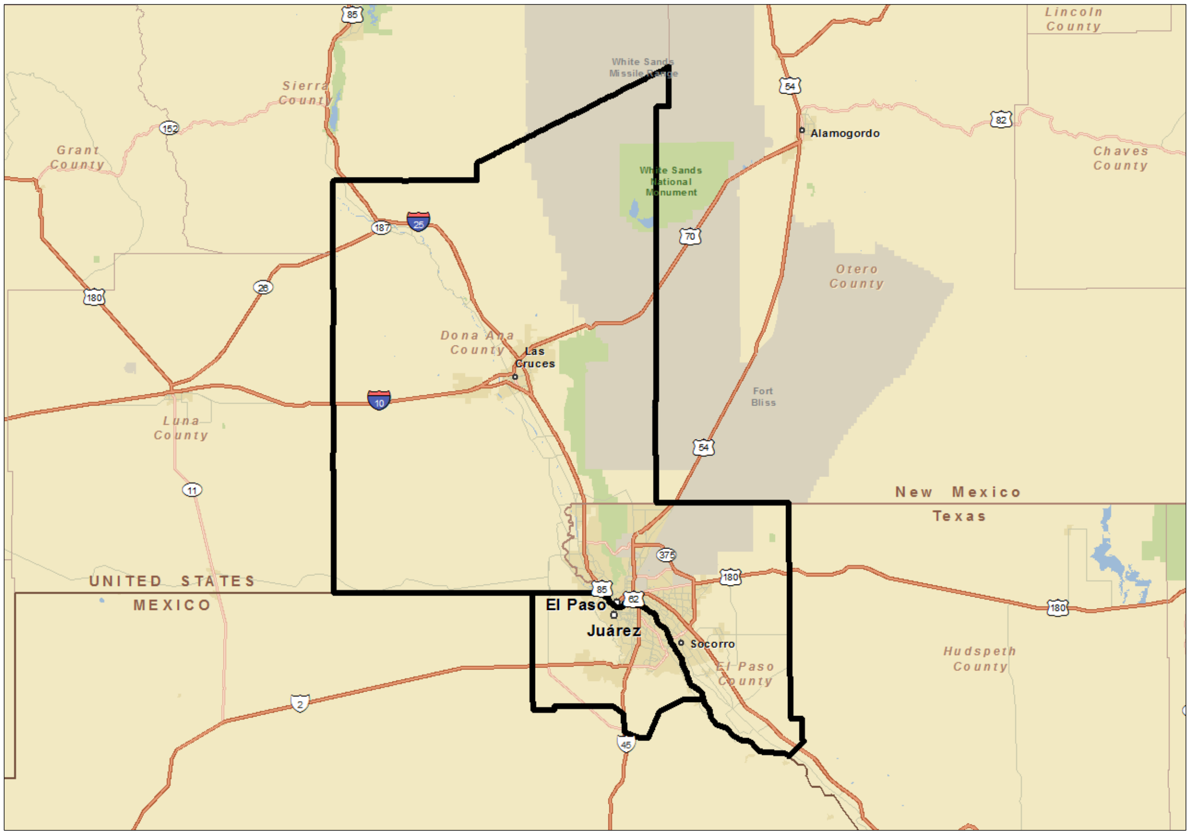

Figure 5. Area of Study.

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[2] U.S. Census Bureau http://www.census.gov
[3] Instituto Nacional de Estadística y Geografía http://www.inegi.org.mx/

CHAPTER 2: DATA COLLECTION

2.1 DATA REQUEST

For data collection purposes, researchers from CIITR met with representatives at the MPOs in El Paso and Las Cruces as well as IMIP to formally request the information on each of the road networks. Researchers asked detailed questions of travel demand modelers at the Las Cruces and El Paso MPOs; however IMIP in Ciudad Juárez could not provide any specific information regarding their road network. Once the network data were obtained, the CIITR modelers verified and validated the format of all the files provided and proceeded to standardize the entire dataset into the GIS software.

CIITR researchers met with the travel demand modelers at the Las Cruces MPO and had contact with the IMIP modelers via telephone and e-mail. In the case of the Las Cruces area TDM, all of the data for their current VISUM TDM was obtained. The Las Cruces modelers reviewed the general information about the data and offered their assistance should there be any future questions. All data for the Las Cruces area were available exclusively in VISUM format and no GIS files were shared by the local MPO modelers. On the other hand, Ciudad Juárez and El Paso data formats were obtained in TransCAD software format, which is GIS compatible.

2.2 DATA AVAILABILITY

Several webpages were identified as potential data sources for this project. The following sections describe those resources and their corresponding data format.

2.2.1 Instituto Municipal de Investigación y Planeación

IMIP is the research and planning institute for the municipal government of Ciudad Juárez. Some of its objectives include the establishing continuity in the planning processes, aiding the local authorities in the urban development processes, and providing efficient planning and programming processes. The institute also is in charge of creating, updating, and managing the municipal statistical database, geographical data, and elaborate urban and regional studies. Looking at the institute’s website, there is a section labeled “Geostatistics and Computing,” which contains the following subsections: General Information, SIGMUN, Satellite Monitoring, Urban Observatory, Statistics, Juárez Interactive Map, and 2007 Projects. In the General Information subsection, there is a brief description of the scope of the section. SIGMUN (Sistema de Información Geográfica Municipal) is a municipal geographic information system used to manage data through intelligent maps and systemization of statistical and cartographic information, to obtain precise data to back up decision making, and to consult with governmental entities and the general public. The Satellite Monitoring subsection gives free access to GPS data to users who have GPS receptors. There is a link that sends the user to another page but it is not functioning properly. The Urban Observatory subsection shows the urban indicators system that is used to constantly monitor the main behavioral data of the city. This subsection also has a link that sends the user to another page, which is also not working properly. The Statistics subsection describes the database used to obtain indicators needed for planning. The Juárez Interactive Map subsection has a link that opens a very basic map of the city showing the main characteristics such as the main streets and avenues, main attractions, hospitals, schools, city hall, and types of land use. The map is oriented for visual purposes and does not include any GIS file that can be modified (*2*).

2.2.2 Instituto Mexicano del Transporte

The Instituto Mexicano del Transporte (IMT) (Mexican Transport Institute) is a decentralized entity of the Secretaria de Comunicaciones y Transportes (Secretariat of Communications and Transportation [SCT]) created in 1987 for research, technological development, specialized services, and technical assistance and assessment. The IMT developed a GIS tool that shows precise and up-to-date information regarding the characteristics and condition of the country's infrastructure and road network generated by other sources related to the transportation sector. The name of the tool is "Sistema de Informacion Geoestadistica para el Transporte (SIGET)," which is a geostatistics transportation information system. This tool is being used by different entities such as national institutions, state governments, and the SCT. The SIGET tool gives access to several transportation related databases that can be consulted, analyzed, and represented on GIS maps. IMT's website gives an introduction and description of the tool but no access or link to SIGET was found. Also no shapefiles or other types of GIS files were found in order to know more about the attributes contained in the tool (*3*) (*4*).

2.2.3 Paso Del Norte Mapa

The Paso del Norte Mapa is a compendium of several agencies that work together to create an efficient GIS covering the region of southern New Mexico, far west Texas, and northern Chihuahua. The website contains printable maps showing different census data, centerlines, economic development zones, foreign trade zones, zip codes, public facilities, and the representative districts. The website also contains several datasets from El Paso City and County, Doña Ana County, and Ciudad Juárez. The El Paso City and County dataset includes downloadable layers such as bike routes, census data, parcels, city limits, transportation analysis zones, land use, major arterials, proposed streets, planning areas, ports of entry, proposed transit projects, traffic counts, subdivisions, and proposed roadway projects. The Doña Ana County dataset includes layers for streets, boundaries, colonias, precincts, railroads, flood zones, school districts, and zoning. The Ciudad Juárez dataset includes layers for census data, city blocks, flood zones, government agencies, landfills, parcels, water sheds, and streets. All layers can be downloaded at no cost. Most of the layers have been updated within the last two years making the data more reliable. The website also includes an interactive map were the layers can be visualized (*5*).

2.2.4 El Paso Metropolitan Planning Organization

El Paso MPO's website includes a section for GIS files. These files correspond to the counties of El Paso in Texas, and Doña Ana and Otero in New Mexico. For Otero County, the files included are census data and streets. For Doña Ana County, the files included are census data, bus routes, boundaries, mile markers, and major arterials. The El Paso County section contains files for census data, bus routes, congressional districts, general land use, hazardous cargo routes, MPO districts and study area, parcels, ports of entry, railroads, and streets (*6*).

2.2.5 Research and Innovative Technology Administration

The Research and Innovative Technology Administration under the United States Department of Transportation is in charge of the Office of Geographic Information Services. This office generates transportation spatial data and analysis nationwide related to the country's economic activity and environment. The four main activities described in the website are: National Transportation Atlas Database, American Recovery and Reinvestment Act, Federal Geographic Data Committee, and Transborder Freight Data Mapping Application. No GIS layers were found on the website that could be downloaded (*7*).

2.2.6 Mesilla Valley Metropolitan Planning Organization

The Las Cruces MPO web page has changed the name to the Mesilla Valley MPO. It was dedicated to serve the City of Las Cruces, Doña Ana County, and the Town of Mesilla starting July 1, 2013. The Mesilla Valley MPO is a multi-jurisdictional agency responsible for the transportation planning in Las Cruces, Mesilla, and Doña Ana County that has been in existence since 1982. The MPO is required to coordinate and continue a comprehensive transportation planning process for urbanized areas with populations greater than 50,000. The MPO is also responsible for all the planning of the transportation systems, roads, bicycle and pedestrian facilities, public transit, and airport. Taking a look at the MPO's website, there is section labeled "Documents," with the following subheadings: TRANSPORT 2040–2010 Metropolitan Transportation Plan, 2014–2019 Transportation Improvement Program, Unified Planning Work Program, Public Participation Plan, Annual List of Obligated Projects, MPO Bylaws, NMDOT Documents, Coordinated Mobility Action Plan for Human Services in Doña Ana County, New Mexico, and Mesilla Valley MPO Access Management Guidelines. Each sub heading contains PDF files about the specific goals to be achieved by the MPO under the different sections within the MPO. In the section labeled "Maps" the following headings are available: Transportation Vision, Goals, and Principles, Functional Classification and Thoroughfare Plan, Transportation Projects Priorities Plan, Bicycle Facilities Priorities Plan, Trail System Priorities Plan, Public Transportation Priorities Plan, Mobility Zones. Each heading contains PDF files with maps for transportation guides for development, transportation users, bicycle, trial, and public transit priority plans, as well as traffic flow maps from the years 1995 to 2011. There are also "Programs," "Resources," and "Related Links," which contain links to useful information related to the MPO with no GIS content related. As in the Documents section and Maps section the entire site has no relevant geographical data, but there are PDF maps and action plans for the area covering the Mesilla Valley MPO (*8*).

2.2.7 Doña Ana County: GIS Division

The Doña Ana County GIS Division website mentions that it maintains over 100 layers of information. The downside to this site is that it states that the division's digital data, which include street centerlines and names, ETZ zoning, County zoning, corporate boundaries, and County maps, are available to the public for a fee at the County Assessor's office (*9*).

2.2.8 Doña Ana County: Parcel Map

This site is an interactive Doña County, New Mexico, Parcel Map and Andy Segovia appears as the County Assessor. The website starts with a warning message stating that the following product is for informational purposes only and not suitable for legal, engineering, or surveying purposes, that reproduction of this map is prohibited without permission from Doña Ana County, and at the end it has an option to either accept and continue or decline and not use the service. The interactive map has plenty of features to obtain quick information with easy access and great control for inexperienced users. The features include "Map layers Tab" with access to Roads, Buildings, City Limits, MLS Zones, Address Labels and 2007 Aerial Photo. The Legend Tab contains Citylimist2, Roads, and MLS_Zones. The following buttons are also available: Zoom in or out, Zoom to extents, Pan, Identify, Measure distance in miles, Measure area in acres and square feet, Clear graphics, Print page, Help, Select search type, and Enter value field. The help button opens a new site with an instructional guide on how to use the interactive map. The only drawback to using this site is that the interactive map only works as a quick informational reference, the information is not accurate for other purposes, and it is prohibited for reproduction without permission, as well as not being downloadable for use in another GIS program (*10*).

2.2.9 Doña Ana County: Zoning Map

This site is an interactive Doña County, New Mexico, Map and is labeled as a general reference map. As you enter the website you also get the same warning message as in the Doña Ana County: Parcel Map website. The interactive map has plenty of features that let you obtain quick information with easy access and great control for inexperience users. The features include: zoom control, pan control, selection a parcel, identifying a map them feature, features on map page, map them buttons, map theme/legend tabs, 2007 aerial photo and address label buttons, parcel search, measure distance, measure area, clear graphics, print page and a map help button which pops up an informational PDF file on how to use the interactive map. This reference map works the same way as the parcels map, but with greater information available. As well as the parcel map the reference map is not downloadable nor it includes databases that one can use on another GIS program and the information is not accurate for other purposes, and it is prohibited for reproduction without permission (*11*).

2.2.10 New Mexico Resource Geographic Information System Program

The New Mexico Resource Geographic Information System Program website is designed to advance GIS technology within New Mexico State agencies, government, and private industry. The website has an easy access to download data by pressing the Get Data tab. There are about 120,070 dataset results including vector, raster image, vector virtual mosaic, raster virtual mosaic, and static file datasets. The site can filter by data theme, and the following are available: area code, boundaries, cadastral, census data, cities and towns, climate, county links, elevation, emergency management, environmental data, land ownership, land use, socioeconomic data, soils, transportation, vegetation, and water resources. The transportation theme includes 2006 Topologically Integrated Geographic Encoding and Referencing (TIGER), railroads, roads, and TAZs for the entire state of New Mexico. There is also an interactive map by clicking on the advanced spatial search button. It filters data using theme, icon legend, map layers, zoom, pan, zoom extent, reset, and search by place name buttons. This map is more complicated to use as opposed to the previous maps mentioned. It is not very user friendly but the website does have a glossary, FAQ, user guide, and order help tabs if you need further assistance in using the interactive map (*12*).

2.2.11 U.S. Department of the Interior Bureau of Land Management: New Mexico

The Bureau of Land Management in New Mexico cares for 13.4 million acres of public lands and 26 million acres of federal lands. The website has several subheadings that offer information about the various land management they do. The first heading is "What we do" and includes energy and mineral, fire, grazing, planning, recreation, national conservation lands, wild horses, law enforcement, and wildlife management. There are other tabs that include "visit us," "information center," "get involved," and "field offices." These tabs have information and education on different activities available through the website and contact information. The website does have a quick link to the maps of New Mexico. Once at the maps there are three different categories such as Statewide Map, Field Office Map, and Spatial Data/Metadata files. The statewide maps have PDFs for every city in New Mexico. The field office map have kml-type files to be used with Google Earth and map files in PDF form for specially designed areas, noise sensitive areas, seasonal closures, oil and gas well locations, and areas closed to wood gathering. The GIS data have downloadable datasets in the form of shape files for specially designated areas, mountain plover habitat, T&E plant habitat, and Farmington field office range allotment boundaries. The spatial data/metadata category has access to New Mexico Statewide Spatial Data, Carlsbad Field Office Spatial Data, Farmington Field Office Spatial Data, and Las Cruces District Office Spatial Data. For the Las Cruces District Office Spatial Data, it includes ground transportation linear features route, McGregor boundary, minerals, range, realty, recreation, and special management areas. Once again the drawback to using the information from this site is that it is intended for reference purposes only, as accuracy is not guaranteed for a legal description (*13*).

2.2.12 Description of New Transportation Developments for 2012

In the Las Cruces area, two main new infrastructure developments were identified that are expected to be completed by the end of 2012. These are:

1. Sonoma Ranch Road, from East Lohman Avenue south to Dripping Springs Road.
2. The interchange of Interstate 10 with Interstate 25.

All new transportation development for Ciudad Juárez area is further explained in section 4.3 "Current Construction Projects in Ciudad Juárez." No new developments were considered for the El Paso area, since the 2012 base-year did not include substantial changes in the network.

2.3 DATA ASSESSMENT

After gathering the initial data, CIITR researchers explored all other datasets and GIS resources for the region that were available on the internet. Websites were accessed such as the United States Geological Survey,[4] the Paso Del Norte Mapa,[5] TIGER products available in the

[4] U.S. Geological Survey http://www.usgs.gov/
[5] Paso del Norte Mapa http://www.pdnmapa.org/

United States Census Bureau,[6] among others. After the initial data gathering and the literature review for available resources through the web, the CIITR research team selected the ones with the highest amount of transportation related attributes and complemented the network datasets with these ancillary dataset attributes.

2.3.1 Data Inventory

In the Las Cruces area, only one set of information was available in the VISUM format. The files include the Dona Ana County TAZ layer with the Dona Ana County road networks. The Las Cruces grid is a utility layer that was created to check the Las Cruces network section by section for errors. The following map shows some of the layers gathered for illustrative purposes.

The set of data includes:

1. Polygon layer of the study area.
2. Point layer of the centroids of the polygon layer of the study area.
3. Line layer of connector links.
4. Line layer of transit routes.
5. Point layer of transit stops.
6. Secondary point layer of transit stops.
7. Line layer of transportation demand model network links.
8. Point layer of transportation demand model network nodes.
9. Polygon layer of transportation demand model network zones.
10. Point layer of transportation demand model network zone centroids.
11. Polygon layer of points of interest.
12. Point layer of centroids of polygon layer of points of interest.
13. Line layer of points of interest (complete road network).

2.3.2 Data Selection

For the Las Cruces data, only one dataset was available, so this dataset was used as the basis of the Las Cruces portion of the master network. This dataset was kept up-to-date by the Las Cruces MPO and was confirmed to have quality data.

[6] http://www.census.gov/geo/maps-data/data/tiger.html

CHAPTER 3: DATA ORGANIZATION AND MANAGEMENT PLAN

3.1 DATA ORGANIZATIONAL STRUCTURE

3.1.1 Overall Data Management Plan

A set of file folders was created on the TTI network. One folder was created to contain the Las Cruces area's raw data, one for Ciudad Juárez's raw data, and one for El Paso's raw data. Each of these contains a folder for the raw data of the original format (TransCAD or VISUM), and also a folder for GIS data, where the original format is transformed into GIS data. Another high level folder was created to store the work products of each researcher and the final work product. This folder contains a subfolder for each researcher in the project and a folder where the work products should be deposited. Finally, another subfolder holds the final product and only the principal investigator has authority to alter products in this folder.

3.1.2 Geographic Projection and Coordinate System Used

The Las Cruces data obtained were in the projected New Mexico Central State plane coordinate system on the North American Datum 1983 with units in feet. The data obtained from El Paso and Ciudad Juárez was in the geographic coordinate system in decimal degrees based on the World Geodetic System (WGS) 1984 datum.

Being this an international project, the most appropriate coordinate system was determined to be based on the international WGS 1984 datum. Also, for the projection it was determined to use the Universal Transverse Mercator (UTM) projection with the units in meters. This projection provides the best compromise between minimizing distance distortion and areal distortion while also being recognized as the preferred projection regarding international geographical referencing. The zone 13 north is the UTM zone that contains the projected area.

CHAPTER 4: DEVELOPMENT OF THE MASTER NETWORK (FIRST PHASE)

4.1 DATA REVISION AND ACTION PLAN

In order to work systematically and as efficiently as possible, the network revision process was divided into three different sections. Each section corresponded to a city in the region and, subsequently, each city was subdivided using a grid for keeping track of checking all attributes and geometric elements in the network. Using this methodology, the research team was able to work simultaneously in the three different networks without compromising the entire network configuration. Figure 6 shows the grid for reviewing the whole region in detail.

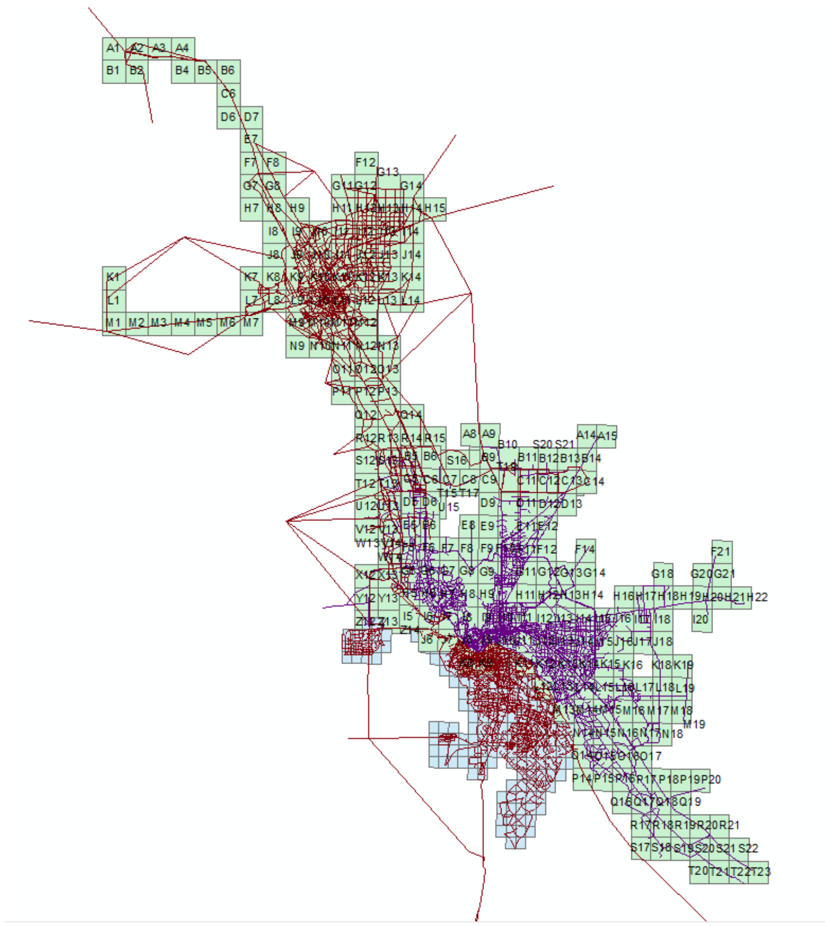

Figure 6. Strategic Grid for Attribute and Geometry Review.

Numbering all quadrants and developing a database containing all issues within a grid helped researchers to keep track of any possible errors, changes in attribute values, editions, etc. that an element would have. Figure 7 illustrates the rectangular area that was used to check the elements within a network.

Figure 7. Quadrant #39 (Showing a Specific Area of the Entire Grid).

After reviewing the elements in the entire grid, researchers selected a set of quadrants that have a vital importance for integrating the networks. These areas contained the common roads (road connectivity) among individual networks. In the case of Ciudad Juárez and El Paso, these areas were identified where the international bridges are located.

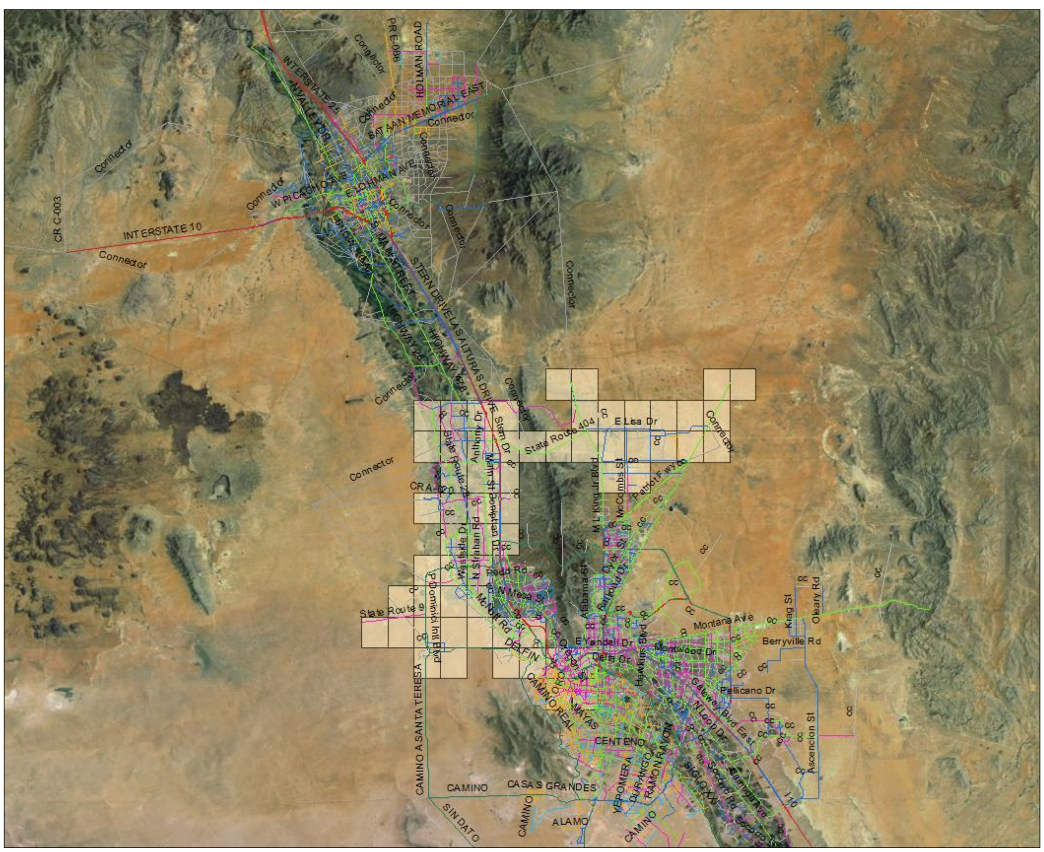

Figure 8. Example of Interconnectivity Zones.

4.2 IMPORTING THE SELECTED NETWORKS INTO GIS-BASED FORMAT

The Las Cruces VISUM TDM obtained from the MPO was imported into a GIS-based format. The first step was to export the network geometry and attributes as shapefiles, which included nodes, links, zones (and centroids), territories, connectors, transit line routes, stops, and points of interest. After the exporting process was complete, the Las Cruces network was imported into the transportation software TransCAD. Lastly, the research team verified that all attributes and geometry of the network had transferred into TransCAD without any errors or loss of data.

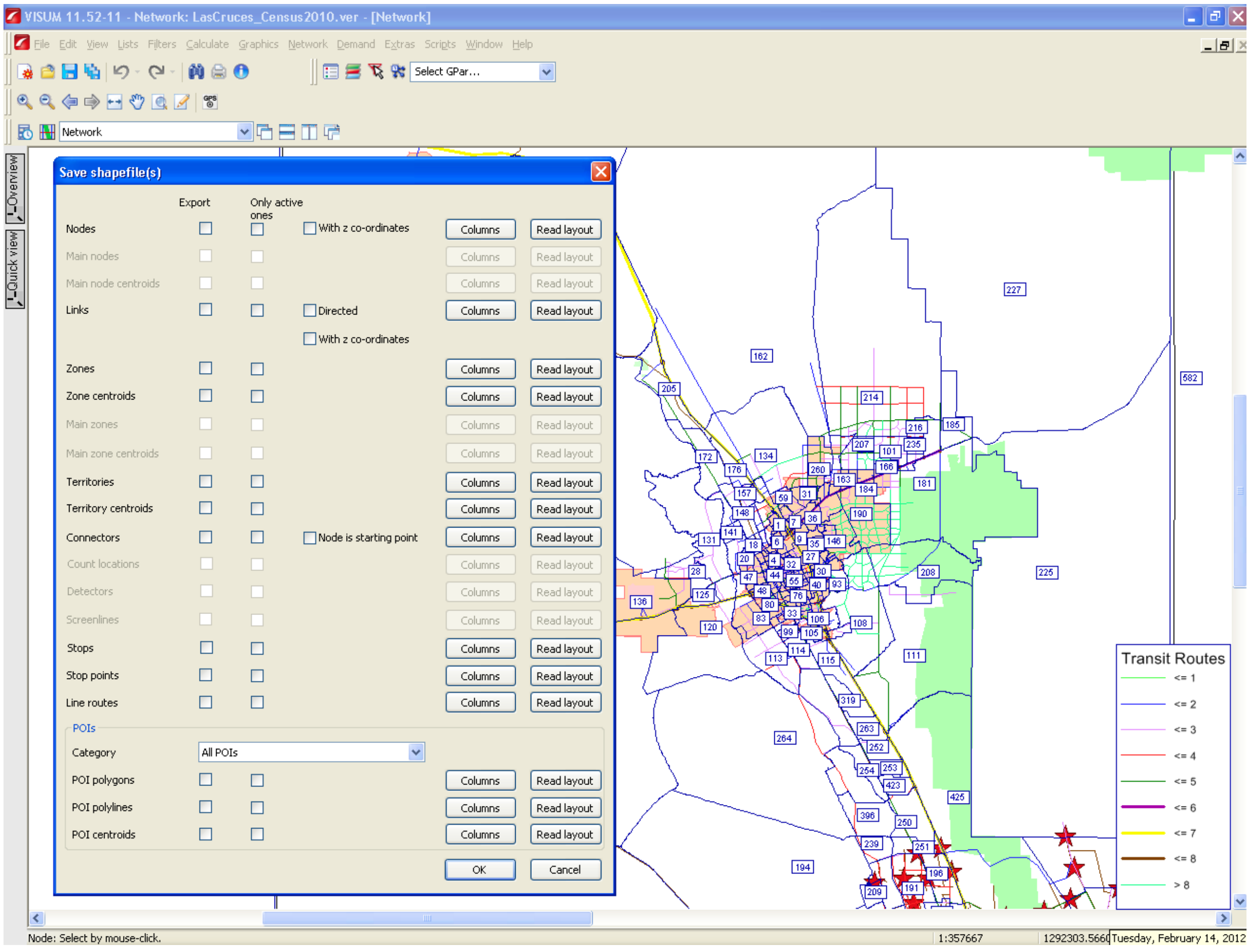

Figure 9. VISUM TDM Shapefile Export Process.

4.3 STANDARDIZING NETWORK ATTRIBUTES

4.3.1 Observations

The main attributes checked in the Juárez network were Direction, Lanes, Speed, and Nombre (Street Name). The Direction attribute had three values: 0 if the link was a two way road, 1 if the link was a one direction road either going north or east, and −1 if the link was a one direction road either going south or west. The Lanes attribute accounted for the number of lanes the link contained. The Speed attribute registered the average speed for the link in km/hr. The

Nombre (Street Name) attribute had the official name of the road or sometimes the name as it is commonly known.

The percentage of errors in the links was considerably high in these four attributes for the Juárez network. The majority of the links were classified as 0, which is not entirely true. As an example two of the main avenues in Ciudad Juárez and several main streets in and around the downtown area are one way but they are coded as two ways in the network. In a lesser amount, some links that were coded as being 1 or −1 had to be changed to 0.

Verifying the exact amount of lanes in several of the links was challenging because of the following reasons: not all the streets that contained a link in the network had the street view option available in Google Maps; the maps date back to 2009, thus it is probable that in three years some of the streets might have some modifications; and it was observed that in some parts of the streets mainly in residential areas the outer lanes were partly occupied as parking space. This is important to take into consideration since it affects speed and capacity.

The speed attribute had the most corrections out of the four attributes. The speed shown in the link was the average speed in km/hr although it seemed that a speed of 17 km/hr was used as a default speed. In Juárez, the speed limit in most of the streets is either 30 or 40 km/hr, while in avenues it increases to 60 km/hr and in the loop the speed limit is 80 km/hr. Even with the traffic congestion generated in most of the avenues in peak hours it is very unlikely to have an average speed of 17 km/hr. In the links that had this average speed, this was changed more closely to the according speed limit.

For the Nombre attribute, there were two common mistakes. The first one corresponds to the fact that many of the streets in Juárez either have two official names or have an official name and another name by which it is commonly known. As an example of a street having two official names, there is a boulevard called Cuatro Siglos (Four Centuries) and also Juan Pablo II (John Paul II). This happened because on one of the city's administration term it was decided to designate the second name. As for the second example, there is a street downtown called Francisco Villa but since the railroad tracks run along the street, it is also widely known as "Ferrocarril" (Railroad Street). Even though "Ferrocarril" is not the official name it is widely used such as in newspapers, TV stations, and among people. The second common mistake, which is in regard to the network itself, is that several links had the name of streets that intersected those links or that were closely parallel to them.

Table 1. Common Attributes Checked during the Process.

FID	Feature ID
SHAPE	Geometry type
OBJECTID	Unique identifer generated by GIS
DIR	Direction of the link that can be: 0=two way, 1=one way either going North or East South or West.
FUNCL	Functional class code
ATYPE	
LANES	Number of lanes in the link
TIME	Link travel time in minutes
AB_CAP	Capacity from node A to node B
BA_CAP	Capacity from node B to node A
TOT_CAP	Total capacity of the link
FACT_CNT	
COUNTY	County=Juarez, El Paso, Doña Ana, Guadalupe or Otero
CONNECT_YN	Indicates if the link is a connector or not
FUTURE	Link that shows future roads
FROMNODENO	From node number
TONODENO	To node number
TYPENO	Type number
CAPPRT	Total capacity in Las Cruces network
COUNT_ST_6	
TWO_WAY_7	Two way road
AADT	Annual average daily traffic
COUNT_YR	Year when counts were done
AM_PK_CO_8	Morning peak counts
PM_PK_CO_9	Afternoon peak counts
TIMS	
ST_NAME	Name of the street in the link
ZONENO	Zone number for TAZ or AGEB
NODENO	Node number that represents TAZ or AGEB
SHAPE_LENG	Length of link
SPEED_KM	Average speed in the link in km/hr
SPEED_MI	Average speed in the link in mi/hr
LENGTH_KM	Length of link in km
LENGTH_MI	Length of link in mi

Once all the 15,491 links and their corresponding attributes were reviewed in a GIS platform, CIITR researchers tested the interconnectivity of the integrated regional master network using a GIS process called check connectivity. This tool automatically reviews and geometrically validates the connectivity of each one of the links. The 15,491 links of the regional master network were successfully connected, and no errors were detected by the tool. In summary, the overall process is illustrated in Figure 10. The attribute checking included a total of 560,000 attributes (cells) checked.

REGIONAL MASTER NETWORK EL PASO, LAS CRUCES AND CIUDAD JUÁREZ

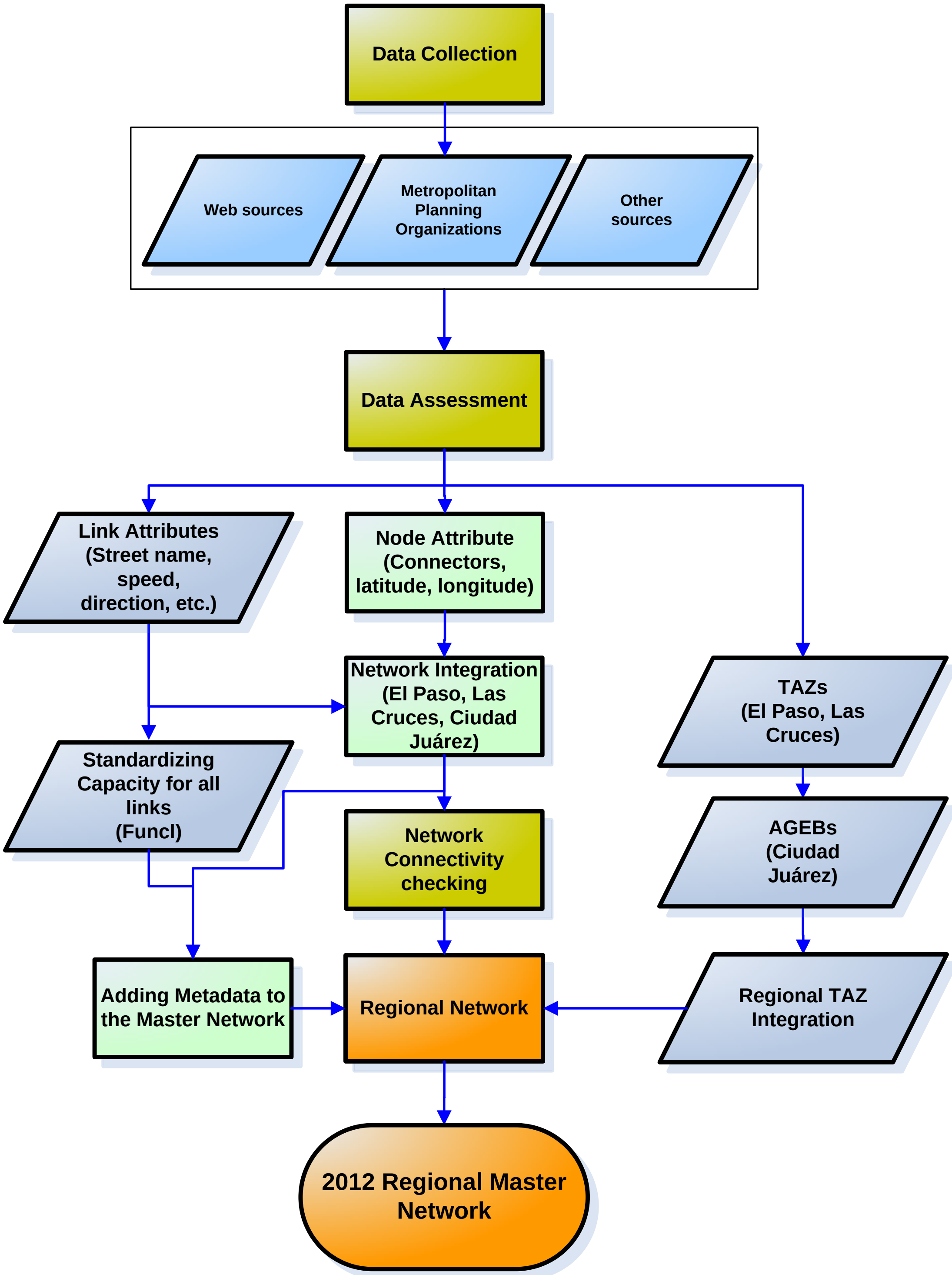

Figure 10. Representation of the Overall Road Network Integrations Process.

4.3.2 Current Construction Projects in Ciudad Juárez

4.3.2.1 Transporte Semimasivo Linea 1 (BRT Line 1) Rehabilitation

Line 1 of the Bus Rapid Transit (BRT) system implemented in Juárez is being rehabilitated by several local contractors. This line is approximately 21 km long and runs between City Hall in the downtown area (north central) and Tierra Nueva (southeast). In its north-south direction, the line runs along Francisco Villa Ave. and Eje Vial Juan Gabriel and turns east in Zaragoza Blvd. In its west-east direction, the line runs along Zaragoza Blvd. until it reaches Independencia Blvd. The whole line runs in a dedicated bus lane built along the streets' median and will contain 34 stations. All left turns along the line have been eliminated thus creating an impact in the surrounding traffic flow.

4.3.2.2 Downtown Rehabilitation

The local and state administrations have been acquiring properties in the vicinity of the Santa Fe Bridge as part of the downtown rehabilitation master plan. The purpose of this rehabilitation is to reactivate downtown's economy through local, national, and international tourism. This rehabilitation also includes the creation of public spaces such as parks, plazas, walking trails, an amphitheatre, a convention center, a world trade center, and parking areas. Up to today, the administrations have been able to demolish old buildings that were located in an area delimited by Santos Degollado Street (west), Mariscal Street (east), Acacias Street (north), and 16 de Septiembre Ave. (south). Public parking has already been built in the block next to 16 de Septiembre Ave. The only building that was not demolished was the municipal gymnasium, which was remodeled. Several streets in this area are being closed to vehicle traffic. Adjacent to the Santa Fe Bridge on its left side facing north, police and fire stations have been demolished. The convention center is expected to be built in this area. On the right side of the Stanton Bridge facing north, several blocks are being joined together for the construction of the World Trade Center building, thus several streets are being closed.

4.3.2.3 Construction of Overpasses/Underpasses

The railroad tracks practically cut Ciudad Juárez in a north-south direction. In the downtown area, the railroad tracks run along Francisco Villa Ave. and then along Eje Vial Juan Gabriel until it exits the city. In order to mitigate the traffic congestion created when the train is crossing from the United States to Mexico and vice versa, two tunnels, two overpasses, and one underpass will be constructed downtown. The underpass was constructed in the intersection of Francisco Villa Ave. and Norzagaray Blvd. next to the US-Mexico border. The first tunnel is to be constructed along Malecon Ave. The second tunnel is under construction and will run along 16 de Septiembre Ave. between Lerdo St. and Mariscal St. Regarding the two overpasses, the first one is to be located along Vicente Guerrero St. and the second one along Municipio Libre Ave. The latter project is in its first phase of construction.

4.3.2.4 Overpasses to Connect Loop

Two overpasses have been constructed to connect the city's loop in the northern part of Ciudad Juárez. One is located near the Stanton Bridge and connects Rafael Perez Serna Ave.

with Norzagaray Blvd. The second overpass runs along Rafael Perez Serna Ave. in its intersection with Heroico Colegio Militar Ave.

4.3.2.5 Baseball Complex

The baseball complex was built next to the current baseball stadium between Reforma Ave., Eje Vial Juan Gabriel, and Sanders Ave. The complex includes the stadium that has an approximate capacity of 15,000 seats, an official store, a food court, administrative offices, a nursery, several ticket booths, 10 radio and television cabins, a museum, and parking space for approximately 2,000 vehicles. The current stadium will be remodeled to have a capacity for 10,000 seats and its main use will be for local amateur tournaments.

Current Construction Projects in Ciudad Juarez (2012)

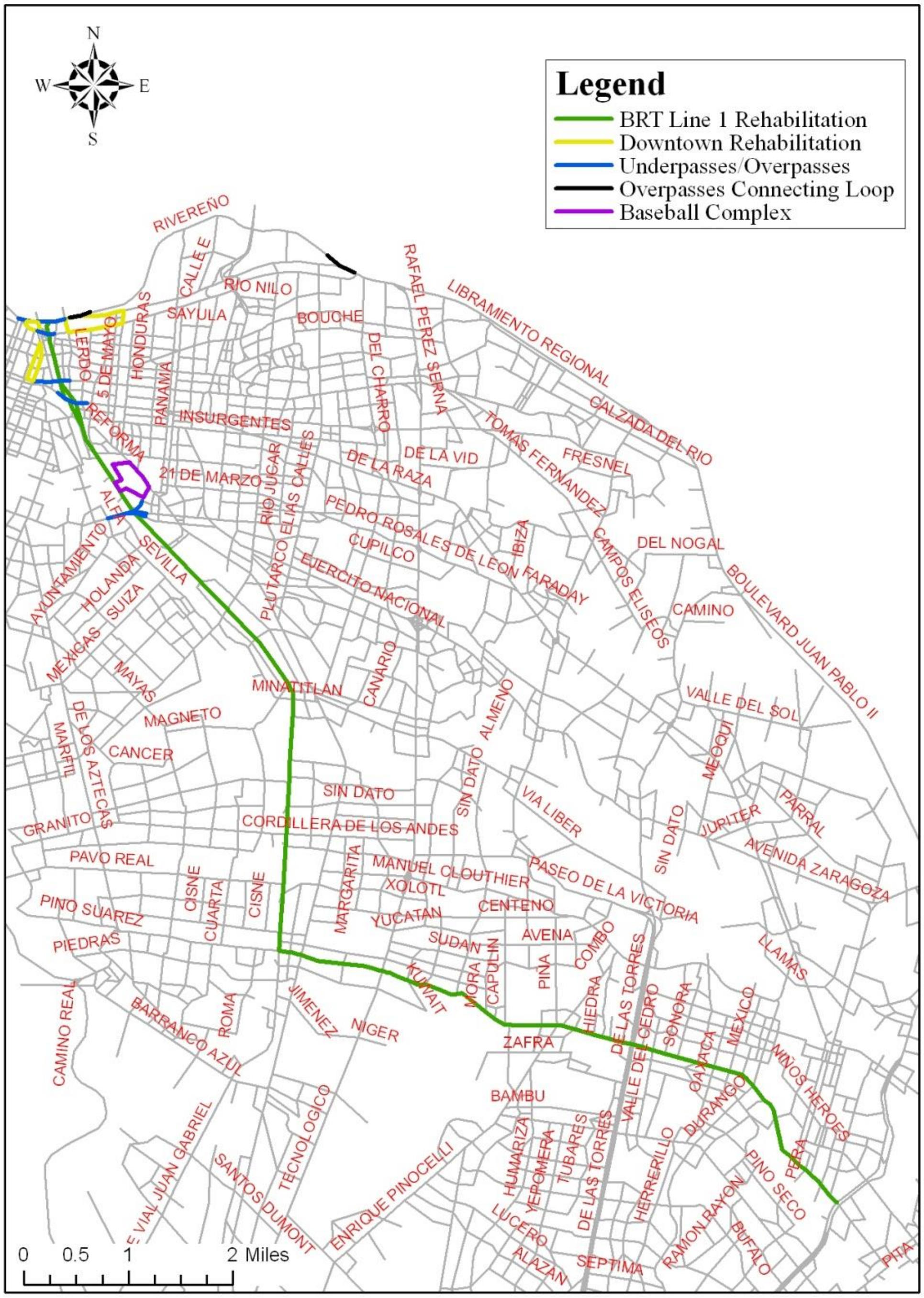

Figure 11. Ciudad Juárez Construction Projects.

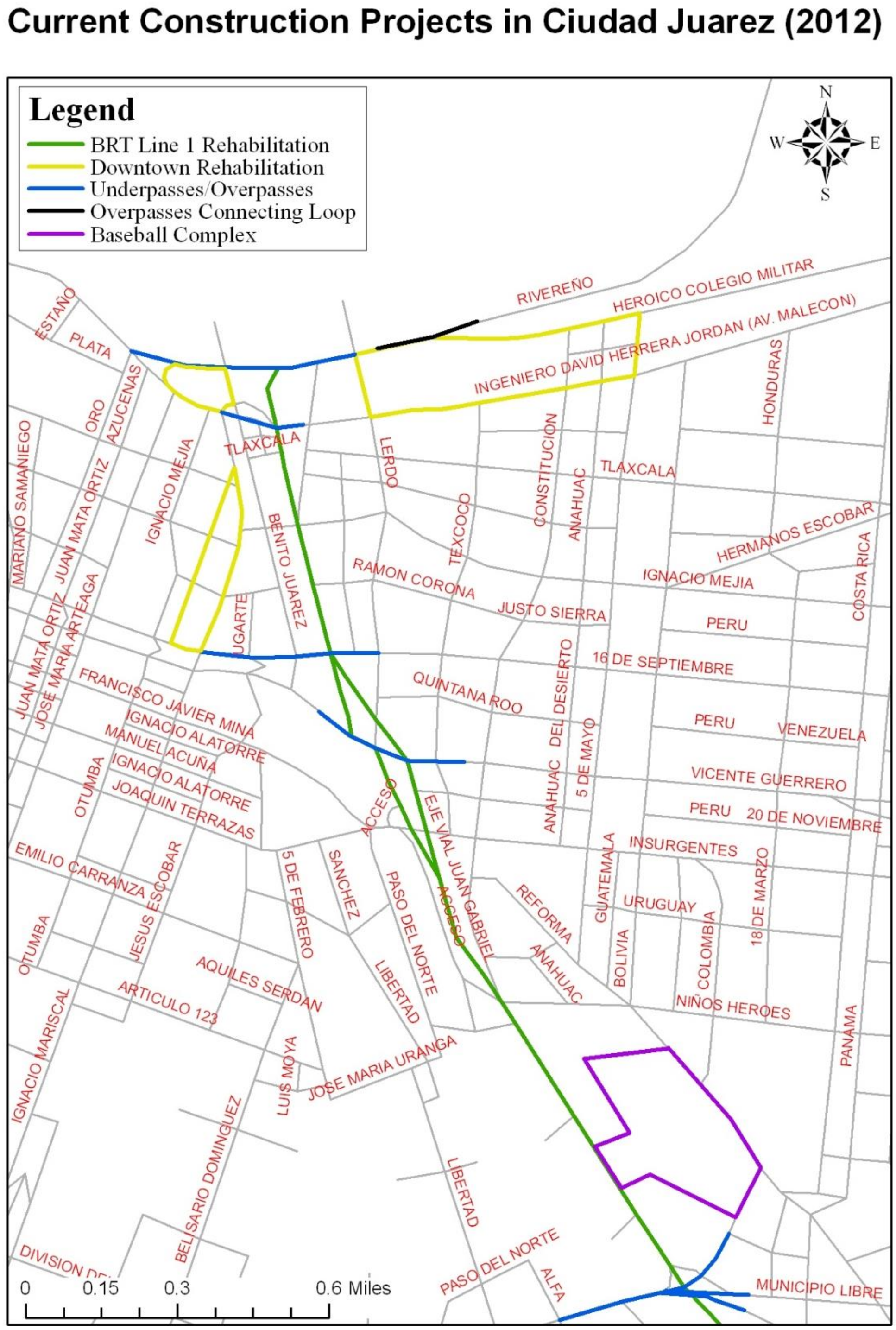

Figure 12. Network Modifications for 2012.

4.3.3 Ciudad Juárez Urban Mobility Program Update

The Urban Mobility Program in Ciudad Juárez considers the construction of 25 roadways, 6 bridges, 1 channel, and reconstruction of 26 roadways. The scope of this program is to develop an efficient and competitive roadway connectivity system with the Camino Real Loop. This program takes into consideration the population, vehicular increase, and economic increase of Ciudad Juárez. All construction projects will aim at easing traffic congestions and reducing travel time within the city. Figure 13 shows the main roadways sections that will be constructed or reconstructed and the bridges and connectors with the Camino Real Loop.

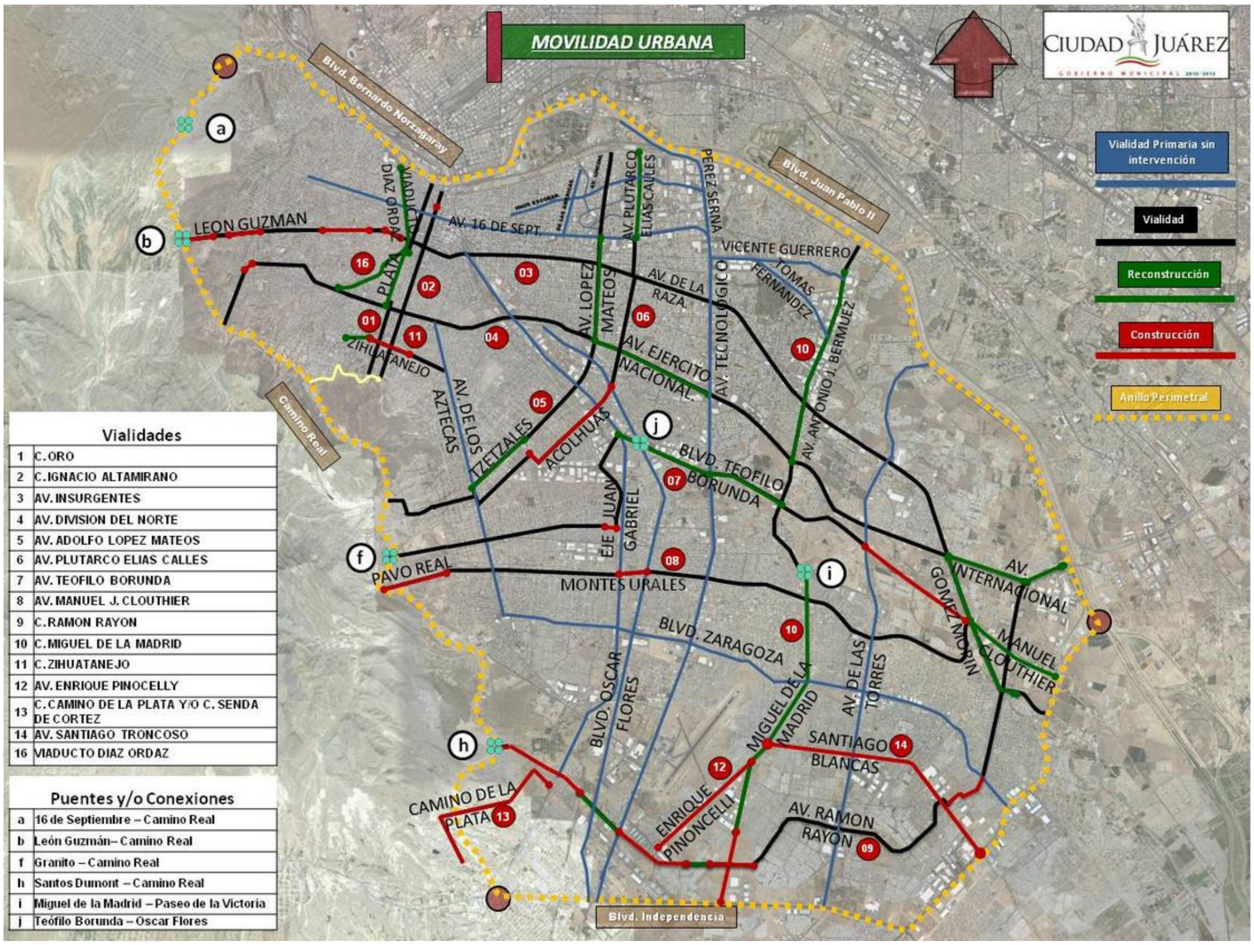

Figure 13. Projects Selected for the Urban Mobility Program.

The program started on January 28, 2013, with the project on the intersection of Santiago Troncoso Avenue [14] and Ramon Rayon Street [09] on the southeast area of the city. This project will consist of constructing a road section that will connect Ramon Rayon Street with its northern part.

The second project is the construction of the bridge that will connect Paseo de la Victoria Avenue with Piña Street [i]. This project started on February 20, 2013, and will help alleviate the congestion generated by traffic that goes from Paseo de la Victoria Avenue to Zaragoza Boulevard through the reconstruction of Piña and Uva Streets [10].

The third project started on February 21, 2013, and is the reconstruction of the Gustavo Diaz Ordaz Viaduct that is located in the northwest part of the city [16]. This viaduct is of great importance because it serves both as a major road artery and water conduct during the rainy season.

On February 26, 2013, the construction of the second of the six bridges considered in the program started. This bridge will connect the Teofilo Borunda Boulevard [07] with the Ramon Rivera Lara Avenue in its intersection with the Oscar Flores Boulevard on the central part of the city. This bridge [j] will alleviate the congestion generated in the intersection above mentioned.

The construction of the third bridge started on March 4, 2013. This bridge [a], located on the northwest part of the city, will connect the 16 de Septiembre Avenue with the Camino Real Loop. This bridge will provide a better connectivity to that area with the rest of the city since the 16 de Septiembre Avenue is part of the longest avenue in Ciudad Juárez (16 de Septiembre, Paseo Triunfo de la Republica, Tecnologico, and Panamericana).

CHAPTER 5: FINAL REMARKS

5.1 LESSONS LEARNED

The most critical challenges faced for the Paso Del Norte regional master network were the standardization of attributes in a region with cultural, social, political, and even language differences; the achievement of all the necessary information; and the tedious process of revision.

Some of the attributes were in fact out of date and very different to the actual (real) conditions in the current roads. A very meticulous process was required while making the three-network final connectivity. Links that represent the ports of entry (international bridges) were the most demanding due to the attribute standardization and geometry. Adding metadata to all official shapefiles was also an important task. Metadata is critical for sharing shapefiles, attribute data, and maps and for searching to see if the resources you need already exist. Additionally, metadata describes geographic information system (GIS) resources in the same way a card in a library's card catalog describes a book[7]..Finally, missing and existing values with incorrect data (such as speed, number of lanes, capacity, functional classification, and directionality) were difficult to identify with simple observations in web-based maps. Thus, several in-situ surveys along some selected arterials and streets were necessary, as well as personnel who were familiar with the selected survey areas.

5.2 TRANSPORTATION ANALYSIS ZONES INTEGRATION AND CONSTRUCTION OF A REGIONAL ORIGIN DESTINATION MATRIX

The CIITR researchers are willing to obtain funds for a third stage of this research project. This stage will consolidate a single structure of the TAZs in terms of quality of socioeconomic data and consistent projections into the future using statistical methods. Once this goal is achieved, the next step, and with no doubt the most challenging, will be to build a regional Origin-Destination Matrix and ultimately, have a master TDM for the entire El Paso del Norte Region.

[7] http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=About_metadata

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APPENDICES

A) DATA AND NETWORK ATTRIBUTES (METADATA)

Las Cruces GIS Data and Network Attributes (Metadata)

In order to work with the Las Cruces Network, GIS files from Las Cruces and Dona Ana County were obtained. The files include the Dona Ana County TAZ layer with the Dona Ana County road networks. For the Las Cruces data the layers are Las Cruces test node, Las Cruces test connectors, and the Las Cruces test link attributes. These were used to test the merging of streets in the network, followed by several back up versions of the same layers. The Las Cruces grid is a utility layer that was created to check the Las Cruces network section by section for errors. Figure 14 shows some of the layers gathered for illustrative purposes.

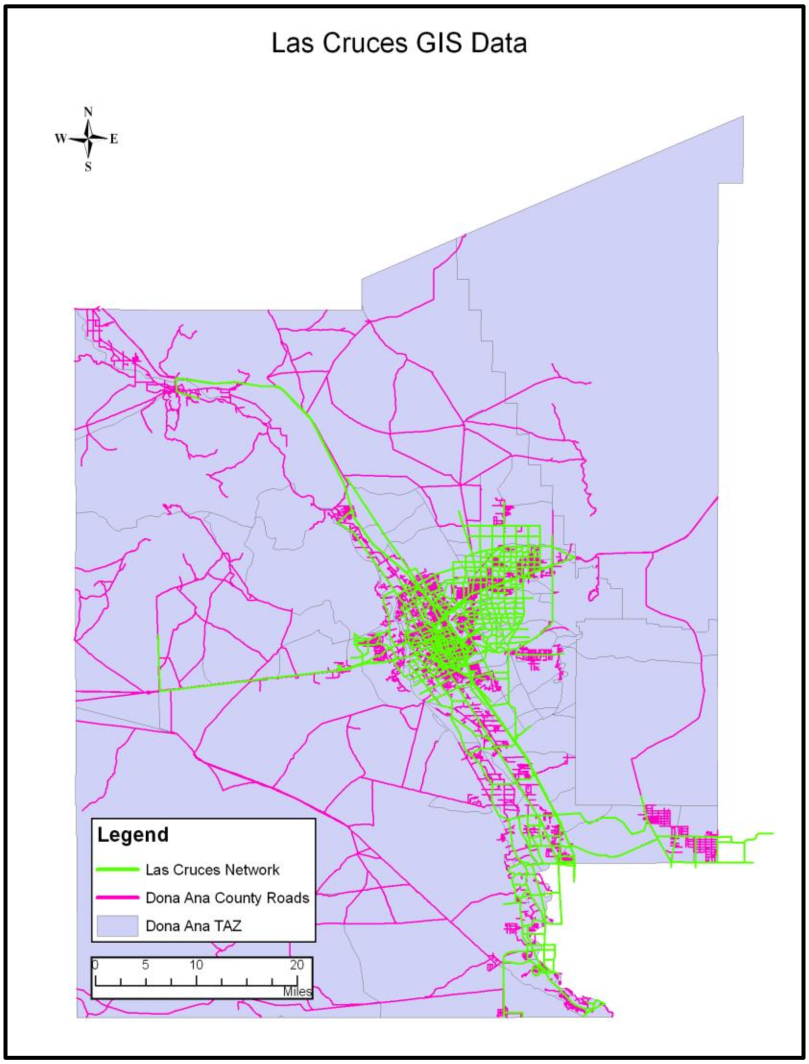

Figure 14. Map Showing the Las Cruces Network.

Ciudad Juárez GIS Data and Network Attributes (Metadata)

The GIS files obtained for the Juárez Network include layers with data for the grid of the whole city, the rehabilitation of the downtown area, the improvements made in several parts of the city, several versions of the master network, some layers testing the merging of streets, the routing of the Line 1 of the TRB system, and the underpasses and overpasses proposed along the railroad tracks to alleviate traffic congestion. Also, a layer containing the roadways for Juárez and El Paso for the 2010 binational network was gathered along with the Juárez TAZs and the 2008 projected network. The following map shows some of the layers gathered for illustrative purposes.

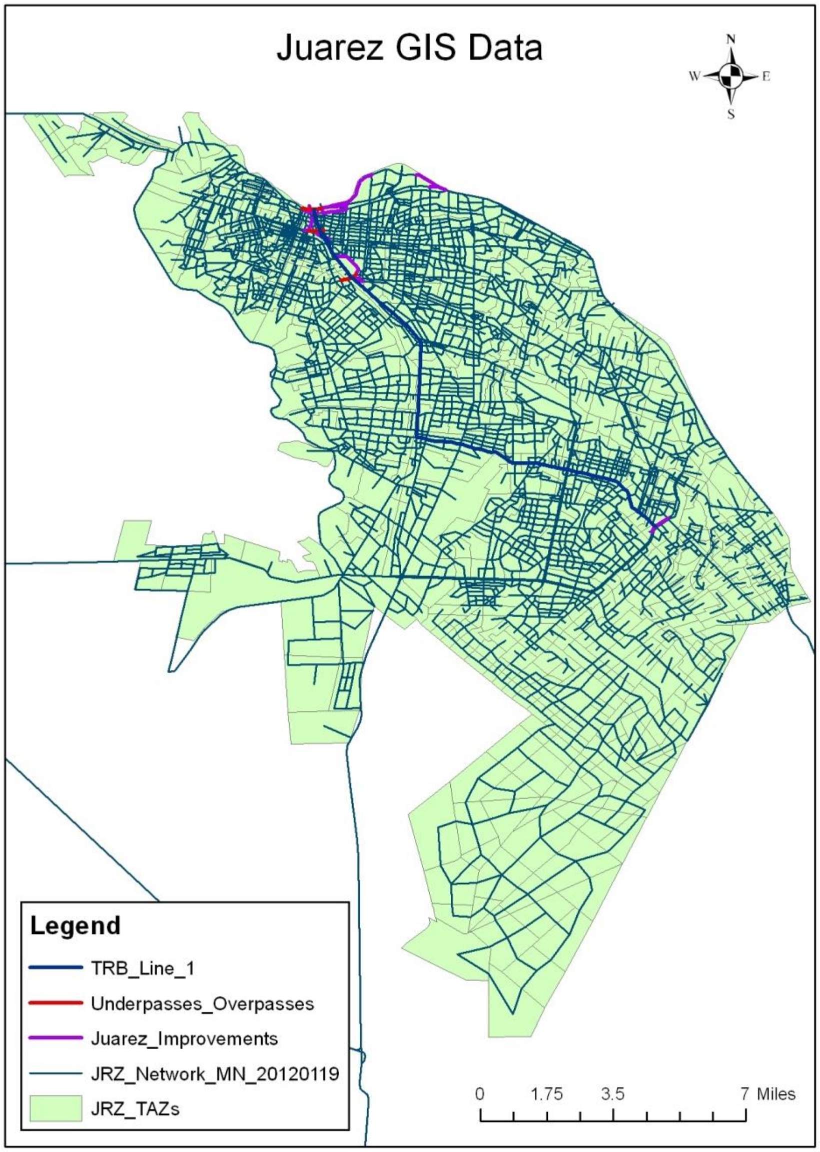

Figure 15. Map Showing Several Layers Gathered for the Juárez Network.

El Paso GIS Data and Network Attributes (Metadata)

For the El Paso data, two GIS layers were gathered. The first layer shows the 2010 TAZs, and the second layer shows the city's street network for 2010. The TAZ layer contains attributes such as the area, acreage, location, jurisdiction (El Paso County, City of El Paso, Doña Ana County, Socorro, etc.), population, median income, household, retail, education, and other parameters not well defined by the user. The layer contains 729 TAZs. Regarding the street network layer, the table of attributes contains data such as the length of the line segment, direction, year, speed, functional class code, number of lanes, capacity, annual average daily traffic, volume, TAZ, and name of street along with other parameters. The layer contains 6671 links within the El Paso area. Both layers can be observed in the following map (Figure 16).

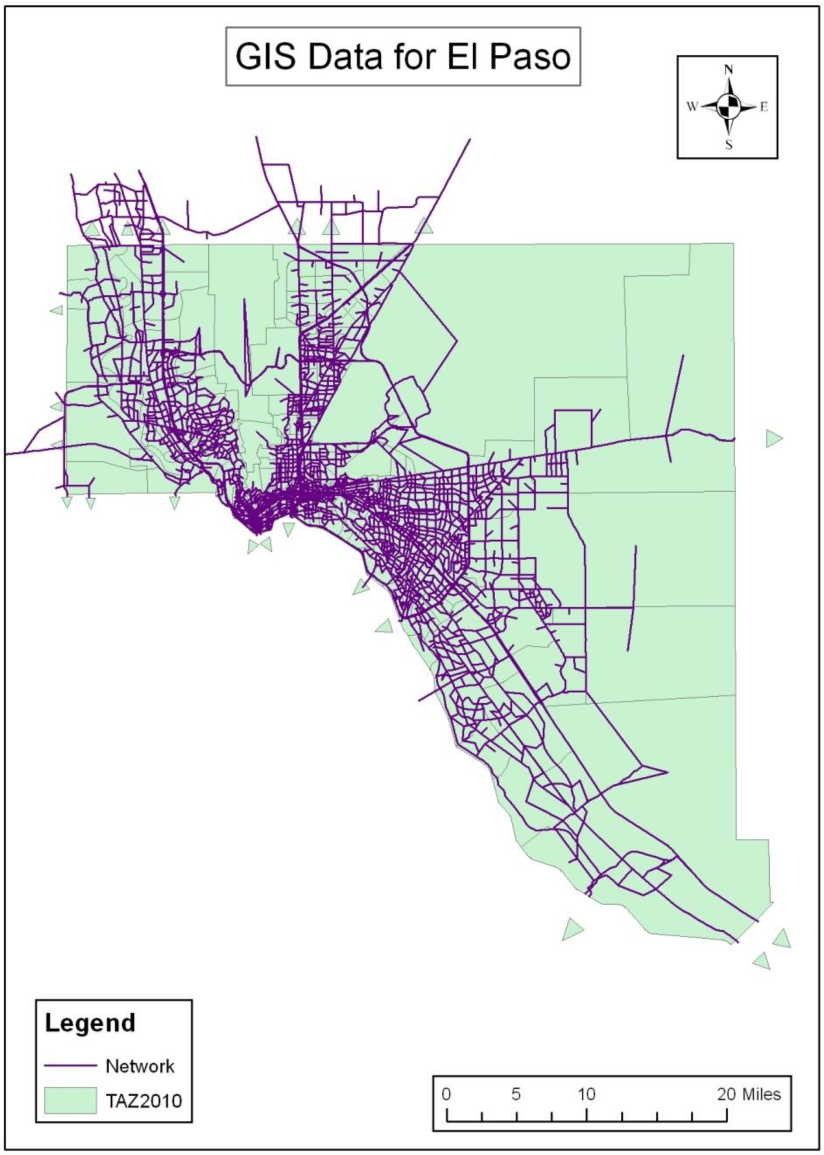

Figure 16. GIS Data for El Paso.

Regional Master Network and Network Attributes (Metadata)

Once the GIS data collected from El Paso, Ciudad Juárez, and Las Cruces were cleaned and corrected, researchers created the Master Network 2012 layer. This layer merges the network links from the three cities into one master network allowing connectivity and data sharing to be simplified. Within the Final Master Network file there are three grid networks: one for El Paso, one for Ciudad Juárez, and one for Las Cruces. These grids allow users to differentiate where each city network domain starts and ends. The overlapping of the grids allows users to see where the connection between networks took place. Figure 17 shows some of the layers gathered for illustrative purposes.

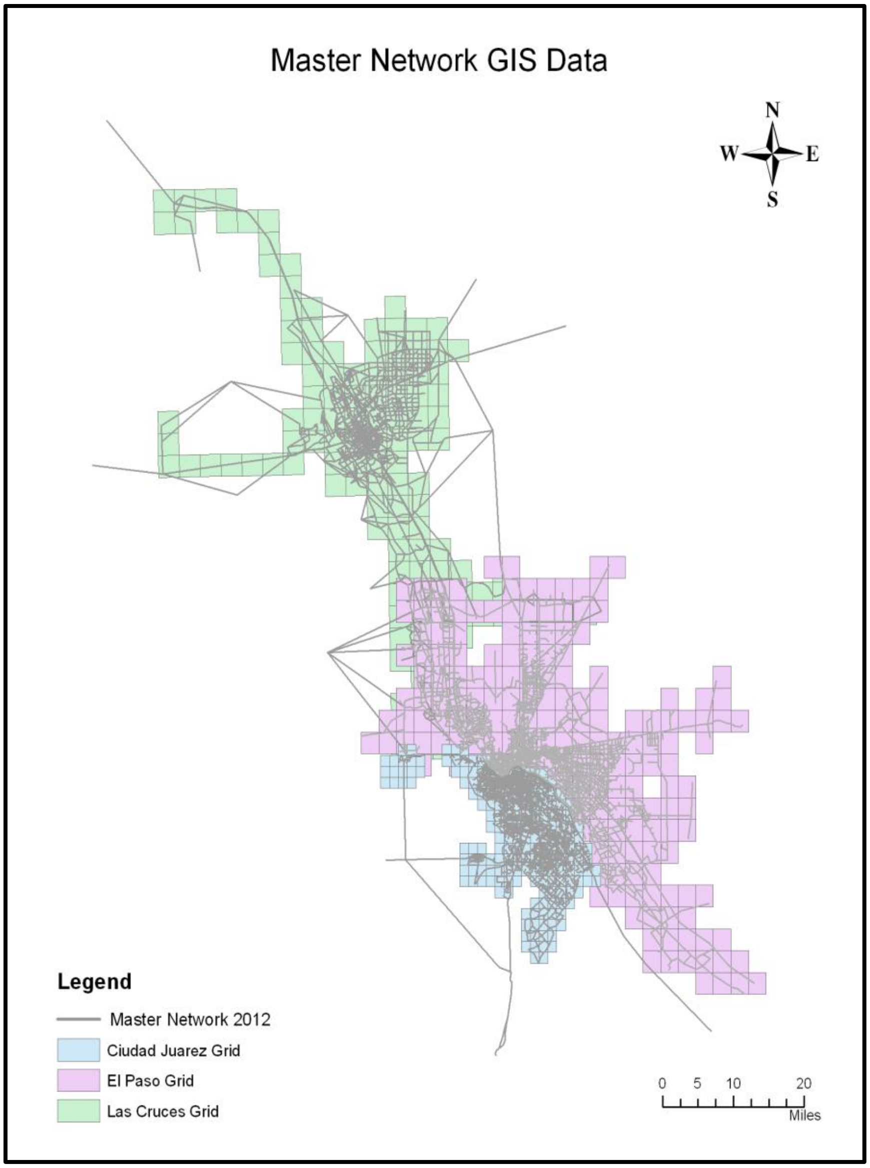

Figure 17. Map Showing the Regional Master Network.

A close up of the master network allows for differentiation of the links within the network based on the newest version of the Federal Highway Administration function class code. To achieve this outcome, the data had to be compared between each city and the function class code to determine the best classification for the link type.

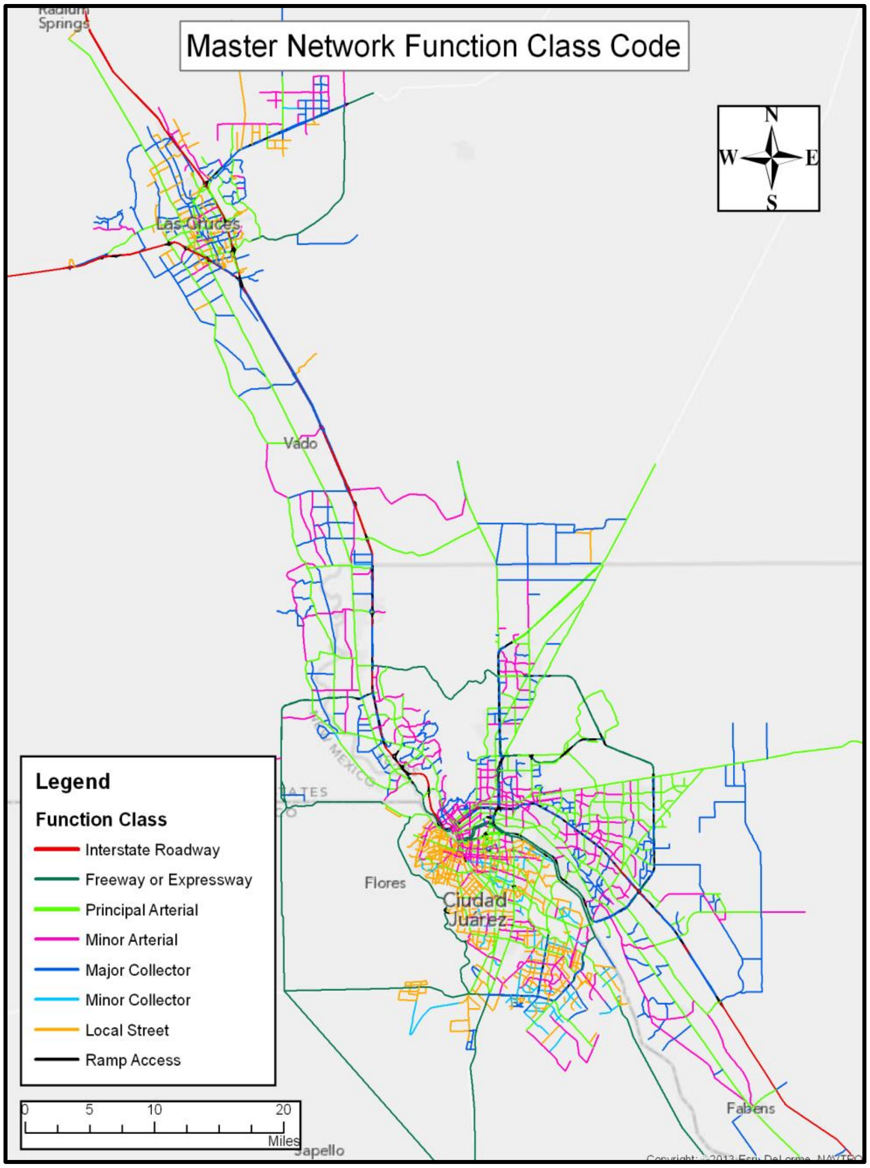

Figure 18. Map Showing the Function Classes for the Master Network.

B) NETWORK ATTRIBUTES

The attributes for El Paso, Las Cruces, and Ciudad Juárez networks data were very different mainly because there is no standard to follow. This led to complications in analyzing the network links to combine them to one master network. Once the main attributes in common for the three cities were found, the combining step was simple. The following three tables represent the attributes for El Paso, Las Cruces, and Ciudad Juárez. The difference can be seen from city to city in which one has more data than the others and with better explanation. The final table represents the mutual attributes used for the final master network. The most common or important attributes that aided in the process for analyzing and combining the network were Direction, Function Class, Lanes, Speed, Street Name, and Origin of the network link.

The Direction attribute had three values: 0 if the link was a two way road, 1 if the link was a one direction road either going north or east, and −1 if the link was a one direction road either going south or west. The Function Class attribute had eight values: 1 if the link is an interstate roadway, 2 if the link is a freeway or expressway, 3 if the link is a principal arterial, 4 if the link is a minor arterial, 5 if the link is a major collector, 6 if the link is a minor collector, 7 if the link is a local street, and 20 if the link is a ramp access. The Lanes attribute accounted for the number of lanes the link contained. The Speed attribute registered the average speed for the link in miles per hour. For Street Name attribute it had the official name of the road or sometimes the name as it is commonly known. The final attribute, Origin of the network link, has the name of the originating network having quick access to know what network the link belongs, either El Paso, Las Cruces, or Ciudad Juárez.

El Paso Network Attributes

Table 2. El Paso Network Attributes.

Attribute Name	Definition
FID	Feature ID
Shape	Geometry type
ID	TransCAD internal ID
LENGTH	Roadway length in miles
DIR	Direction of the link: 0=two way, 1=one way either going north or east, −1=one way either going south or west
DIR_07	Direction of the link in year 2007: 0=two way, 1=one way either going north or east,−1=one way either going south or west
DIR_10	Direction of the link in year 2010: 0=two way, 1=one way either going north or east, −1=one way either going south or west
DIR_20	Direction of the link in year 2020: 0=two way, 1=one way either going north or east, −1=one way either going south or west
DIR_30	Direction of the link in year 2030: 0=two way, 1=one way either going north or east, −1=one way either going south or west
DIR_40	Direction of the link in year 2040: 0=two way, 1=one way either going north or east, −1=one way either going south or west

Attribute Name	Definition
YR07	Link available in the network for year 2007
YR10	Link available in the network for year 2010
YR20	Link available in the network for year 2020
YR30	Link available in the network for year 2030
YR40	Link available in the network for year 2040
POSTED_SPE	Posted speed limit
SPEED_07	Projected average speed limit for year 2007
SPEED_10	Projected average speed limit for year 2010
SPEED_20	Projected average speed limit for year 2020
SPEED_30	Projected average speed limit for year 2030
SPEED_40	Projected average speed limit for year 2040
FUNCL_07	Functional class code for year 2007
FUNCL_10	Functional class code for year 2010
FUNCL_20	Functional class code for year 2020
FUNCL_30	Functional class code for year 2030
FUNCL_40	Functional class code for year 2040
ATYPE_07	Area type for year 2007
ATYPE_10	Area type for year 2010
ATYPE_20	Area type for year 2020
ATYPE_30	Area type for year 2030
ATYPE_40	Area type for year 2040
LANES_07	Number of lanes in year 2007
LANES_10	Number of lanes in year 2010
LANES_20	Number of lanes in year 2020
LANES_30	Number of lanes in year 2030
LANES_40	Number of lanes in year 2040
AB_CAP_07	Capacity from node A to node B for year 2007
BA_CAP_07	Capacity from node B to node A for year 2007
TOTCAP_07	Total capacity of the link for year 2007
AB_CAP_10	Capacity from node A to node B for year 2010
BA_CAP_10	Capacity from node B to node A for year 2010
TOTCAP_10	Total capacity of the link for year 2010
AB_CAP_20	Capacity from node A to node B for year 2020
BA_CAP_20	Capacity from node B to node A for year 2020
TOTCAP_20	Total capacity of the link for year 2020
AB_CAP_30	Capacity from node A to node B for year 2030
BA_CAP_30	Capacity from node B to node A for year 2030
TOTCAP_30	Total capacity of the link for year 2030

Attribute Name	Definition
AB_CAP_40	Capacity from node A to node B for year 2040
BA_CAP_40	Capacity from node B to node A for year 2040
TOTCAP_40	Total capacity of the link for year 2040
AADT	Annual average daily traffic
AB_FLOW	Volume flow of vehicles from node A to node B
BA_FLOW	Volume flow of vehicles from node B to node A
TOT_VOL	Total volume of link
VC_RATIO	Volume to capacity ratio
TIME_07	Modeled time to travel link in 2007
TIME_10	Modeled time to travel link in 2007
TIME_20	Modeled time to travel link in 2007
TIME_30	Modeled time to travel link in 2007
TIME_40	Modeled time to travel link in 2007
WLK_TIME	Modeled time to walk the link
ALPHA	Modeling parameter alpha
BETA	Modeling parameter beta
TAZ	TAZ zone number
COUNTY	County= Juárez, El Paso, Doña Ana, Guadalupe, or Otero
VMT	Vehicle miles traveled
LOCAL_STRE	Local street name
STATE_SYST	State system identity
COMMENTS	Comments
TOLL_COST_	Toll cost
TOLL_COST	Toll cost

Las Cruces Network Attributes

Table 3. Las Cruces Network Attributes.

Attribute Name	Definition
FID	Feature ID
Shape *	Geometry type
NO	Link number
FROMNODENO	Number of the “from” node
TONODENO	Number of the “to” node
TYPENO	Link type number
LENGTH	Roadway length in miles
NUMLANES	Number of lanes in link
CAPPRT	Route capacity
V0PRT	Posted velocity of the route
COUNT_ST_6	Counts for the route
ROADWAY	Name of the roadway link
SEGMENT	Beginning and ending cross streets
AADT	Annual average daily traffic in vehicles per day
COUNT_YR	year of last DOT count
AM_PK_CO_8	Modeled morning peak volume
PM_PK_CO_9	Modeled evening peak volume
MODEL_AM	Modeled morning volume
MODEL_PM	Modeled evening volume
MODEL_ADT	Modeled average daily traffic
NEWNET	Indicates if it is part of the new network
NO_	Additional link number
Midpoint_Y	Latitude of the link midpoint
Mpt_X	Longitude of the link midpoint
ST_NAME	Name of the street in the link
SURFACE	Type of surface
CLASS	Route class
SPEED	Average speed in the link
ROW_WIDTH	Width of the right of way
AADT_1	Average annual daily traffic
BUILT	Indicates if the route is built
DIR	Direction of the link: 0=two way, 1=one way either going north or east, −1=one way either going south or west

Ciudad Juárez Network Attributes

Table 4. Ciudad Juárez Network Attributes.

Attribute Name	Definition
FID	Feature ID
Shape *	Geometry type
ID	TransCAD internal ID
LENGTH	Length of the link in miles
DIR	Direction of the link: 0=two way, 1=one way either going north or east, −1=one way either going south or west
FUNCL08	Functional class code in 2008
FUNCL	Functional class code
ATYPE	Area type
LANES08	Number of lanes in the link in 2008
LANES	Number of lanes in the link
SPEED	Average speed in the link
TIME	Link travel time in minutes
AB_CAP	Capacity from node A to node B
BA_CAP	Capacity from node B to node A
TOT_CAP	Total capacity of the link
TOT_VOL	Total volume of the link
VMT	Vehicle miles traveled
TAZ	TAZ zone number
COUNTY	County= Juárez, El Paso, Doña Ana, Guadalupe, or Otero
COMMENTS	Comments
NOMBRE	Name of the street in the link
CONNECT_YN	Indicates if the link is a connector or not
Future	Indicates if the link is a future road or not

Regional Master Network Attributes

Table 5. Regional Master Network Attributes.

Attribute Name	Definition
OBJECTID *	Unique identifier generated by GIS
Shape *	Geometry type
DIR	Direction of the link: 0=two way, 1=one way either going north or east, −1=one way either going south or west
FUNCL	FHWA functional class code
TYPENO	Type number
FUNCL_MN	New FHWA functional class code
ATYPE	Area type
LANES	Number of lanes in the link
TIME	Link travel time in minutes
AB_CAP	Capacity from node A to node B
BA_CAP	Capacity from node B to node A
TOT_CAP	Total capacity of the link
FACT_CNT	Unknown Attribute (probably referring to a local function)
COUNTY	Juárez, El Paso, Doña Ana, Guadalupe, or Otero
CONNECT_YN	Indicates if the link is a connector or not
Future	Indicates if the link is a future road or not
FROMNODENO	Number of the “from” node
TONODENO	Number of the “to” node
AADT	Annual average daily traffic
COUNT_YR	Year when counts were done
ST_NAME	Name of the street in the link
ZONENO	Zone number for TAZ or AGEB
NODENO	Node number that represents TAZ or AGEB
Speed in km	Average speed in the link in km/hr
Speed in Miles	Average speed in the link in mi/hr
Length in km	Length of link in km
Length in Miles	Length of link in mi
ID	Link ID
LENGTH	Roadway length in miles
DIR_07	Direction of the link in year 2007: 0=two way, 1=one way either going north or east, −1=one way either going south or west
DIR_10	Direction of the link in year 2010: 0=two way, 1=one way either going north or east, −1=one way either going south or west
DIR_20	Direction of the link in year 2020: 0=two way, 1=one way either going north or east, −1=one way either going south or west
DIR_30	Direction of the link in year 2030: 0=two way, 1=one way either going north or east, −1=one way either going south or west

Attribute Name	Definition
DIR_40	Direction of the link in year 2040: 0=two way, 1=one way either going north or east, −1=one way either going south or west
YR07	Indicates the link is part of 2007 Network
YR10	Indicates the link is part of 2010 Network
YR20	Indicates the link is part of 2020 Network
YR30	Indicates the link is part of 2030 Network
YR40	Indicates the link is part of 2040 Network
POSTED_SPE	Posted speed limit
SPEED_07	Projected average speed limit for year 2007
SPEED_10	Projected average speed limit for year 2010
SPEED_20	Projected average speed limit for year 2020
SPEED_30	Projected average speed limit for year 2030
SPEED_40	Projected average speed limit for year 2040
FUNCL_07	Functional class code for year 2007
FUNCL_10	Functional class code for year 2010
FUNCL_20	Functional class code for year 2020
FUNCL_30	Functional class code for year 2030
FUNCL_40	Functional class code for year 2040
ATYPE_07	Area type in 2007
ATYPE_10	Area type in 2010
ATYPE_20	Area type in 2020
ATYPE_30	Area type in 2030
ATYPE_40	Area type in 2040
LANES_07	Number of lanes in year 2007
LANES_10	Number of lanes in year 2010
LANES_20	Number of lanes in year 2020
LANES_30	Number of lanes in year 2030
LANES_40	Number of lanes in year 2040
AB_CAP_07	Capacity from node A to node B for year 2007
BA_CAP_07	Capacity from node B to node A for year 2007
TOTCAP_07	Total capacity of the link for year 2007
AB_CAP_10	Capacity from node A to node B for year 2010
BA_CAP_10	Capacity from node B to node A for year 2010
TOTCAP_10	Total capacity of the link for year 2010
AB_CAP_20	Capacity from node A to node B for year 2020
BA_CAP_20	Capacity from node B to node A for year 2020
TOTCAP_20	Total capacity of the link for year 2020
AB_CAP_30	Capacity from node A to node B for year 2030
BA_CAP_30	Capacity from node B to node A for year 2030
TOTCAP_30	Total capacity of the link for year 2030
AB_CAP_40	Capacity from node A to node B for year 2040
BA_CAP_40	Capacity from node B to node A for year 2040
TOTCAP_40	Total capacity of the link for year 2040
SATCOUNT	Saturation counts

Attribute Name	Definition
RAMPCOUNT	Ramp counts
AB_FLOW	Volume flow of vehicles from node A to node B
BA_FLOW	Volume flow of vehicles from node B to node A
TOT_VOL	Total volume of link
VC_RATIO	Volume to capacity ratio
TIME_07	Modeled time to travel link in 2007
TIME_10	Modeled time to travel link in 2007
TIME_20	Modeled time to travel link in 2007
TIME_30	Modeled time to travel link in 2007
TIME_40	Modeled time to travel link in 2007
WLK_TIME	Modeled time to walk the link
ALPHA	Modeling parameter alpha
BETA	Modeling parameter beta
TAZ	TAZ zone number
VMT	Vehicle miles traveled
ANOTE	Additional note
NETYEAR	Year link added to network
LOCAL_STRE	Local street name
STATE_SYST	State system identity
COMMENTS	Comments
TOLL_COST	Toll cost
Shape_Length	Length of link
Grade in Percent	Grade in Percent
Origin Network of the Link	Origin Network of the Link

C) TAZ AND AGEB

The GIS map labeled "TAZs_EP+LC" contains the TAZs layers for El Paso and Las Cruces. The El Paso TAZs layer has 681 entries, and some of the attributes includes the area, acreage, population, household size, median income, area type, non-home based productions, non-home based attractions, home based work productions, home based work attractions, total employment, basic employment, retail employment, service employment, home based non-work productions, home based non-work attractions, external local vehicle trip productions, external local vehicle trip attractions, truck-taxi productions, and truck-taxi attractions. The Las Cruces layer contains 213 entries, and some of the attributes include data for area, length, population, schools, hotels, service, industries, retail, and other parameters that are not well defined in the metadata.

El Paso TAZs Attributes

Table 6. El Paso TAZ.

Attribute Name	Definition
FID	Unique identifier generated by GIS
Shape *	Geometry type
ID	GIS Internal ID
AREA	Size of area
ACRES	Size in acres
POP30	Population in 2030
HH30	Household size in 2030
POPHH	Population size per Household
MEDINCOME	Median income
EMPT	Total employment
EMPB	Basic employment
EMPR	Retail employment
EMPS	Service employment
ATYPE	Area type
ATYPMPO	Area type by MPO
NHBP	Non-home based productions
NHBA	Non-home based attractions
HBWP	Home based work productions
HBWA	Home based work attractions
HBNP	Home based non-work productions
HBNA	Home based non-work attractions
EXLOP	External local vehicle trip productions
EXLOA	External local vehicle trip attractions
TRTXP	Truck-taxi productions
TRTXA	Truck-taxi attractions
AREATYPE	Location of area type

Las Cruces TAZs Attributes

Table 7. Las Cruces TAZ.

Attribute Name	Definition
OBJECTID *	Unique identifier generated by GIS
Shape *	Geometry type
NO	Number
PER_HHCHV0	Percentage of Households for CHV0

Attribute Name	Definition
PER_HHCHV1	Percentage of Households for CHV1
PER_HHCHV2	Percentage of Households for CHV2
PER_HHCHV3	Percentage of Households for CHV3
PER_HHNOV0	Percentage of Households for NOV0
PER_HHNOV1	Percentage of Households for NOV1
PER_HHNOV2	Percentage of Households for NOV2
PER_HHNOV3	Percentage of Households for NOV3
PER_HHREV0	Percentage of Households for REV0
PER_HHREV1	Percentage of Households for REV1
PER_HHREV2	Percentage of Households for REV2
PER_HHREV3	Percentage of Households for REV3
HHCHV3	Number of Households for CHV3
HHCHV0	Number of Households for CHV0
HHCHV1	Number of Households for CHV1
HHCHV2	Number of Households for CHV2
HHNOV0	Number of Households for NOV0
HHNOV1	Number of Households for NOV1
HHNOV2	Number of Households for NOV2
HHNOV3	Number of Households for NOV3
HHREV0	Number of Households for REV0
HHREV1	Number of Households for REV1
HHREV2	Number of Households for REV2
HHREV3	Number of Households for REV3
HH	Total number of Households
INDUSTRIAL	Number of industrial
RETAIL	Number of retail
SERVICES_7	Number of services in 7
SCHOOLS	Number of schools
SERVICES_8	Number of services in 8
HOTELS	Number of hotels
INDUSTRI_9	Number of industrial in 9
RETAIL_00	Number of retail in 00
SERVICE_10	Number of services in 10
SERVICE_11	Number of services in 11
SCHOOLS_00	Number of schools in 00
HH_00	Number of Households in 00
HOTEL_00	Number of hotels in 00
INDUSTR_19	Number of industrial in 19

Attribute Name	Definition
RETAIL_30	Number of retail in 30
SERVICE_20	Number of services in 20
SERVICE_21	Number of services in 21
SCHOOLS_30	Number of schools in 30
HH_30	Number of Households in 30
HOTEL_30	Number of hotels in 30
INDUSTR_22	Number of industrial in 22
RETAIL_10	Number of retail in 30
SERVICE_23	Number of services in 23
SERVICE_24	Number of services in 24
SCHOOLS_10	Number of schools in 10
HH_10	Number of Households in 10
HOTEL_10	Number of hotels in 10
NEWNUMBER	New number
INDUSTR_27	Number of industrial in 27
RETAIL_40	Number of retail in 30
SERVICE_28	Number of services in 28
SERVICE_29	Number of services in 29
SCHOOLS_40	Number of schools in 40
HH_40	Number of Households in 40
HOTEL_40	Number of hotels in 40
POP10	Population in 10
Shape_Length	Length of shape
Shape_Area	Area of shape

In Mexico, the National Institute of Statistics and Geography divides the land into Basic Geostatistical Areas (AGEBs), which are the equivalent to TAZs in the United States. These AGEBs can be either designated either as urban or rural depending on their characteristics. There are approximately 850 AGEBs in Ciudad Juárez The AGEBs layer's attribute table contains 161 columns. The first column indicates the Feature ID (FID), the second column shows the type of shape which in this case all of them are polygons, and the third column shows the Geostatistical Key (CVEGEO) for all AGEBs. The rest of the columns show the population per age. The first of these columns (POB1) give the total population for the AGEB. As an example, POB29 shows the total population of people less than 29 years old. The column range goes from year 2 to year 81. The columns labeled with a "_R," give the percentage of that age column. As an example, the total population for AGEB #1694 is 3466 and the population less than 29 years (POB29) is 170, which is 4.9 percent (POB29_R) of the total population. The last column shows the Object ID (OID) for the AGEBs.

Ciudad Juárez AGEBs Attributes

Table 8. Juárez AGEB.

Attribute Name	Definition
FID	Unique identifier generated by GIS
Shape *	Geometry type
CVEGEO	Geostatistical key
POB1	Total population
POB2	Total population less than 2 years old
POB2_R	Percentage of population less than 2 years old
POB3	Total population less than 3 years old
POB3_R	Percentage of population less than 3 years old
POB4	Total population less than 4 years old
POB4_R	Percentage of population less than 4 years old
POB5	Total population less than 5 years old
POB5_R	Percentage of population less than 5 years old
POB6	Total population less than 6 years old
POB6_R	Percentage of population less than 6 years old
POB7	Total population less than 7 years old
POB7_R	Percentage of population less than 7 years old
POB8	Total population less than 8 years old
POB8_R	Percentage of population less than 8 years old
POB9	Total population less than 9 years old
POB9_R	Percentage of population less than 9 years old
POB10	Total population less than 10 years old
POB10_R	Percentage of population less than 10 years old
POB11	Total population less than 11 years old
POB11_R	Percentage of population less than 11 years old
POB12	Total population less than 12 years old
POB12_R	Percentage of population less than 12 years old
POB13	Total population less than 13 years old
POB13_R	Percentage of population less than 13 years old
POB14	Total population less than 14 years old
POB14_R	Percentage of population less than 14 years old
POB15	Total population less than 15 years old
POB15_R	Percentage of population less than 15 years old
POB16	Total population less than 16 years old
POB16_R	Percentage of population less than 16 years old
POB17	Total population less than 17 years old

Attribute Name	Definition
POB17_R	Percentage of population less than 17 years old
POB18	Total population less than 18 years old
POB18_R	Percentage of population less than 18 years old
POB19	Total population less than 19 years old
POB19_R	Percentage of population less than 19 years old
POB20	Total population less than 20 years old
POB20_R	Total population less than 20 years old
POB21	Total population less than 21 years old
POB21_R	Percentage of population less than 21 years old
POB22	Total population less than 22 years old
POB22_R	Percentage of population less than 22 years old
POB23	Total population less than 23 years old
POB23_R	Percentage of population less than 23 years old
POB24	Total population less than 24 years old
POB24_R	Percentage of population less than 24 years old
POB25	Total population less than 25 years old
POB25_R	Percentage of population less than 25 years old
POB26_R	Percentage of population less than 26 years old
POB27_R	Percentage of population less than 27 years old
POB28_R	Percentage of population less than 28 years old
POB29_R	Percentage of population less than 29 years old
POB30_R	Percentage of population less than 30 years old
POB31	Total population less than 31 years old
POB31_R	Percentage of population less than 31 years old
POB32	Total population less than 32 years old
POB32_R	Percentage of population less than 32 years old
POB33	Total population less than 33 years old
POB33_R	Percentage of population less than 33 years old
POB34	Total population less than 34 years old
POB34_R	Percentage of population less than 34 years old
POB35	Total population less than 35 years old
POB35_R	Percentage of population less than 35 years old
POB36	Total population less than 36 years old
POB36_R	Percentage of population less than 36 years old
POB37	Total population less than 37 years old
POB37_R	Percentage of population less than 37 years old
POB38	Total population less than 38 years old
POB38_R	Percentage of population less than 38 years old

Attribute Name	Definition
POB39	Total population less than 39 years old
POB39_R	Percentage of population less than 39 years old
POB40	Total population less than 40 years old
POB40_R	Percentage of population less than 40 years old
POB41	Total population less than 41 years old
POB41_R	Percentage of population less than 41 years old
POB42	Total population less than 42 years old
POB42_R	Percentage of population less than 42 years old
POB43	Total population less than 43 years old
POB43_R	Percentage of population less than 43 years old
POB44	Total population less than 44 years old
POB44_R	Percentage of population less than 44 years old
POB45	Total population less than 45 years old
POB45_R	Percentage of population less than 45 years old
POB46	Total population less than 46 years old
POB46_R	Percentage of population less than 46 years old
POB47	Total population less than 47 years old
POB47_R	Percentage of population less than 47 years old
POB48	Total population less than 48 years old
POB48_R	Percentage of population less than 48 years old
POB49	Total population less than 49 years old
POB49_R	Percentage of population less than 49 years old
POB50	Total population less than 50 years old
POB50_R	Percentage of population less than 50 years old
POB51	Total population less than 51 years old
POB51_R	Percentage of population less than 51 years old
POB52	Total population less than 52 years old
POB52_R	Percentage of population less than 52 years old
POB53	Total population less than 53 years old
POB53_R	Percentage of population less than 53 years old
POB54	Total population less than 54 years old
POB54_R	Percentage of population less than 54 years old
POB55	Total population less than 55 years old
POB55_R	Percentage of population less than 55 years old
POB56	Total population less than 56 years old
POB56_R	Percentage of population less than 56 years old
POB57	Total population less than 57 years old
POB57_R	Percentage of population less than 57 years old

Attribute Name	Definition
POB58	Total population less than 58 years old
POB58_R	Percentage of population less than 58 years old
POB59	Total population less than 59 years old
POB59_R	Percentage of population less than 59 years old
POB60	Total population less than 60 years old
POB60_R	Percentage of population less than 60 years old
POB61	Total population less than 61 years old
POB61_R	Percentage of population less than 61 years old
POB62	Total population less than 62 years old
POB62_R	Percentage of population less than 62 years old
POB63	Total population less than 63 years old
POB63_R	Percentage of population less than 63 years old
POB64	Total population less than 64 years old
POB64_R	Percentage of population less than 64 years old
POB65	Total population less than 65 years old
POB65_R	Percentage of population less than 65 years old
POB66	Total population less than 66 years old
POB66_R	Percentage of population less than 66 years old
POB67	Total population less than 67 years old
POB67_R	Percentage of population less than 67 years old
POB68	Total population less than 68 years old
POB68_R	Percentage of population less than 68 years old
POB69	Total population less than 69 years old
POB69_R	Percentage of population less than 69 years old
POB70	Total population less than 70 years old
POB70_R	Percentage of population less than 70 years old
POB71	Total population less than 71 years old
POB71_R	Percentage of population less than 71 years old
POB72	Total population less than 72 years old
POB72_R	Percentage of population less than 72 years old
POB73	Total population less than 73 years old
POB73_R	Percentage of population less than 73 years old
POB74	Total population less than 74 years old
POB74_R	Percentage of population less than 74 years old
POB75	Total population less than 75 years old
POB75_R	Percentage of population less than 75 years old
POB76	Total population less than 76 years old
POB76_R	Percentage of population less than 76 years old

Attribute Name	Definition
POB77	Total population less than 77 years old
POB77_R	Percentage of population less than 77 years old
POB78	Total population less than 78 years old
POB78_R	Percentage of population less than 78 years old
POB79	Total population less than 79 years old
POB79_R	Percentage of population less than 79 years old
POB80	Total population less than 80 years old
POB80_R	Percentage of population less than 80 years old
POB81	Total population less than 81 years old
POB81_R	Percentage of population less than 81 years old
OID_1	Object ID