Users Manual

TELUM (Transportation Economic and Land Use Model)

Version 5.0

March 2005

Table of Contents

4. Data Preparation

1. Introduction to *TELUM*

Welcome to *TELUM*

This manual is intended to assist a new user of ***TELUM*** in learning to make efficient use of its many capabilities. The manual contains a brief introduction to the history of the system, along with detailed instructions for using ***TELUM***. In order to obtain useful and correct forecast results, and in order to minimize disruptions to the health of your computer operating system, it is imperative that users (this means you) follow this manual closely. This system links to Microsoft's Excel, to Microsoft's Access, to other system utilities such as Wordpad, and to ESRI's ArcView, as well as to system components for Visual Basic and for FORTRAN computing languages. For your ease of use, there are over 500 User Interface Screens along with all the computer code to connect them. Successful installation and use of a system this complex **REQUIRES** that you read and follow the instructions carefully.

1. Overview of the *TELUM* Manual

This manual is organized in the following manner. You will find it useful to read each chapter thoroughly before starting the corresponding section of ***TELUM***.

1. Introduction
History and Basics of ***TELUM***

2. Installation
Setting Up and Configuring ***TELUM*** on Your Computer

3. *TELUM* Tutorial
Running a Sample Forecasting Project to Provide Familiarity and Experience in Using ***TELUM***

4. Data Preparation
Gathering, Formatting, and Entering Regional and Zonal Data

5. *MAP IT*
Using GIS to Analyze and Forecast Results

6. Travel Impedance Preparation Unit
Format and Input of Travel Impedance Files

7. Model Calibration
Checking Data, Estimating Equation Parameters, and Explaining Calibration Results

8. Forecasting
Explaining the Forecasting Process, Implementing Baseline and Policy Forecasts

2. What can you do with *TELUM*?

TELUM is an integrated interactive system that can be used to assist in evaluating the effects of a region's planned transportation improvement projects. It may also be used to make long term forecasts of a region's spatial patterns, as well as to produce forecasts which address the transportation and land use consistency that is required as input to the air quality estimates now required by the CAAA and TEA21 (and ISTEA before that). ***TELUM*** uses current and prior residential, employment, and land use data to forecast the future locations of each of those by employment sector, household income group, and land use type. The interrelationships between transportation and land use can be just as important, and in some cases more important, than the individual direct consequences of either. Having articulated a framework for examining, analyzing, or understanding the transportation and land use interactions, it then becomes possible to consider the consequences of a wide assortment of different kinds of policies. This includes policies that attempt to achieve their aims by changes on the demand side, in terms of urban design and land use control, as well as those that attempt to achieve their aims by acting on the supply side in terms of various kinds of transportation improvement. These transportation improvements can be for highways, transit or combinations thereof, as well as in increases in utilization efficiency of existing facilities.

3. Introduction to Integrated Transportation and Land Use Modeling

With Federal Highway Administration sponsorship in 1971, Professor Stephen H. Putman began the development of what became known as the Integrated Transportation and Land Use Package – ITLUP. The specific intent of that package was to provide a means to properly represent the interrelationships of transportation and land use. The original package, developed in a university setting, was able to demonstrate the general importance of these linkages, which were previously overlooked in transportation policy analyses. Another result of that work was the inclusion, in the early 1980s, of a portion of the package as part of the final release of the Federal Highway Administration's Urban Transportation Planning System - UTPS software package.

In succeeding years, extensive upgrades, revisions, and modifications were made to all portions of ITLUP. All or portions of the integrated transportation and land use package have been applied in more than twenty different metropolitan areas in the United States, as well as in cities overseas. In the thirty years that have passed since the first work on ITLUP, there has been a transformation in computer technology that was quite unimaginable in 1971. Perhaps nowhere is this more true than in the development and adoption for agency use, of Geographic Information Systems – GIS. In the summer of 1997, ***METROPILUS***, a new land use modeling system, was first applied in an operating agency. The new system, like its predecessor ITLUP, contained several models for location analysis, as well as software, or links to external software for all the necessary data analysis, statistical analysis, and display, including mapping, of outputs and results. In addition, the components of the package could be applied as separate models, and also could be connected to other models currently in use by a student or a planning agency for forecasting and analysis tasks. The entire modeling system, along with numerous utility programs as well as Graphical User Interfaces – GUIs, was embedded in ESRI's popular ArcView GIS operating environment.

Beginning in 1999, Professor Putman embarked on a five-year U.S. Department of Transportation sponsored project to retool ***METROPILUS*** as a land use component for the Transportation Economic Land Use System (***TELUS***). The TELUS Land Use Model (***TELUM***) evolved from the earlier ***METROPILUS*** work to become a self contained, novice-friendly land use modeling system designed to project the location of new residential and nonresidential development based upon analysis of (1) prior and existing residential and nonresidential development, (2) the location of transportation improvement(s), and (3) overall congestion in the system. ***TELUM*** forecasts the location and amount of household and employment growth for up to 30 years, information needed by an MPO's external travel-demand-forecasting models to estimate network flows and subsequent congestion induced changes in travel times.

It is important to understand that within ***TELUM*** the DRAM and EMPAL models borrowed from ***METROPILUS*** and now known as TELUM-RES and TELUM-EMP, constitute only a portion of a complete regional transportation, location, and land use model system. Such a system would involve location and land use allocation models as well as a set of transportation analysis models including the steps of trip generation, trip distribution, mode split, and trip assignment. All of the agencies making use of ***TELUM*** are expected to have their own transportation analysis software already installed and operational. The outputs of ***TELUM*** then become the inputs to the agency's own travel demand models and trip assignment package (e.g. EMME2, MINUTP, TRANPLAN, TRANSCAD, UTPS, etc.). The congested network travel times and/or costs produced as output from these packages may then be used as inputs to subsequent time period forecasts from ***TELUM***.

Most planning professionals have a good, intuitive sense of how employment and household location patterns develop over time, and how those patterns are affected by changes in transportation systems. Human intuition cannot, however, encompass all the thousands of data items and interactions that describe transportation, location, and land use in a metropolitan region. Computer models such as ***TELUM*** can both process this data in a consistent fashion, and, by making explicit much of the intuitive understanding of these phenomena, effectively describe these important interactions. In addition, both ***TELUM*-EMP** and ***TELUM*-RES** contain provisions for user augmentation of forecasts. This can be done by use of constraints on activity location, which will be described in this manual. Furthermore, and of particular importance here, by altering inputs to the models in order to represent policy assumptions, policies can be evaluated by the same data-rich, replicable, and behaviorally consistent process.

4. *TELUM* Basics

In this document we describe the components of ***TELUM***, how to organize a data set for your region, how to use the data with the software, and how to interpret the results obtained.

In the manual font styles are used to indicate whether directions refer to menu items, directory names, file names, Excel spreadsheets, or command buttons. In the box to the right are samples of how these font styles are used.

Pull-down>pull-down sub-item

Button

DIRECTORY NAME

FILENAME

Excel Worksheet

Naming instructions for the files you create will be covered in each relevant section of the manual.

Before you begin using the ***TELUM*** application, you should know some of the program features available to you. These features are built in aids that help you work through the model preparation and forecasting without having to always refer to this manual.

Operating System

TELUM, HELP, and the User Manual assume that you are proficient in the use of the Windows operating system. If you need help with the operating system, please consult its user documentation or appropriate technical support personnel in your organization.

The following sources of information are designed to help you successfully navigate the ***TELUM*** system:

1. **Tutorial**

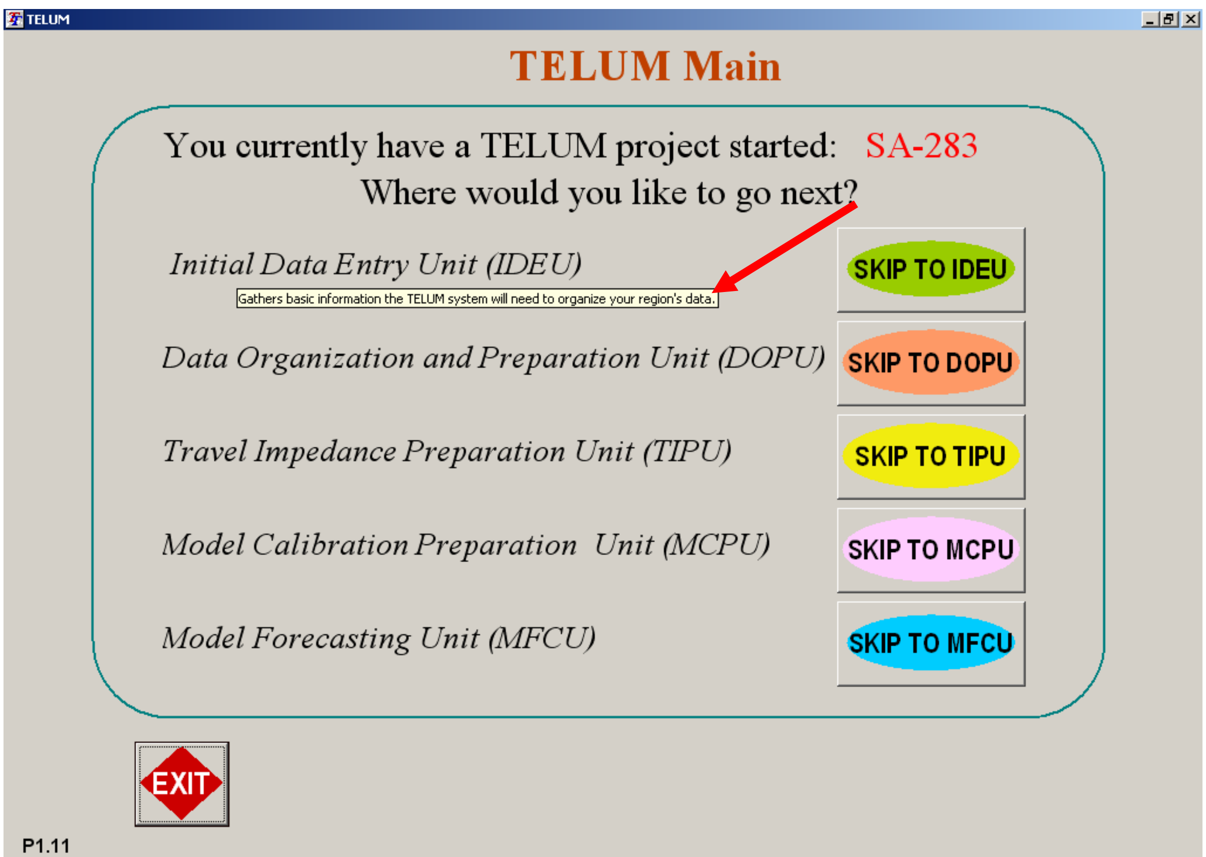
On your ***TELUM*** CD-ROM you will find a folder labeled *TUTORIAL* containing all the files you will need to produce forecasts for a sample 20-zone region in ***TELUM***. We strongly recommend you use the Tutorial to become more familiar with the system and its data requirements. A guide to the Tutorial is provided in this manual in chapter 3.

2. **Hyperlinks**

Hyperlinks are blue underline texts that provide additional ways to present more information about ***TELUM*** features. Once you have clicked a hyperlink, ***TELUM*** will automatically turn the underline text purple to indicate that you have already visited the text link. Print buttons are often provided with the hyperlinks in case you need a printed copy of the information for use at a later date.

3. **MouseOvers**

MouseOvers are tips that pop up when the mouse pointer is paused over a text feature. Currently this feature is only used in the ***TELUM*** MAIN screen and *MAP IT*.



4. Information Tips

Information Tips are small buttons labeled with i found inside the ***TELUM*** DOPU Data Preparation workbook. By clicking on the information button, ***TELUM*** pops up a small text box that describes the data requirements of the tables.

5. Comment Boxes

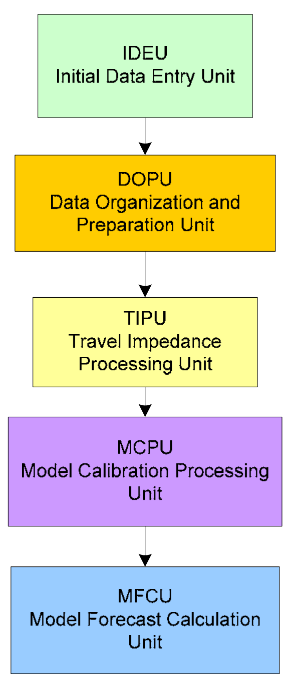
Comment Boxes are small red triangles that appear in the upper right corner of the ***TELUM*** DOPU *Data Preparation* workbook (spreadsheet). Comment boxes pop up when the mouse pointer is paused over a cell with a red triangle.

6. HELP

This feature is currently under construction. In the future, you will be able to access this manual and troubleshooting information from an internal ***TELUM*** file.

5. Flow of the *TELUM* System

To complete a full set of model forecasts for your region you must work through the ***TELUM*** system in the following order: *IDEU, DOPU, TIPU*, *MCPU*, *MFCU*. Once you have successfully completed each section you may move between modules to do additional work. These modules are designed to gather, organize, calibrate, and forecast your regional employment and households.



TELUM **Flowchart**

In the following section we provide an overview of land use modeling and how ***TELUM*** can be used in your region. While this background information is not required for running the ***TELUM*** system, you may find these sections informative.

6. Land Use Modeling: Overview

Phenomena as complex as the location of jobs and people in a large region require complex analysis tools. In recent years a number of regional planning agencies in the US have carried out the process of implementing forecasting models of employment and household location and land use, both for the purpose of doing forecasts and policy analyses, as well as for the purpose of providing inputs to their transportation and air quality modeling efforts.

The overall approach, as embodied in a package of computer programs and procedures, involves several major components. These are (1) first, procedures for forecasting the spatial location of employment and households in a metropolitan region, (2) second, a procedure for using these location forecasts to produce a set of origin destination trip matrices, (3) third, a procedure, when appropriate, for doing mode-split analysis, (4) fourth, a procedure for assigning (in most cases only highway) trips to a capacity-constrained highway network and (5) fifth, a set of procedures for linking the congested travel times back to the employment and household forecasting procedures.

Such an approach, overall, is the only one that allows for explicit representation, analysis and evaluation of the effects on traffic congestion and transportation efficiency resulting from changes in urban design and land development patterns, in combination with variations in socio-economic factors.

Decades of transportation and land use studies of every sort have shown us clearly that there are relationships between transportation and land use or land development. However, if we look over all these many studies, it is sometimes very difficult to understand how the varying results can be considered logically consistent.

One important result from the integrated transportation and land use package development was that its overall construct provided a clear way to see that often the apparently conflicting results from transportation and land use studies were in fact conflicting only because of the way in which they were initially viewed. The most obvious example is in some of the traditional approaches to solving local congestion problems. In such cases a study will be done of a physical transportation facility and a need will be defined for increased capacity of one sort or another on the network. This capacity, an additional highway lane, a new road, etc., will be constructed and will result, in the short-term, in an improvement of vehicle flow and a reduction in the observed congestion. Unfortunately, in the long-term, such strategies often have just the opposite result. The increased network capacity is used by trip makers to make more trips and/or longer trips. Thus, in the long-run, it has often been the case that an improvement in a transportation system, most frequently in terms of highway construction, while having a short-term effect of improving the situation for travelers, has a long-term effect of doing just the opposite. Indeed, one of the consequences of highway construction in the absence of demand management or urban design in an attempt to in some way regulate land use and land development has been to spread greater network congestion over a larger number of links in the network.

The traditional transportation planning approach makes it very difficult to anticipate these kinds of system responses to particular policies. In this analysis process, a series of externally produced estimates of trip demands, usually in the form of origin-destination trip matrices, is calculated using exogenously estimated sets of socio-economic data. So, for example, let us consider an agency preparing in 2004 long-term transportation plans for the year 2030 or 2040 or beyond. In such a case, typically a series of socio-economic forecasts, in terms of employment locations and household locations spatially distributed over a large region would be prepared first. These would be based upon information about the highway system that the region was expected to have, though in fact, there would be, even at this early stage in the process, an inconsistency because the system that the region would be expected to have would show different characteristics to users as a function of what the users were doing about using the system, i.e. the traffic flows and congestion.

In any case, a set of forecasts would be developed and then, based on the forecasts of the location of employment and households, a set of estimates would be made of the number of trips originating from each zone and terminating in each zone. Then, a trip distribution procedure would be implemented that would calculate the number of trips going from each particular origin zone to each particular destination zone in the region. These trips would then be assigned to the links of the proposed highway network. Any of a variety of trip assignment algorithms might be used. The intention of any of them would be to calculate how many trips would travel across each of the individual links in the highway network. Then, based on the number of trips using each link, an estimate would be made of the congestion: the increased time or cost that would be experienced by each of the users of that particular link in the network.

Once these congestion levels have been calculated for all of the links in the network, it becomes possible to trace the minimum cost paths from each zone to each other zone over the congested network. Looking at these minimum cost paths as well as the congestion levels on individual links of the system, the conventional analysis procedure would then identify links that should have capacity increases, which normally would be accomplished by construction or modification of one sort or another. After these links have been identified, construction projects could be described and budgeted and the analysis would be completed in the form of a set of recommendations as to places where the network could be improved.

The defect in this procedure is that the congestion that results from the initial estimates of trip makers and thereby from the initial estimates of the locations of employment and households would, in and of itself, result over a long-term span of years, since forecasts traditionally are concerned with a re-arrangement of the locations of employment and households. Thus in order to properly estimate the congestion it is, in effect, necessary to know the congestion. In order to properly know the congestion, it is necessary to know the location of employment and population and the resulting demand for trip flow on the network and so on and so forth. This is a classical example of a system that can only be properly analyzed by use of an interactive technique that includes both the direct and the indirect connections or, as is sometimes described, both the feed-forward and the feed-back connections amongst the elements of the system.

A complementary system to this one is traditional land use or urban design analysis. In such a case, descriptions of the transportation system, which may include highway as well as transit, are taken from exogenous sources. That is to say, somewhere someone will provide an estimate of the zone-to-zone travel time and travel cost on various modes that a user might experience, let us say in the year 2010 or 2020. Based on these estimates, as well as on base year data regarding the initial locations of employment and households, and on a set of regional forecasts of total employment and total households, a calculation can be made that will estimate their location in the zones of the region. Often, a whole series of such forecasts will be made, at five- or ten-year intervals from some base year, out to some long-term planning horizon.

The defect in this approach, which is analogous to the defect in the traditional transportation planning approach, is that no cognizance is given to the fact that the locations of employees and households will, by virtue of the trips necessary to interconnect them, congest the network. The congested network times will, in most cases, be somewhat if not significantly different from the initial estimates of the network times. What is needed is an interactive procedure that includes both the effects of the location of employees and households on the transportation system as well as the variation of the location of employees and households caused by congestion-induced changes in the transportation system characteristics.

It is precisely this integrated interactive process that the original ITLUP model system was designed to properly represent. It is this transportation and land use consistency that is required as input to the air quality estimates now required by the CAA and TEA21 (and by ISTEA before that). Even the earliest tests of ITLUP, done nearly 20 years ago, showed that the interrelationships between transportation and land use can be just as important, and in some cases more important, than the individual direct consequences of either set of phenomena. Having articulated a framework for examining, or analyzing, or understanding the transportation and land use interactions, it then becomes possible to consider the consequences of a wide assortment of different kinds of policies. For the first time, this included policies that attempt to achieve their aims by changes on the demand side, in terms of urban design policies, land use control policies, and the like, as well as policies that attempt to achieve their aims by acting on the supply side in terms of various kinds of transportation improvements, either in highways or transit or combinations thereof, as well as in access and increases in utilization efficiency of existing facilities.

7. Forecasting with ***TELUM***

Land use forecasting is best done in time increments (usually of five years length), as this acknowledges the difficulties of obtaining data for any more detailed set of intervals, while at the same time allowing for some amount of adjustment of employment, residence, land use, and transportation forecasts in response to each other within these intervals. Each increment would begin with the execution of ***TELUM***-EMP. The model is normally used for 4 to 8 employment sectors with individually estimated parameters. To forecast the location of employment of type k in zone j at time t+1, ***TELUM***-EMP uses the following input variables:

- Employment of type k in all zones at time t
- Population of all types in all zones at time t
- Total area per zone for all zones
- Zone-to-zone travel cost (or time) between zone j and all other zones at time t.

Following the employment location forecasts produced by ***TELUM***-EMP, ***TELUM***-RES automatically produces a set of residence location forecasts. This model is normally used for 4 to 5 household types (usually income groups) with individually estimated parameters. Then, the land use submodel, LANCON, calculates land consumption, making a simple reconciliation of the demand for location by employers and households with the supply of land in each zone. To forecast the location of type h residents in a zone at time (t +1) ***TELUM***-RES uses the following input variables:

- Residents of all h types in zone i at time t (the previous time period)
- Land used for residential purposes in zone i at time t
- The percentage of the developable land in zone i that has already been developed at time t
- The vacant developable land in zone i at time t
- The zone-to-zone travel cost (or time) between zone i and all other zones at time t+1
- Employment of all k types in all zones at time t+1.

The residence and employment location forecasts produced by ***TELUM*** may then be used (sometimes after a further step of spatial disaggregation) as input to travel models that generate and distribute trips, split trips by mode, and then assign vehicle trips to the transportation network(s), and calculate congestion.

So, for example, one could take the outputs of ***TELUM*** and use these as inputs to the trip generation and distribution components of some standard transportation planning model package. Having completed the assignment of trips to the network using this package, one could calculate the minimum paths through the network. If multiple modes are being analyzed, the minimum times through the networks via these different modes are calculated. They would be combined in a composite cost calculation and then the composite cost estimates of zone-to- zone composite travel times or travel costs would be taken and used as inputs to the recalculation of employment and household location in ***TELUM***.

Many different configurations of land use and transportation linkages have been tested using ITLUP and ***METROPILUS***. While the current implementation of the ***TELUM*** model system does not permit all of these configurations to be examined, there is adequate scope, in an agency setting, for preparing an accurate baseline forecast, which can be used as inputs to the agency’s travel modeling system, as well as for making forecasts of the consequences of various possible policy alternatives. Throughout this manual we present a mix of theory discussion with instructions for specific model operation. Our intent is to enable thoughtful users to make effective use of this powerful analysis tool. In the next chapter we provide information on installing ***TELUM***, and follow this with a description of data requirements for use of these models. We then provide detailed instructions for the preparation of a small test data set to be used for the education of students and new users.

2. Installation of *TELUM*

1. Setup

System Requirements

It is imperative that the user follows these setup instructions closely. We cannot over emphasize the importance of this preliminary check and setup of your computer. Deviation from these instructions will cause your computer and ***TELUM*** to malfunction. To aid your successful installation of the ***TELUM*** system, use the following checklist.

Please review the list and confirm that everything is in order on your computer ***before*** you start the TELUM installation. We cannot overemphasize the importance of this preliminary check and setup of your computer. A successful TELUM installation depends on the following:

- Your computer must be equipped with a registered Windows 2000 (with the upgrade to Service Pack 5) or Windows XP (with Service Pack 2), and you must have the Microsoft Office software package, including full installation of Microsoft Access and Microsoft Excel.

- Microsoft Excel must include both the ***Analysis ToolPak*** and the ***Analysis ToolPak-VBA*** extensions. Please load these extensions before installing TELUM. Directions are provided below. Please note that some computer installations, especially in the case of networked systems have these extensions setup to be uninstalled when the user turns off their PC or even in some cases if they "log off" the network. You will need to be sure that they are present prior to each use of TELUM.

  [Open an Excel workbook, Go to ***Tools → Add-Ins***, click on ***Analysis ToolPak AND Analysis ToolPak-VBA***]

  Note: You might need to use your Microsoft Office CD-ROM in order to install these extensions. Please contact your systems administrator if you are experiencing problems loading these extensions.

- Microsoft Excel must be set on "Low" Macro Security whenever you are running your TELUM project.

  [Open an Excel workbook, Go to ***Tools → Macro → Security***, select "***Low***"]

- ***ESRI ArcGIS*** must be installed on your computer in order to use TELUM mapping module called MAPIT. Current version of TELUM is compatible with ***ArcGIS versions 8.3 and 9.x***.

- In addition to desktop installation of ArcGIS you also must install ***ArcGIS Developer Kit*** (versions 8.3, 9.0 and 9.1) or ***ArcGIS Desktop SDK for Visual Basic*** (versions 9.2). This is necessary as some of the ArcGIS scripts and software libraries used by TELUM are not installed with the ArcGIS basic desktop installation.

- If you do not have ArcGIS or you do not have a version of ArcGIS compatible with TELUM installed on your computer, you can not use MAPIT module. Please select "No" when prompted by MAP IT. The embedded GIS procedures of TELUM will only run with above versions of ArcGIS, though you can export completed calibration and forecasting data from TELUM after completing the runs and use them in other GIS software.

- Land use data values are to be in the unit of ***acres*** only.

- When prompted by TELUM, users are asked to place file(s) inside the TELUM project folder. Files copied into TELUM ***must not*** have the "read only" property. Check file properties after you copy them into TELUM folder, especially if you are copying them from a backup CD (many of which automatically set file property to "read only"). To change the "read only" property, please follow the instructions.

  [Select the file(s), then right-click mouse on the file(s), go to ***Properties → General***, and check if the property "***Read only***" is selected. If it is, then unselect it and click "***Apply***". Do the same with the rest of the files you copied in TELUM.]

- You should remove all former versions of TELUM prior to installing TELUM ver. 5.

  BEFORE removing former versions of TELUM, you have the option to save the data that you have already entered in TELUM's Dataprep.xls spreadsheet. In order to do that you should save your old dataprep.xls with a new name and in a different folder of your choice.

  AFTER installing the new version of TELUM, and when you have gotten to the Data Organization and Preparation Unit (DOPU) with your new dataprep.xls spreadsheet open, you will be able to transfer your data using ***Copy*** and ***Paste Special → Values***. Open the old (renamed) dataprep.xls directly (outside of TELUM). At the prompt click "***No***". The spreadsheet will open and you will be able to access your data.

  NEVER copy an old TELUM spreadsheet into a newer version of the program. The spreadsheets are not compatible and will cause malfunctions in your project.

  FYI, a safe way to uninstall former versions of TELUM is via the standard procedure that Microsoft Windows offers, using the "***Add/Remove Programs***" option:

[Go to ***Start → Settings → Control Panel → Add Remove Programs***. Scroll down until you find TELUM. Click on TELUM and then click on the "Change/Remove" button. In addition, go to TELUM folder and erase the whole folder.]

How to Install TELUM

1. Once you have checked off **ALL** of the above TELUM project requirements, begin your installation by double-clicking on the ***SETUP.exe***.

2. If you are installing TELUM from TELUS CD, during installation TELUM will ask you to select version of ArcGIS you are using. If you are using any of the 9.x versions, please select ArcGIS 9.0. If you do not have ArcGIS installed on your computer, please select "I do not have ArcGIS 8.3 or higher". Click "Install" button after making the above selections.

   OR

   If you are downloading installation files from TELUS/TELUM website, please select installation package that matches the version of ArcGIS that you currently have on your computer.

3. TELUM installation will begin automatically. Please follow the instructions on the screen.

4. At the conclusion of installation, your system will reboot automatically, unless you are using a Windows XP operating system. With Windows XP a reboot is not necessary.

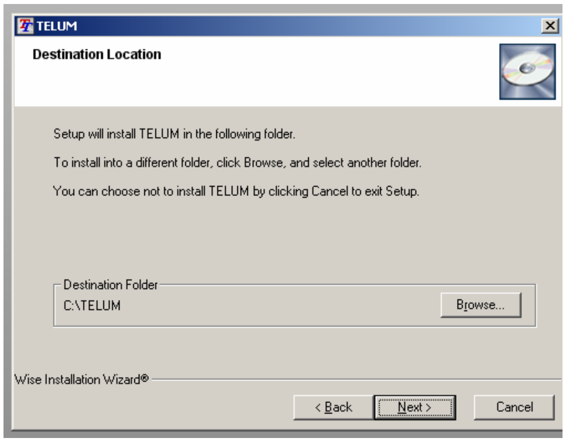
Running SETUP.EXE

1. The program will prompt you to choose an installation directory. The default directory is C:\TELUM. Click the **Browse** button to install the ***TELUM*** system on a different directory.

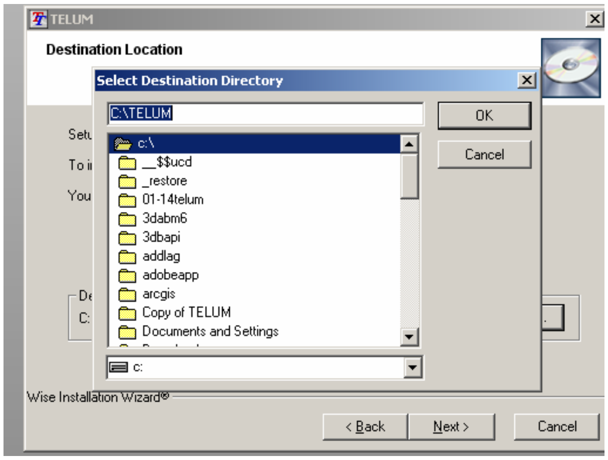
   ******NOTE**: *Please do not use any spaces in the name of the directory.*

   Correct: C:\TELUMNEW

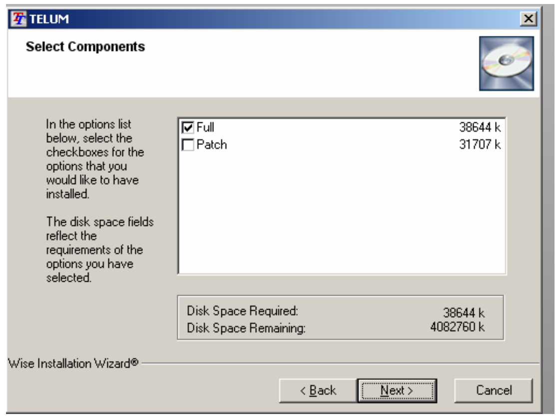
   Incorrect: C:\TELUM NEW



2. If you click the **Browse** button, you will see a dialog box similar to the one below, which allows the user to install ***TELUM*** into an alternate directory:



3. The installation package will then prompt you to select **Full** or **Patch** installation. For a new ***TELUM*** installation, you must select "**Full**." A "**Patch**" is only used for system upgrades.



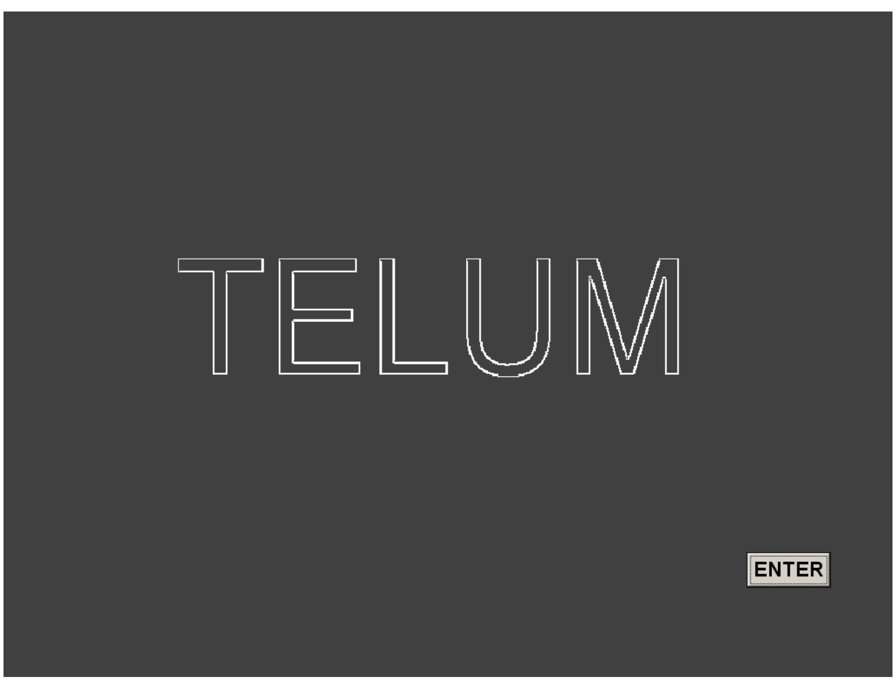
4. Installation will be completed a few seconds after your component selection is made.

5. Your project filename will be, by default, **TELUM.EXE**.

After installation, a shortcut to ***TELUM*** will be added to your computer as a Desktop icon. Your system will reboot automatically, unless you are using a Windows XP operating system, in which case a reboot is unnecessary.

2. Configuring *TELUM*

To open your project, go to the **Desktop** and locate the ***TELUM*** icon for your project. When you double-click the ***TELUM*** icon you will see this screen:



Username Settings

When you open your ***TELUM*** project for the first time, you will be prompted to create a username and password. At this time, this function is set with a default username and password. When prompted enter you will need to enter username and password in order to start the application. To obtain the username and password, please contact TELUM user support or FHWA Resource Center (please refer to Section 4. User Support (below) for contact information).

3. How to Change or Move Your *TELUM* Project

With an installed version of ***TELUM*** on your computer you can begin land use modeling activities for your agency. If at any time you should decide to change or move your agency project you must re-install ***TELUM*** onto another computer. If you decide to reinstall ***TELUM*** on a machine where you are currently running a ***TELUM*** project, it is imperative that you rename your old ***TELUM*** folder or modify the name of the new folder. Otherwise ***TELUM*** will reinstall itself over the existing C:\TELUM folder and the resulting file mismatches will render both the original and new versions of ***TELUM*** inoperable.

Circumstances that require a *TELUM* Reinstallation

The following types of project change cannot be accomplished within an existing ***TELUM*** project. To change any of the following, you must reinstall ***TELUM***.

1. The number of zones increases or decreases.
2. The number of employment and/or household categories increase, decrease, and/or change names.
3. Your agency builds a new regional GIS shapefile for your ***TELUM*** project.
4. Your ***TELUM*** project is being relocated to a different computer.

Once installation has been successfully completed, we strongly recommend the you run through the Tutorial section in Chapter 3 to familiarize yourself with the data entry and program requirements. This tutorial offers valuable practice and will reduce the danger of errors in your forecast. Based on extensive testing, it is extremely unlikely that you will be able to successfully complete a forecast without the operating skills gained through running the ***TELUM*** Tutorial.

Instructions for installing the ***TELUM*** Tutorial are covered in the next chapter of the manual.

4. User Support

For user support please visit TELUS website at www.telus-national.org. If you are an MPO, State DOT, or other public transportation or planning agency in the United States you can also contact TELUS development team:

Transportation, Economic and Land Use System (TELUS)
New Jersey Institute of Technology
Tiernan Hall, Suite 287
University Heights
Newark, NJ 07102
E-mail: telus@njit.edu
Phone: (973) 596-5700
Fax: (973) 596-6454

If you are not an MPO, State DOT, or other public transportation or planning agency in the United States, please contact Federal Highway Administration (FHWA) Resource Center for more information about user support for TELUM:

FHWA - Office of Planning
Lorrie Lau
Senior Transportation Planner
1200 New Jersey Ave, SE
Washington, DC 20590
E-mail: lorrie.lau@dot.gov
Phone: (415) 265-2589

3. *TELUM* Tutorial

Tutorial Contents:

1. Introduction

Welcome to the ***TELUM*** Tutorial. This tutorial is a 20-zone student ***TELUM*** project for Rancho Carne, a fictitious California coastal region. Please use this document and the accompanying data inside the *Tutorial* folder to walk-through the Rancho Carne project. The *Tutorial* folder is located on your ***TELUM*** CD-Rom. This data set was originally developed by Daniel Schack and Leah Wright as one of the requirements for a course on Urban Simulation Modeling taught by Dr. Putman. It has since been modified to improve its teaching function.

How to use this Tutorial

This tutorial is intended to provide an overview of ***TELUM*** as well as practice in data entry and output comprehension. The *Tutorial* folder contains all the files and data you will need to complete a calibration and a set of model forecasts for the Rancho Carne region.

As you work through this project hyperlinks are available to help explain the various functions and data inputs more thoroughly than you will see here. Throughout this tutorial you will see screen numbers used to refer to various sections of the ***TELUM*** software. These screen numbers are located in the lower left corner of each ***TELUM*** screen. (e.g. **P3.15.1**) If you have a question or concern while you are working with ***TELUM***, you must record the screen number where the problem occurred. Referencing a screen number improves the ***TELUM*** staff's ability to respond to your question or concern in a timely manner.

After you have completed this tutorial you will be better prepared to build and run a ***TELUM*** project for your region.

2. Initial Data Entry Unit (*IDEU*)

In this section you will do the following:

1. Install ***TELUM***
2. Enter your ***TELUM*** username and password
3. Start your ***TELUM*** project
4. Review and enter regional data

1. Install *TELUM*

Begin by performing a ***TELUM*** installation, as described in Chapter Two of this manual.

2. Enter ***TELUM*** Username and Password

Once you have completed the installation process, a ***TELUM*** icon will appear on your computer's desktop. Double-click on the ***TELUM*** icon. Upon entering ***TELUM***, the program will prompt you to enter your username and password. To obtain the username and password, please contact TELUM user support or FHWA Resource Center (please refer to Chapter 2, Section 4. User Support for contact information).

3. Start your ***TELUM*** project

After a series of welcome screens, the opening screen appears with a number of colorful buttons. These buttons later allow you to skip directly to different sections of the ***TELUM*** system. You will only use these buttons later, when you click "**EXIT**" in ***TELUM*** and subsequently wish to return to the section in which you stopped working. However, at this point, your first time through, you must begin by clicking on "**CONTINUE**" to enter the Initial Data Entry Unit (*IDEU*).

4. Review and Enter Regional Data

IDEU is where you provide ***TELUM*** with the basic information the system will need to organize your region's data. The purpose of *IDEU* is to help you prepare the data you will need in the next component of ***TELUM***, *DOPU*. Listed below are the ***TELUM*** data requirements for *IDEU*. The last column contains sample data you will use to run your tutorial session.

Enter Your Rancho Carne *IDEU* Data

The sample data inputs below contain employment and household activity name abbreviations for the Rancho Carne region. Employment and household activity name abbreviations will vary from one ***TELUM*** project to another. The definition of each abbreviation follows the table below:

Screen	*TELUM IDEU* Data Categories	Sample Data for Rancho Carne, CA
P2.3	Name of your Region	RC
P2.4	Number of Zones	20
P2.4	Total Regional Population	62819
P2B.7	Current Data Year	2000
P2B.7	Lag Data Year	1995
P2B.8.1	Number of Employment Categories	5
	Name of Employment Category 1	AGR
	Name of Employment Category 2	LMFG
	Name of Employment Category 3	PROF
	Name of Employment Category 4	RTL
	Name of Employment Category 5	FIRE
P2B.9.1	Number of Household Categories	4
	Name of Household Category 1	LI
	Name of Household Category 2	MI
	Name of Household Category 3	UMI
	Name of Household Category 4	UI
P2B.12	Total Land Area of Region	184,332
P2B.12.1	Total Land	Available
	Usable Land	Available
	Unusable Land	Available
	Land Used for Basic Employment	Available
	Land Used for Commercial Employment	Available
	Residential Land	Available
	Streets	Available
	Vacant Developable	Available
P3.13.1	Number of Forecast Time Periods	6
P3.15	Employment to Household Conversion Ratio	PUMS Ratio
P3.16.1	Employment per Household by Income	EHIC Ratio
P3.17	Unemployment	UR Ratio
P3.18	Net Commutation Rate	RNCR Ratio
P3.19	Regional Jobs per Employee	Select “Do Not Know”

RC- Rancho Carne
AGR- Agriculture
LMFG- Light Manufacturing
PROF- Professional/Scientific/and Management
FIRE- Finance/Insurance/and Real Estate
LI- Low-income Households
MI- Middle-income Households
UMI- Upper Middle-income Households
UI- Upper-income Households
PUMS- Public-Use Microdata Sample
EHIC- Employees per Household by Income
UR- Unemployment Rates
RNCR- Regional Net Commuting Ratio

After entering your regional data, ***TELUM*** provides a summary report of the data you entered in *IDEU*, as pictured below. Please compare this report to your data to ensure accuracy.

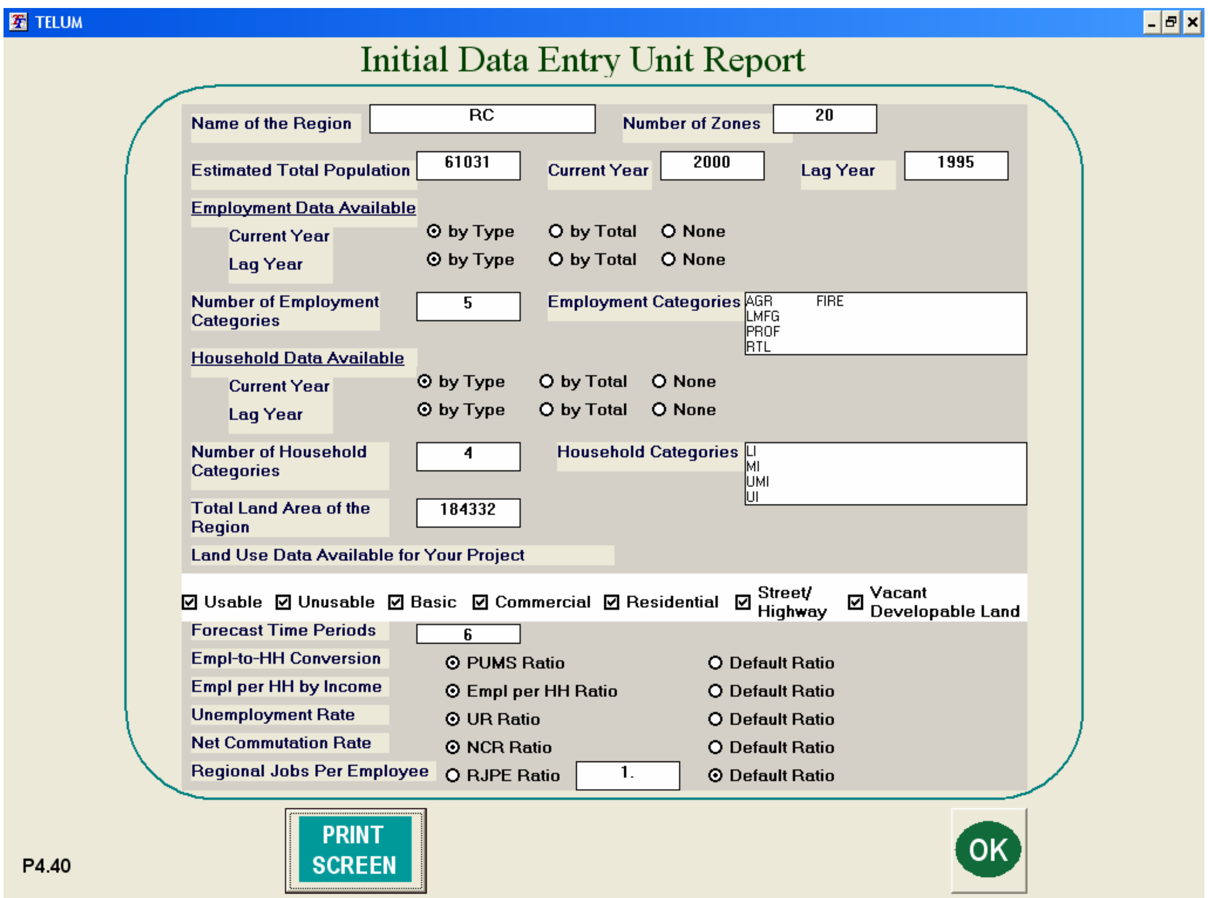


Figure 1- IDEU Initial Data Entry Unit Report

3. Data Organization and Preparation Unit and *MAP IT*

In this section you will do the following:

1. Work in the **Data Preparation Workbook**
2. Check the consistency of the link between *IDEU* data and the *GIS* files in *MAP IT*

1. Work in the *DOPU* Workbook

You will enter zonal data related to the employment, household, and land use activity taking place in your region. Zonal data for Rancho Carne is available in the RC_DOPU_DATA.xls file located in the *Tutorial* folder.

Enter Your Rancho Carne *DOPU* Data

Upon entering the *DOPU* Workbook, you will be prompted to answer if this is your first time (or not) entering DOPU module. For the purpose of this tutorial click on the "Yes" button.

Working with your *DOPU* Workbook

You may enter the Rancho Carne data into the ***TELUM*** *DOPU* Employment, Household, Land Use and Projection Worksheets manually or by using the "copy" option.

*****NOTE-** The data will paste correctly **only** if you use the "**paste special**" options in Excel. Import data from your worksheet using "paste special" as "**values**."

You need to import data into the blue cells only in your *DOPU* worksheets. Once your data is correctly imported, **your zonal household, population, and employment numbers will appear** in the worksheet. An example of these worksheets as you will first see them before data entry into the *DOPU* workbook follows:

Households: 2000												
Zone	*HH1 2000*	*HH2 2000*	*HH3 2000*	*HH4 2000*	*HH5 2000*	*HH6 2000*	*HH7 2000*	*HH8 2000*	*Total Households 2000*	*Population in Group Quarters*	*Total Household Population 2000*	*Average Population per Household 2000*
1	0	0	0	0	0	0	0	0	0	0	0	0.000
2	0	0	0	0	0	0	0	0	0	0	0	0.000
3	0	0	0	0	0	0	0	0	0	0	0	0.000
4	0	0	0	0	0	0	0	0	0	0	0	0.000
5	0	0	0	0	0	0	0	0	0	0	0	0.000
6	0	0	0	0	0	0	0	0	0	0	0	0.000
7	0	0	0	0	0	0	0	0	0	0	0	0.000
8	0	0	0	0	0	0	0	0	0	0	0	0.000
9	0	0	0	0	0	0	0	0	0	0	0	0.000
10	0	0	0	0	0	0	0	0	0	0	0	0.000

Figure 2- *TELUM* DATAPREP – Households Worksheet for Current Year Zonal Data

	Population	Employment								
Year	Total Population	Employment 1	Employment 2	Employment 3	Employment 4	Employment 5	Employment 6	Employment 7	Employment 8	Total Employment
1995	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0

Household Size:	0.0000

Figure 3- ***TELUM*** DATAPREP – Projections Worksheet

*****NOTE-** The data will paste correctly as values **only** if you open **both** the *DOPU* Workbook **and** the RC_DOPU_DATA.xls in the same instance of Excel. Do this by opening the *DOPU* workbook through ***TELUM*** as instructed. Then open your regional data workbook from which you will paste your data by choosing ***File>Open*** and browsing to locate the other file.

After pasting, save your *DOPU* Workbook and RC_DOPU_DATA.xls by clicking on ***File > Save***.

After you have finished entering data into each of your *DOPU* worksheets, click again on ***File > Save***. There will be an **X** on the main worksheet next to each workbook name, as shown below.

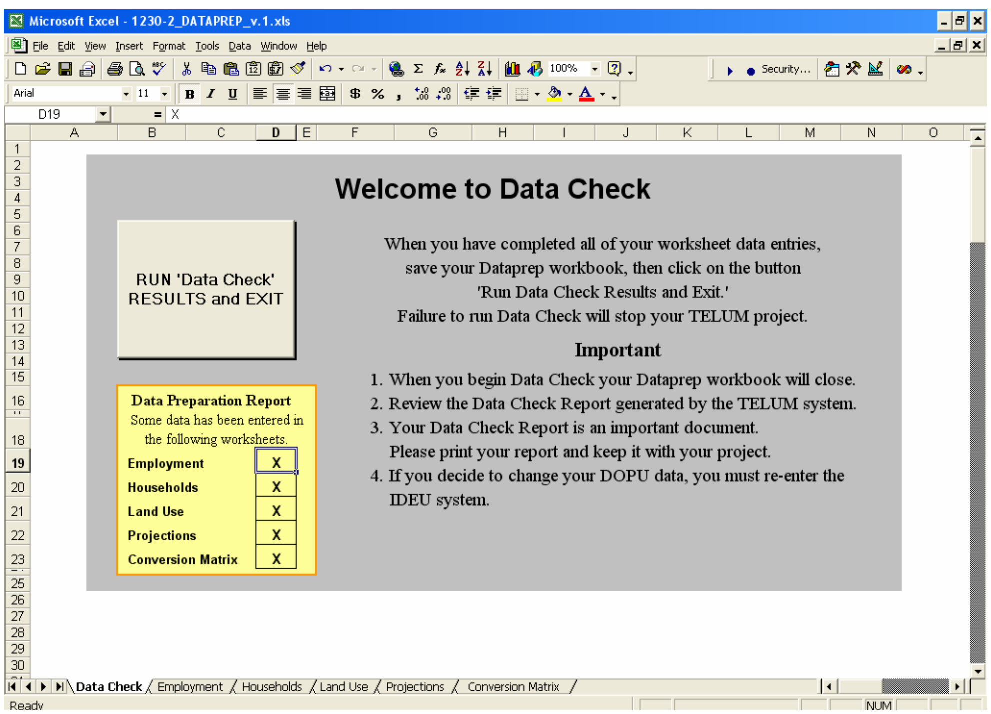


Figure 4- *DOPU* Opening Screen

*****NOTE-** Please save and exit the RC_DOPU_DATA.xls file **before** running the *DOPU* Workbook "Data Check."

The “**Run Data Check Results**” button inside the “Data Check” worksheet will then be enabled when you click this button. ***TELUM*** will then run a consistency check of your data. In this report, ***TELUM*** will highlight values that are not within the predefined ranges considered normal. We strongly recommended that you review these reports and pay special attention to any highlighted values.

Check Your Data Consistency Results

The following chart contains the values we expect you will see as you view your *DOPU* Data Consistency Check for Rancho Carne.

Screen	Data Variable	Value
P4.30	Correlations	
	Total Current vs. Lag Household Correlation	0.786
	Total Current vs. Lag Employment Correlation	0.924
	Total Household vs. Employment Correlation	-0.186
	Total Household vs. Population Correlation	0.997
P4.30.1	Employment Correlations	
	AGR vs. AGR	0.830
	LMFG vs. LMFG	0.946
	PROF vs. PROF	0.921
	RTL vs. RTL	0.967
	FIRE vs. FIRE	0.926
P4.30.3	Consistency Check of Regional Ratios	
	Population per Household	2.5
	Population per Employment	1.8
P4.30.2	Percentage Change	
	Households	10.2%
	Employment	11.0%
	Population	11.5%
	Employment, Current to Forecast	2.6%
	Land Use Check	0

If consistency results in the tutorial or later with your regional data show red text or a warning, this indicates low or high correlations or percentage change in parameters. If this occurs, you should double-check your data entries and agency sources for accuracy. In the Racho Carne example, there is a low correlation for total households vs. employment, as place of residence in this region do not correlate with place of work.

2. *MAP IT* - Check Zones and Data Check

If you have ArcView 8.3 installed on your computer system, you have access to ***TELUM*** *MAP IT*, a mapping tool for visually displaying your data and your calibration and forecasting results. In this section, ***TELUM*** will ask you if you wish to use *MAP IT*. If you select "**No**," this will be the last time ***TELUM*** presents *MAP IT* as an option.

If you should decide to use *MAP IT* later, you will need to revisit the ***TELUM*** *DOPU* section and select the "**Yes**" option. If you select "**Yes**," *MAP IT* will require a set of regional shapefiles inside the main ***TELUM*** folder. Inside your *Tutorial* folder is a set of shapefiles for Rancho Carne, labeled ZONE.SHP, ZONE.DBF, ZONE.SHP.XML, ZONE.SHX. Place these four files inside the main ***TELUM*** folder before enabling the *MAP IT* function.

Launch *MAP IT*

TELUM begins *MAP IT* by instructing users to complete a mapping check, called "Check Zones." "Check Zones" is used to ensure mapping consistency. If they find their check zone maps to be inaccurate, the user must correct the problem before this feature can be enabled for future use. *MAP IT* will prompt you to "select the shapefile field that contains the zone number." For your Rancho Carne project, select the "**ID**" field.

*****NOTE-**If you do not select the "**ID"** field when prompted as you enter *MAP IT* for the first time, your data will not map correctly.

You can change the appearance settings of your maps as desired. The following are examples of the Highest Total Employment and Upper Middle Income Household Location maps from the Rancho Carne data:

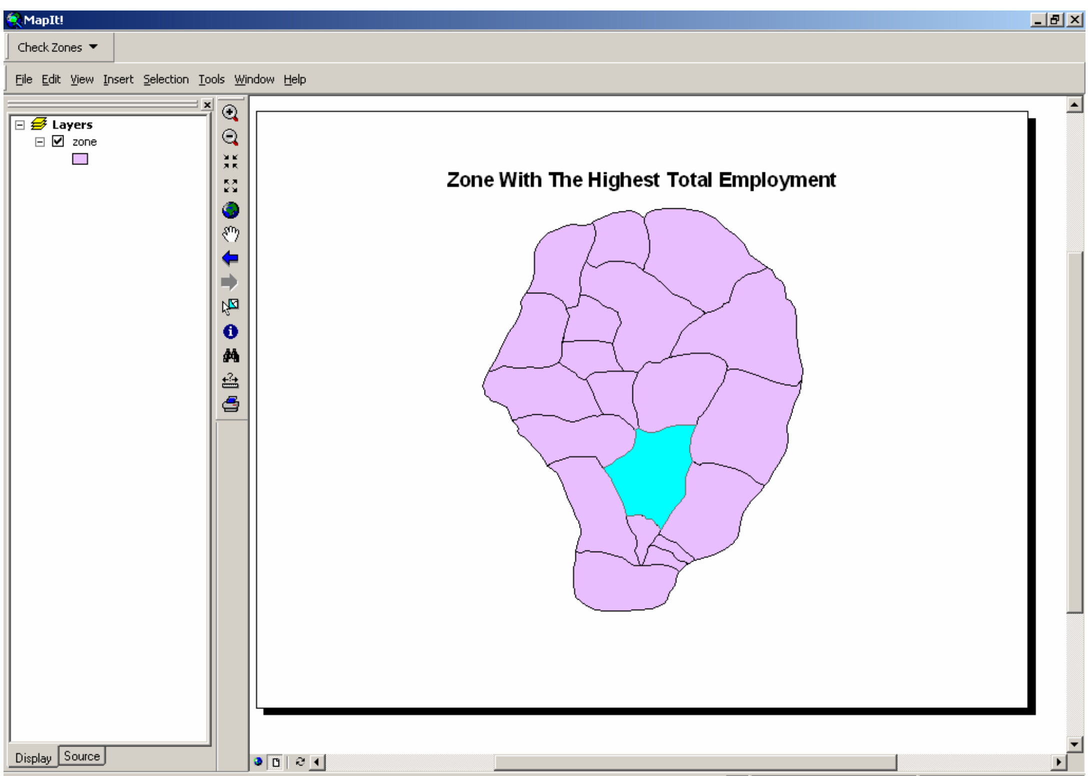


Figure 5- MAP IT Output 1

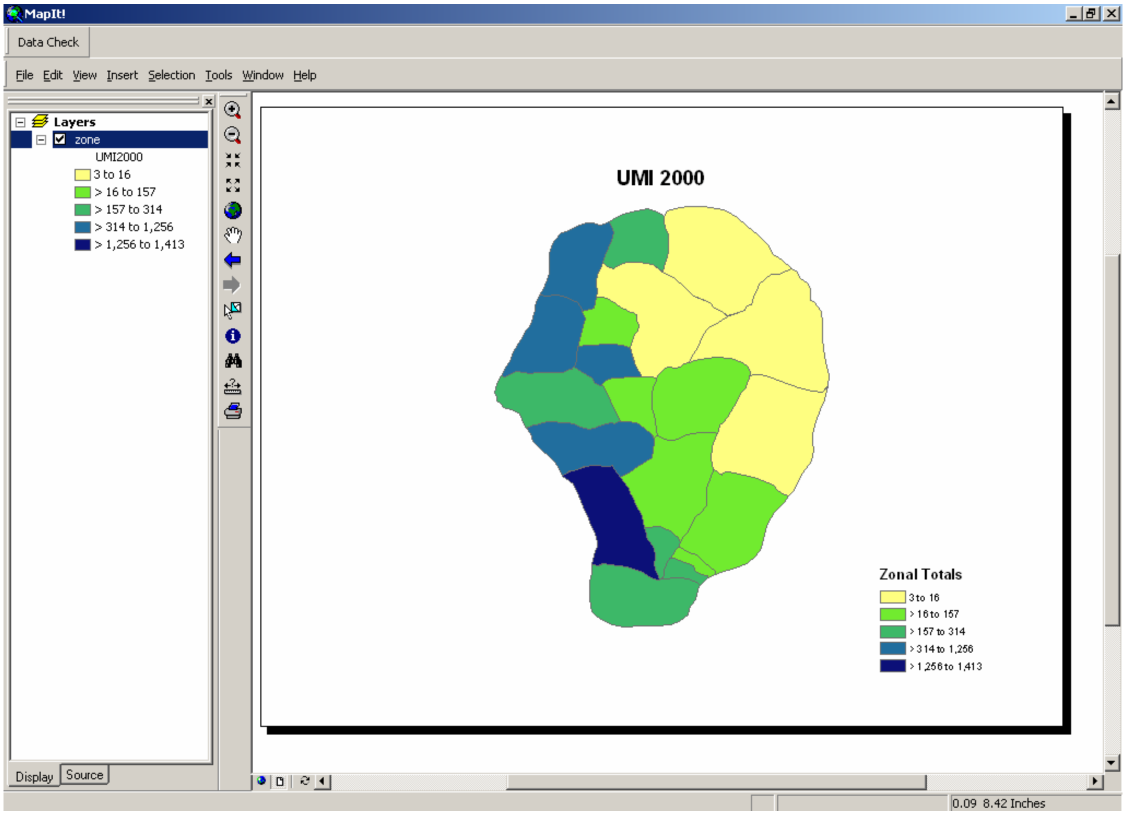


Figure 6- MAP IT Output 2

When you have finished working in *MAP IT*, please exit ArcView to return to ***TELUM***.

After you have viewed "Check Zones" in *MAP IT*, ***TELUM*** will prompt you to answer three questions regarding your maps. For the purpose of this tutorial, please answer "**Yes**" to all of the "Check Zone" questions.

4. Travel Impedance Preparation Unit

In this section you will prepare a Travel Impedance File. The term "impedance" refers to the travel time, travel cost, or a composite of both, calculated by travel models not included in ***TELUM*** to describe differences in zone-to-zone difficulty of interaction. An impedance file would typically be available from your agency's transportation department. ***TELUM*** provides steps and examples for converting an impedance file for your ***TELUM*** project. For the Rancho Carne project, an impedance file is provided in your *Tutorial* folder, labeled IMPD.txt. Place this IMPD.txt file inside your C:\TELUM\DATA folder if it is not already there. Instructions for creating an IMPD.txt file with your regional data are provided in Chapter 4, Data Preparation.

TIPU Impedance Data Inputs

The Travel Impedance Preparation Unit (*TIPU*) runs a data validation procedure on the contents of your IMPD.txt file. In order to run this validation you must enter the following data into ***TELUM*** as you work through the *TIPU* section.

Screen	*TIPU* Data Variable	Input Value
P5.30.3	Average Impedance	87
P5.30.4	Smallest Impedance	7
P5.30.5	Largest Impedance	197
P5.30.6	Top 4x4	
		10, 45, 31, 87
		45, 7, 30, 42
		31, 30, 8, 67
		87, 42, 67, 23
P5.30.7	Bottom 4x4	
		14, 61, 39, 28
		61, 14, 34, 33
		39, 34, 28, 21
		28, 33, 21, 29

When you have completed these steps correctly, ***TELUM*** will search for the impedance file, verify its contents, and display the frequency distribution of impedences by zone. You will then automatically be escorted into the next section, *MCPU*.

5. Model Calibration and Preparation Unit

In this section you will do the following:

1. Run a Model Calibration
2. Review the Calibration Analysis of Results and *MAP IT*
3. Run a Land Consumption Regression Model

1. Run Employment and Household Model Calibrations

Model calibration is a process of estimating the model parameters (equation coefficients) to obtain a match between observed and model estimate distributions of a region's employment and household location. The Employment and Household Model Calibrations are calibrated by use of non-linear regression. ***TELUM*** will use your *IDEU*, *DOPU*, and *TIPU* inputs to run the model calibration. The calibration is computationally intensive and may take up to 30 minutes to complete. Upon completion of the employment and household calibration, ***TELUM*** immediately provides a calibration "Analysis of Results" section.

2. Review Calibration Analysis of Results

The Analysis of Results contains statistical measures used to describe the model's fit to your data. The better the fit of the model to the data, the more reliable the forecasts it can produce. An example of calibration results for Observed vs. Estimated Employment Location for the Retail category of employment follows:

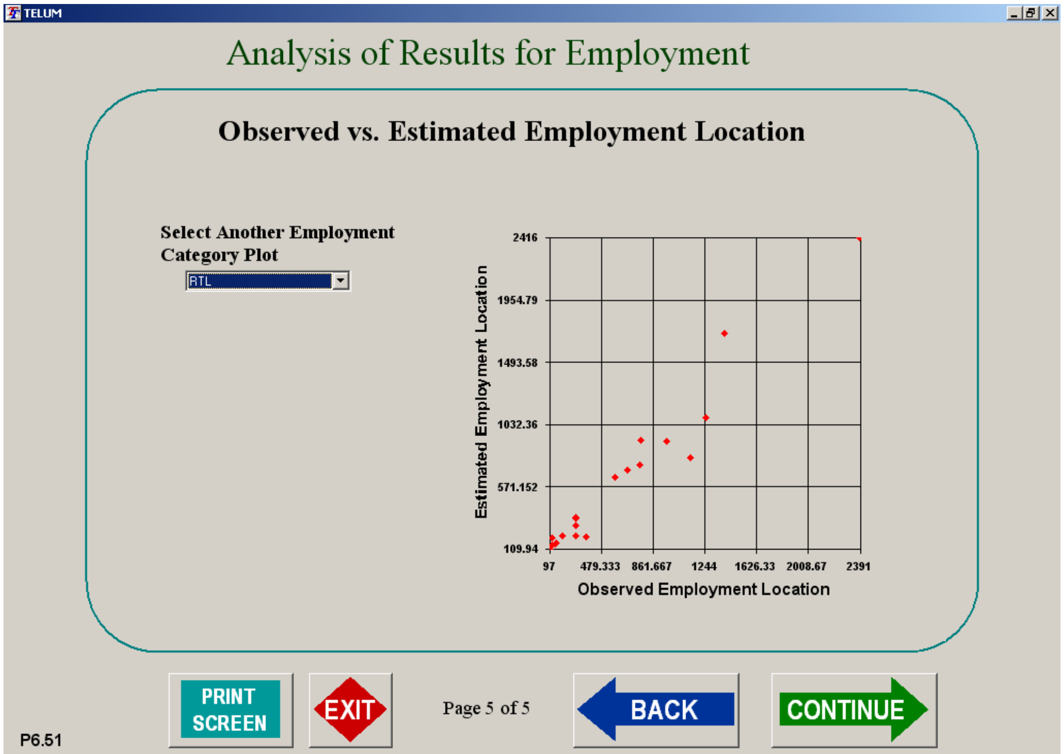


Figure 7- MCPU Analysis of Results for Employment

MAP IT also appears in this section for you to view your Calibration Residuals. Residual maps show where the model over and under estimates the zonal location of employment and households in the region. An example of MAP IT outputs for Low Income Household Residuals follows:

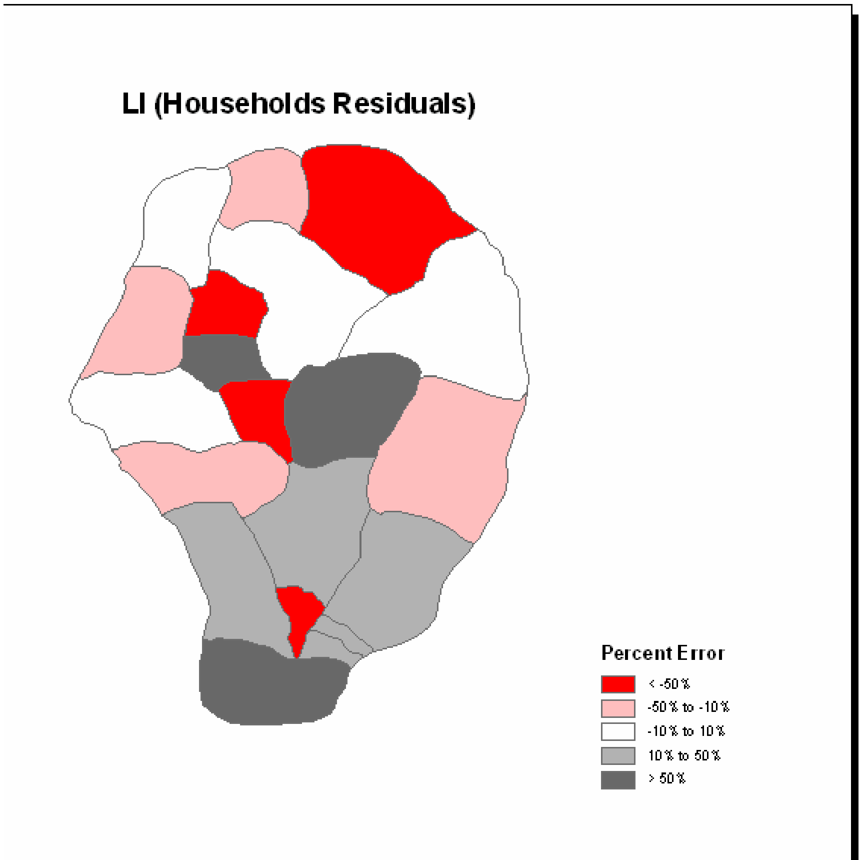


Figure 8- MAP IT Output 3

To explain the role of calibration residuals, let's assume that a zone in Rancho Carne contains the regional airport. The presence of the airport shows a concentration of employment. Under other circumstances, a concentration of employment like this will cause an increase in household attraction, which is not the case here because households are prohibited from locating near the airport. While the model is unable to know zonal specifics, a user may be able to identify the model's source of high over or under estimation. A zone with a high over estimation of households, as discussed in this example, will appear in the darkest gray scale shade. Zonal characteristics like this are important to document as they can later be added as "local knowledge" to the model to modify zone attractiveness and thus improve the accuracy of forecasts.

3. Run a Land Consumption Regression Model

The Land Consumption Model (LANCON) is the last section in the *MCPU* component. LANCON uses your land use, employment and household data to forecast the change in the amount of land, by zone, that will be used by each of these categories. LANCON calibration is done by use of linear multiple regressions. Much like the employment and household calibration analysis, LANCON provides statistical measures for your region's land use data.

At the startup of LANCON, the calibration (regression) procedure will ask you to enter the following:

1. Indicate for ***TELUM*** which employment categories in Rancho Carne are Basic. (Basic categories are industries that produce goods.) For Rancho Carne please check **AGR** and **LMFG**.

2. Indicate for ***TELUM*** which household categories in Rancho Carne are Low and High Income. (Low and High incomes refer to households that fall in the bottom or top quartile/quintile in the region, respectively.) For Rancho Carne please check **LI** as your Low Income household category and **UI** as your High Income household category.

3. Execute LANCON by clicking on the **LANCON** button. This process takes time. Please wait for the **Continue** button to become enabled before trying to proceed.

4. Your LANCON findings will be displayed by Residential, Commercial, and Industrial Land Consumption category in the **LANCON** Statistical Report. A sample report looks like this:

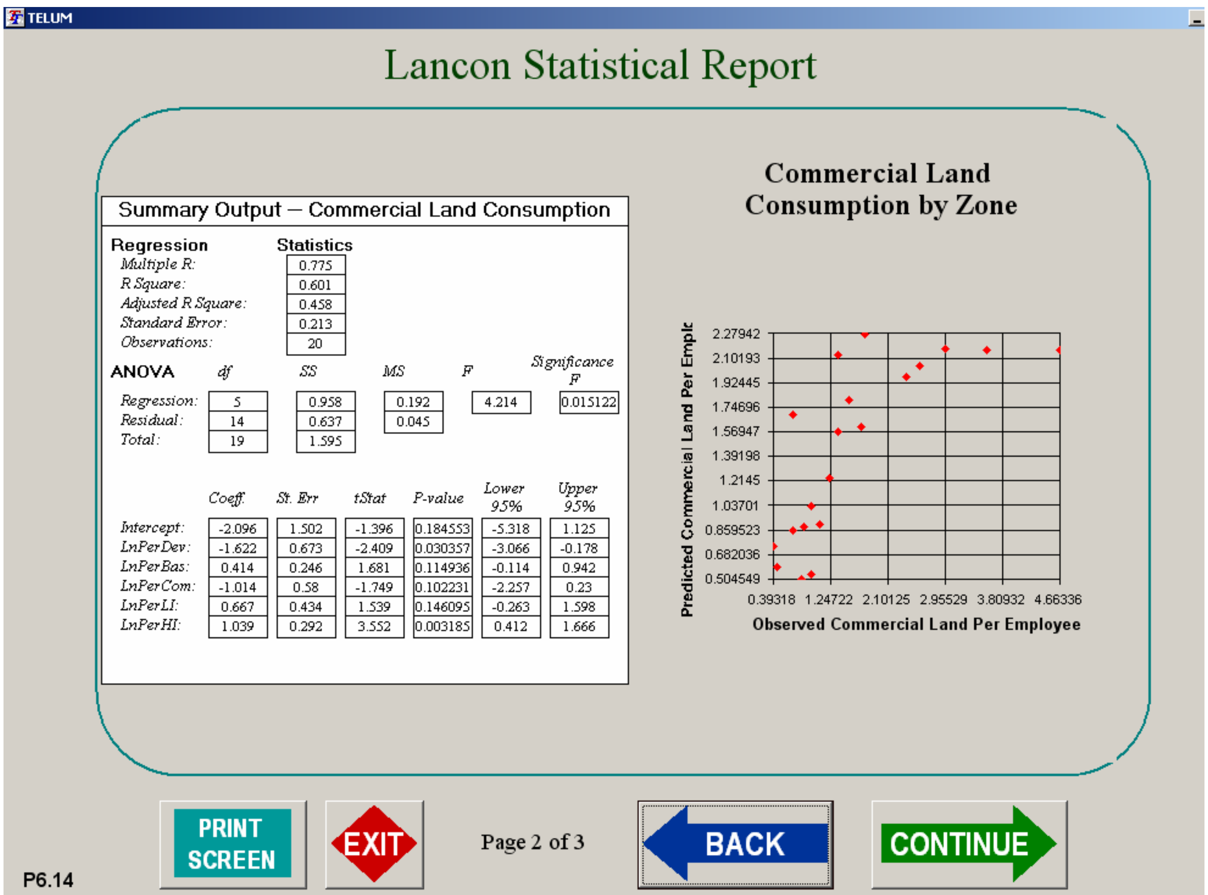


Figure 9- LANCON Statistical Report

Explanation of LANCON findings

LANCON calibration is done with multiple regression analysis. The results of LANCON calibration are given in terms of goodness of fit of the model to the data. In an actual agency project the user might wish to examine land use types and zones for which there were large errors to see whether data corrections would improve results.

6. Model Forecasting Unit

In this section you will do the following:

1. Prepare Files for a Forecast Model
2. Run a Baseline Model Forecast
3. Rerun a Model Forecast
4. Run a Policy Model Forecast
5. *MAP IT* - Map and Compare Forecast Results

1. Prepare Files for a Forecast Model

When you enter the *Model Forecasting Unit*, ***TELUM*** prepares your files for the first set of model forecasts, called "Baseline." Baseline forecasting is the spatial allocation of employment and households to zones based on an observed level of activity and calibrated attractiveness variables obtained from your current and lagged year data inputs. During your Baseline forecast ***TELUM*** provides you with an opportunity to:

- Change the number of "forecast time periods"
- Add an additional impedance file for a future forecast time period
- Change your region's total employment and household projections

2. Run a Baseline Model Forecast

For Rancho Carne, run your Baseline forecasts with changes to the forecast time periods, impedance file, and projections table as shown below:

Screen	MFCU Variable	Input Value
P7.26.1	Change Regional Employment and Household Projections	No
P7.13	Add Future Impedance File	No
P7.6	Continue with Forecast Time Periods	Yes
P7.5	Impose Employment or Household Constraints	No

At the conclusion of your Baseline forecast, ***TELUM*** will immediately provide an "Analysis of Forecast Spatial Patterns" to summarize the growth/decline of the region's employment and household spatial allocations. It is important to review this report carefully in conjunction with the *MAP IT* Forecasting results.

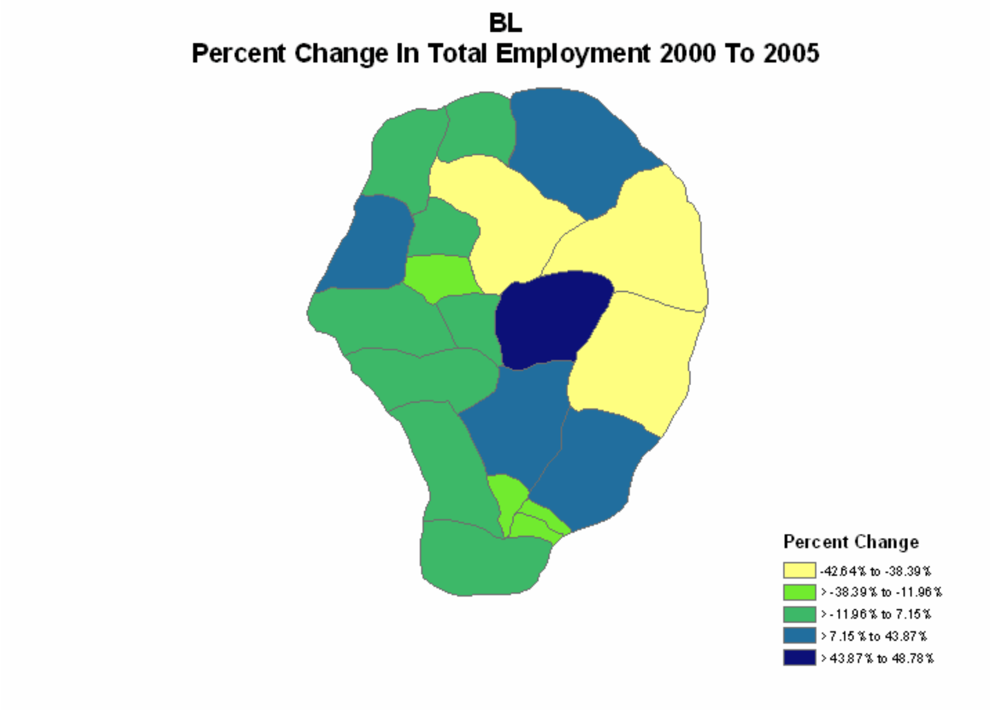


Figure 10- MAP IT Output 4

After you review “Analysis of Forecast Spatial Patterns” ***TELUM*** screen **P7.8.1** prompts you to select one of the following tasks:

1. Rerun a Model Forecast
2. View a prior Model Forecast
3. Run a new Model Forecast
4. Exit the ***TELUM*** system

3. Rerun a Model Forecast

Upon completion of your baseline or policy forecast(s), you may elect to rerun the forecast with changes to the regional data inputs. ***TELUM*** walks you through a series of information screens that are used to organize and store your next model forecast. The following options are presented to screen **P7.8.3**:

- Change the original *DOPU* data set.
- Change the regional control totals inside the *DOPU* Conversion Matrix.
- Add or change a future year impedance file.
- Change the regional employment and household projections.

****NOTE When rerunning a policy forecast, users may only select options C and D.

Rerun the Rancho Carne Baseline Forecast

The following charts provide the information and data you will need to provide ***TELUM*** for the "Rerun" of Rancho Carne's "Baseline" forecast.

Screen	MFCU Rerun Variable Inputs	Input Value
P7.8.1	Forecasting	Rerun Model Forecast
P7.8.1A	Rerun Model Forecast	Baseline
P7.8.1C	Model Forecast File Storage	OLD-BL
P7.8.3	Do you wish to make changes?	EMP/Household Projections
P7.6	Forecasting Time Periods	Yes
P7.8.4	Enter new EMP/Household Projections	See table below
P7.13	Travel Impedance	No

When prompted by ***TELUM***, enter the following projections into the Employment and Household projections table:

	Population	Employment					
Year	Total Pop	AGR	LMFG	PROF	RTL	FIRE	Total Emp
1995	57450	1977	3820	4123	11755	7408	29083
2000	62819	1936	5434	6121	11121	6402	31003
2005	70016	851	9599	5670	10787	8103	35010
2010	74750	834	10227	6324	11492	8346	37223
2015	77219	751	11084	6975	12299	8763	39872
2020	79664	669	11398	7248	12845	8938	41098
2025	81953	710	11611	7486	13141	9117	42065
2030	82776	684	11743	7573	13274	9482	42756

4. Run a Policy Model Forecast

Agencies often run model forecasts in addition to their "Baseline" set referred to as a "Policy" forecast. For a "Policy" forecast a user must intend to:

- Add or change a future year impedance file
- Change the regional employment and household projections

Run a New Forecast for Rancho Carne

The following charts provide the information and data you will need to provide to run this "New" forecast for Rancho Carne. In this new forecast you will add a "Future Year Impedance" file for the year 2010. Rancho Carne has adopted a new tax incentive policy in zones 6, 7, 16, 17, and 18 that is expected to increase both employment and households to these areas. With an increase in population and employment, Rancho Carne's transportation department has issued new travel impedances for 2010. Your new policy run name is FC2 (Forecast 2). The following charts provide the information and data you will need to complete this "New" forecast.

Screen	MFCU New Run Variable Inputs	Input Value
P7.8.1B	New Forecast Name	FC2
P7.8.3	Do you wish to make changes?	Add Impedance file
P7.15	Travel Impedance Data	1; 2010
P7.16	Move your IMPD10.txt file into the ***TELUM*** \DATA folder.	
P7.19	Impedance File values	see table below
P7.6	Forecasting Time Periods	Yes
P7.8.4	Enter new EMP/Household Projections	No

Page	Future Year IMPD10	Input Value
P7.19	Average Impedance	82
	Smallest Impedance	7
	Largest Impedance	197
	Top 4x4	
		10, 45, 31, 87
		45, 7, 30, 42
		31, 30, 8, 67
		87, 42, 67, 23
	Bottom 4x4	
		98, 427, 273, 28
		427, 98, 238, 33
		273, 238, 196, 21
		28, 33, 21, 29

5. *MAP IT* - Map and Compare Forecast Results

With a Baseline and FC2 forecast completed, you can launch the Forecasting *MAP IT* if you have ArcView capabilities. *MAP IT* provides a variety of Mapping Options to help you visually interpret the spatial changes in your region's employment and household location.

The Mapping Options in *MAP IT* Forecasting include:

- Zonal Forecasts- the zonal value for each employment and household category present
- Calculated Zonal Differences- the zonal growth/decline of each employment and household category between two time periods and/or forecast runs
- Calculated Zonal Percent Change- the zonal growth/decline between two time periods and/or forecast runs expressed as a percentage
- Simple Zonal Density- total zonal developable land divided by the total number of zonal employment and/or households observed

An example of Baseline and New Forecast *MAP IT* outputs follows:

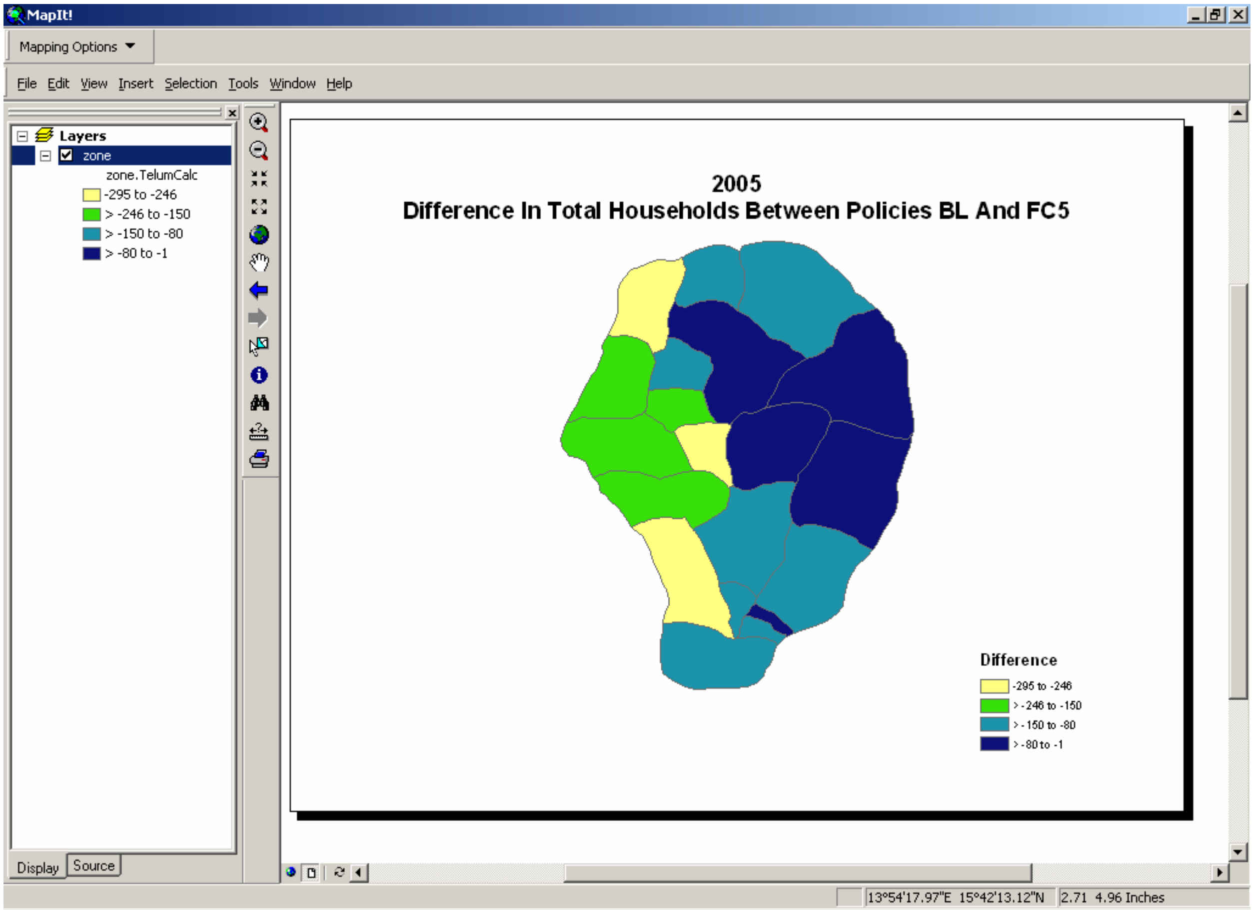


Figure 11- MAP IT Output 4

This concludes your ***TELUM*** Tutorial. If you have questions, please feel free to contact the ***TELUM*** staff.

J.Brugger, 2004 Oct 15
C:/Putman/Putman/Edits/22EDITTELUM

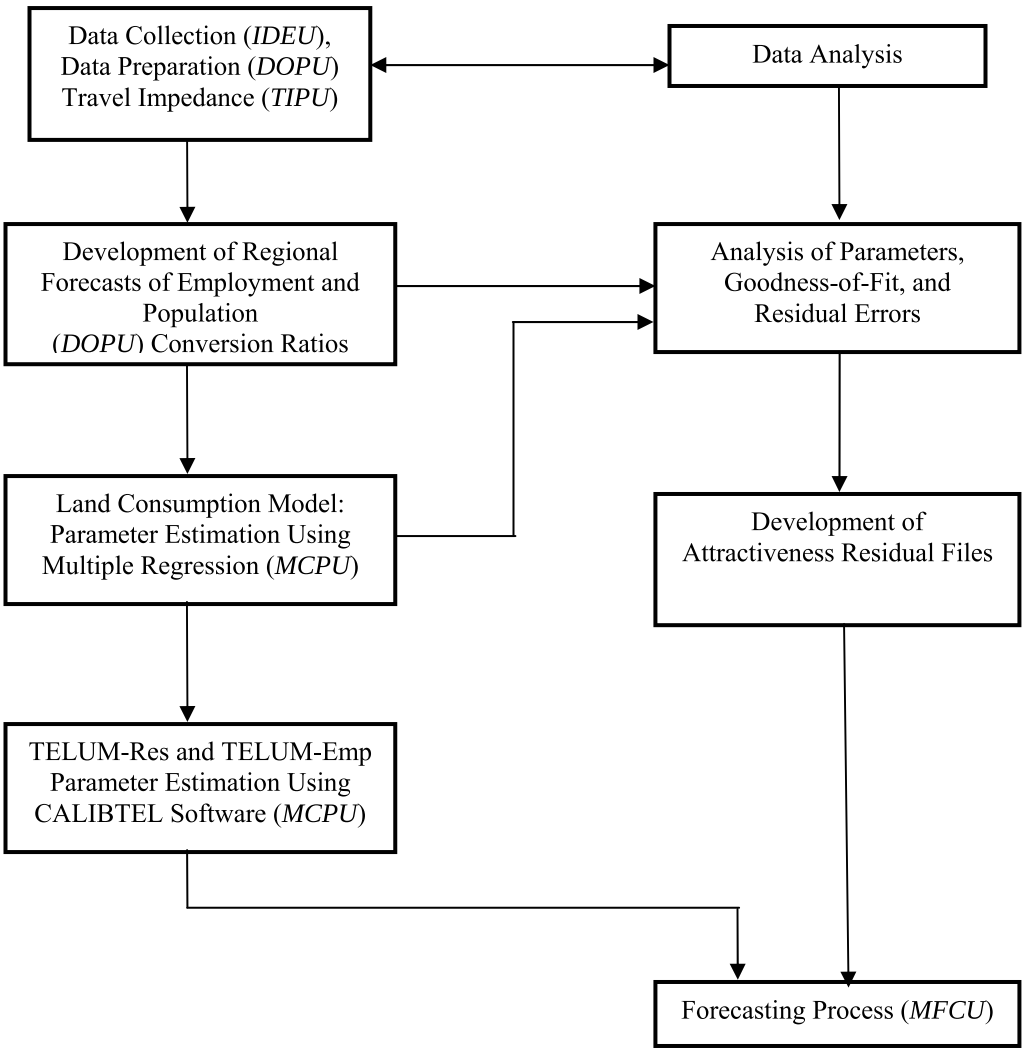
4. Data Preparation

Data Preparation Index

Because it is likely that users will make frequent reference to the sections of this chapter while preparing the data for their ***TELUM*** project, we have included a separate chapter index here.

1. The *TELUM* Process

The following flow chart outlines the general processes the user will follow in using ***TELUM***. This chapter tells how to prepare and compile the data required. You will then calibrate the model, using current and lag year data. This process will provide the parameters, statistically estimated equation coefficients, which serve to "fit" the models to your data. You will the use these parameters to assure accurate forecasting into future time periods. Later, you may develop policies that affect the final forecasts. To evaluate these policies you may modify the data input variables or the parameters, and you may impose constraints on household and employment locators.



2. Data Requirements for *TELUM*

Data for use in transportation, location, and land use models are required at different levels of spatial, sectoral, and temporal detail. It is useful to distinguish between what information is needed about the overall modeling *region*, and the *zone-specific* information that is necessary for detailed spatial representation and analysis. *Region*, as it is used in ***TELUM***, means the geographic area you are modeling. The region is defined by the Metropolitan Planning Organization (MPO), and may be a single county, or an aggregate of multiple counties or parts of counties. The following discussion is divided into region-level data requirements and spatially disaggregated (zonal) data requirements.

Region-Level Requirements

There are three groups of data required at the region level. First are the model *parameters* that are derived from a statistical analysis of regional patterns, the process of *calibration,* or of fitting the model to the data. These parameters must be estimated prior to using the models for forecasting or policy analysis. The second group of regional inputs is the *regional ratios*. These include unemployment rates, jobs per employee, employees per household, persons per household, and other similar statistics. The third group of inputs for the total region is the regional forecasts. Here it is necessary to develop estimates (or to obtain them from public or private sources) of regional totals of population and employment for the forecast years, i.e. for all future time points.

The following is a list of **required** region-wide inputs for each model for ***each forecast time period***.

***TELUM*-Emp (Employment)**

- Regional ratios:
  - -None
- Regional forecasts:
  - -Total employment for ***each*** employment type

***TELUM*-Res (Households)**

- Regional ratios:
  - -Percent unemployment, by employment type (if available)
  - -Employees per household, by household type
  - -Matrix of households by income per employee (Conversion Matrix) by employment type
  - -Jobs per employee
  - -Net regional rate of employee commutation
- Regional forecasts:
  - -Total population

Spatially Disaggregated (Zonal) Requirements

A *zone* is a unit of spatial analysis that can be defined in terms of census tracts, voting districts, traffic analysis zones, or an aggregation of these categories. In previous land use model applications, zones with an average population between 3,000 to 10,000 persons have worked best. At this level of geographic detail the classes of data fall into substantive groups, including population, households by income and place-of-residence, and employment by type and place-of-work. These data are usually available from census publications. The household and land use data are required for one time point, by place of residence. Prior work with ***TELUM*-Res** calibrations has shown the benefits of adding a five-year lagged total household variable, by zone, to the data set.

Zonal employment data are required by place-of-work. For the purpose of calibration of the employment model ***TELUM*-Emp**, employment data are required for two different time periods. The ideal household and land use data are for a census year such as 1990, while the second lag time point of employment data as well as the lagged total households, are for five years earlier.

The following is a list of spatially disaggregated input requirements for ***TELUM*-Res** and ***TELUM*-Emp**. These requirements are for data for ***each zone*** or district in the region. The design of these zone systems is not a trivial matter, but it is often a matter over which the analyst has little or no control. These data are required only for the base or starting year for a forecast, and also for a lag year (where noted) for calibration. In subsequent forecasts the outputs of each simulated time period become the inputs to the next.

***TELUM*-EMP**
- Households, by type
- Employment, by type, current and lagged values
- Total land area
- Land area occupied by basic employment
- Land area occupied by commercial employment
- Zone-to-zone travel times and/or costs

***TELUM*-RES**
- Households, by type, current and lagged (lagged can be total households by zone)
- Total population
- Total employed residents
- Group quarters population
- Total households
- Total land area
- Unusable land (undevelopable – restricted or reserved)
- Land area occupied by basic employment (industrial)
- Land area occupied by commercial employment
- Residentially occupied land
- Total usable land (developed + vacant developable)
- Land used for streets and highways
- Vacant land (developable)
- Employment, by type
- Land area occupied by basic employment (industrial)
- Land area occupied by commercial employment
- Zone-to-zone travel times and/or costs

These above data may not be available in convenient form in every metropolitan area. This is often the case in urban areas outside the United States and Western Europe as well as in smaller areas in the U.S. In such cases, it has been possible in past tests and applications to do useful planning and analyses with somewhat reduced data sets. One example of using a reduced data set is to substitute for zonal employment data, by type, with zonal employment totals for the current or lagged year time periods. A complete absence of employment data, by place of work, would make it impossible to run ***TELUM***.

There are differences in the calibration, vis-à-vis the forecasting, and data requirements as well. For the purpose of calibration, a reduced employment data set of zonal totals is evenly divided between each of the region's employment types. Once calibrated, the model can produce forecasts using projected regional employment totals, by type, as an input for the model. The model estimates where employment and households are most likely to locate based on the initial attractiveness parameters found when the model was fitted to the zonal data. This procedure is also applicable for smaller (reduced) household data sets as well. The ability to collect and use data during calibration that most accurately reflects the type and level of activity taking place in the region, even with reduced variables, is more important than having an artificially complete data set with low reliability.

3. Preparation of Data Inputs For *IDEU*

The success of every forecasting or analysis project is critically dependent upon the quality of its data inputs. In general, the more comprehensive and complex the proposed forecasting method, the more extensive and expensive the required input data. As most planning agencies have relatively limited resources available it is not possible for them to collect and process *all* the data. It is necessary to develop a specific list of data requirements, which can be specified along three dimensions:

1. Geographic Detail
2. Temporal Detail
3. Activity Sectoral Detail

In the following pages each of these three dimensions will be discussed. In application, default data values may be used to temporarily close data gaps. Directions for preparing default values are provided in the subsequent data sections and in the ***TELUM*** help system.

1. Geographic Detail

The level of geographic detail employed depends on the requirements and limitations of models and data and competing interests amongst users of the analysis results. No matter the final level of geographic detail selected for assembling data and performing analyses, the level of detail will not satisfy every user's needs. The greater the degree of geographic detail in the data (i.e. the smaller the individual zones or analysis areas), the greater the cost of obtaining the data, the greater the required complexity of the model, and, inevitably, the lower the statistical reliability of the forecasts.

Prior models have been executed at several levels of detail, but the majority of applications have been in roughly the same zone size range. The Houston data set (used by the Houston-Galveston Area Council some years ago) contained five counties that were divided into 199 analysis zones. Some of these zones were aggregates of just a few census tracts, while others were somewhat larger. At the rural edges of the region, some zones were large in area but relatively low in population and employment. A similar scale of analysis was used for the San Diego region, which contained only one very large county, but was divided into 161 zones. Here, too, some zones contained few census tracts, while others were aggregates of quite a few. The comments regarding zone area vis-à-vis zonal activity levels apply here. Analyses of the Washington, D.C. region were also done by an aggregation of several counties, divided into 182 analysis zones. Successful results have been obtained at the census tract level of detail for regions such as Atlanta, Colorado Springs, Kansas City, and Sacramento.

The location of regional boundaries also must be addressed. Again, there is not a rigidly set definition of a regional boundary. In general, it is best to try to set the boundary so that the amount of economic and social interaction crossing it is as small as possible. It will not always be possible to achieve this goal, and the models have provisions for including constrained external zones to address this problem. Perhaps the most extreme case was illustrated in Orange County CA, in a project done in the late 1980's, where the greatest interest was in the analysis zones within and immediately adjacent to the County. Yet the County is closely tied to the rest of the Southern California region. In this application a zone system was developed with small zones in and near Orange County, and progressively larger zones outside. The external zones were constrained in the model runs. The calibration results from this hybrid data set turned out quite well.

2. Temporal Detail

TELUM calculates zonal *forecasts* in five-year increments, starting five years beyond the "current" data year, e.g. 2000, yielding forecasts for 2005, 2010, 2015, etc. Virtually all tests of the predecessors of ***TELUM*-Emp** and ***TELUM*-Res** used five-year (or approximately five-year) increments. There is little chance that sufficient data will become available in the near future to enable the use of shorter time periods. While some attempts have been made to try to work with ten-year time increments, this causes several problems. The principal problem is that too much takes place in ten years for the user to feel comfortable with this size increment. In order to model the essential interactions between the various locating activities, as well as between any of the activities and the transportation system, a five-year feedback or interaction time is much more appropriate than a ten-year period. Even so, the exigencies of data availability may sometimes make it necessary to make do with less than the ideal data set.

3. Sectoral Detail

The sectoral detail situation is somewhat less nebulous. Prior to the development of ***TELUM*-Emp** and ***TELUM*-Res**, most earlier model applications used few, or just one, categories of locators. While the final model outputs were produced in considerable detail, the actual location procedures often involved only one or two locating categories. A major goal in finding a means for modeling an increased number of locator types is to model each with individual, and typically different, locating behavior. In addition, the location behavior differences are determined from statistical analyses of the base year data for the specific region to which the models are being applied. ***TELUM*** provides for the use of up to eight employment types and eight household types. The precise number of different locators depends on both data availability and the intended use of the model outputs.

IDEU Zonal Input Checklist

Use the following sub-sections as an aid in determining the data requirements for your region's model calibrations. During data entry, ***TELUM*** will provide you with hyperlinks that explain each requirement in more detail.

Employment Data

For calibration of ***TELUM*-Emp** it is necessary to have employment data by employment type and by zone for two time points roughly five years apart. As stated before, in most cases the "current" time is census year, such as 2000, and then the "lagged" time is taken five years earlier.

For calibration of ***TELUM*-Res** it is necessary to have employment data by employment type and zone for only one time point. It is customary that the ***TELUM*-Emp** "current year" matches the ***TELUM*-Res** time point. For example, if the main ***TELUM*-Res** time point is 2000, the ***TELUM*-Emp** "current year" will ideally be 2000 as well.

The ***TELUM*-Emp** employment data are the only data that *require* two time points in the calibration of the models; the two time points are necessary for the calibrations only.

The employment sectors are usually taken as aggregations of the one-digit NAICS (North American Industry Classification System) employment types. In most of the recent ***TELUM*-Emp** applications we used eight employment sectors that closely match the one-digit NAICS or SIC codes.

Household and Population Data

For calibration of ***TELUM*-Emp** it is necessary to have the population data, usually by household type, for one year or time point, to match the employment “current year.”

For calibration of ***TELUM*-Res** it is also necessary to have the population data by household type for one point and, again, it is usually the same as the ***TELUM*-Emp** “current year.” The population data are usually derived from the decennial population census. ***TELUM*-Res** allows the use of lagged household variables, which require household data for a prior time period, normally five years earlier. We strongly recommend that a lagged household total variable be used in calibration.

The household data, by zone, are divided into household types. These are usually households by income category, such as low income, low-middle income, etc. Most previous applications of DRAM, the predecessor of ***TELUM*-Res**, have used four or five household types, roughly corresponding to income quartiles or quintiles. ***TELUM*-Res** can handle as many as eight household types, allowing for a greater number of income groups or, for example, a cross tabulation of income and life cycle. In an application for Chicago, income groups were divided into eight household categories. In a Detroit application, households were divided into four income groups and further subdivided into households with or without children, for a total of eight household types.

Land Use Data

For calibration of ***TELUM*-Res** and the LANCON land consumption model, it is necessary to have a "current year" data set of land use by category in each zone. The categories are relatively straightforward by definition, but questions often arise in determining where to place certain categories that may have been defined differently for the original data files from which the data are being prepared. For each zone, it is necessary to know the following:

- Total zonal area
- Residential area (all types)
- Unusable area (e.g. water or environmentally sensitive lands)
- Industrial area (used for basic employment)
- Vacant developable area
- Commercial area (used for commercial employment)

Problems tend to arise in determining what constitutes *vacant usable* land area. The models treat this category as developable land, or land that can be used for residential, industrial, or commercial purposes. How agricultural land, parkland, streets and highways, and wetlands are to be treated is a matter for decision by the agency.

In forecast model runs, it is necessary to have specific values for these categories, and to develop a definition or set of definitions that are used for the baseline runs, but may be tested as work progresses. It is particularly important to consider issues of consistency in the land use category definitions. The following are guidelines for consistency checking.

Checking the Consistency of the Land Use Variables

When a ***TELUM*-Res** data set is constructed, it is important that the land use data is internally consistent. Land area must be in acres, not square miles, and should be consistent throughout all data sets or estimated land consumption rates will be inaccurate.

The input data set for forecasting with the ***TELUM*-Res** model has eight land use variables:

TAA	Total Land Area
AU	Unusable Land
AAAB	Land Used for Basic Employment
AAC	Land Used for Commercial Employment
GAAR	Residential Land
USBL	Total Usable Land
STS	Land Used for Streets and Highways
VAC	Vacant Developable Land

It is especially important for Unusable, Usable, and Vacant Land to be calculated consistently. Finding consistent values for these three variables can be confusing, since each variable's definition depends on the definition of the other two. The best strategy is to fix the value for one variable and then determine the values for the other two variables.

Formulas for Unusable, Usable, and Vacant Land Variables

1. Vacant Land Fixed, Usable and Unusable Land Calculated

In the ***TELUM*-Res** land accounting procedure developed land (DEV) is defined as:

DEV = AAAB + AAC + GAAR + STS

If the vacant land values are known, then usable land is defined as:

USBL = DEV + VAC

Unusable land (AU) is defined as:

AU = TAA - DEV - VAC

2. Unusable Land Fixed, Usable and Vacant Land Calculated

If the values of Unusable land are known, then vacant land is defined as:

VAC = TAA - DEV - AU

Usable land is defined as:

USBL = DEV + VAC

3. Usable Land Fixed, Unusable and Vacant Land Calculated

If the values of usable land are known, then vacant land is defined as:

VAC = USBL - DEV

Unusable land is defined as:

AU = TAA - DEV - VAC

Translating From Local Land Use Inventory to *TELUM* Land Use

In many cases, the land use inventories available to the planning agency will not have their land use categorized in the same terms as those described above. This means that it will be necessary to use professional judgment to translate the data from the local land use inventory categories to your ***TELUM*** categories. As an example, the following definitions were used in work for the Houston region:

Total Area = Land Only (i.e., no water) = Unusable + Usable

Unusable Land = Parks + Environmentally Constrained

Usable Land = Vacant Developable + Developed

Vacant Developable = Total Vacant Land - Environmentally Constrained

Developed = Commercial + Residential + Basic + Streets and Highways

Commercial Employment Land = Retail and Office Employment Land Use

Residential Land = All housing types

Basic Employment Land = Industrial and Institutional Employment Land Use

Streets and Highways Land = Rights of Way

4. Data Organization and Preparation Unit (*DOPU*)

Once you have completed the Initial Data Entry Unit (*IDEU*), you are ready to input your zonal data into the workbook provided in ***TELUM*** Data Organization and Preparation Unit (*DOPU*), DATAPREP. Data may be transferred into DATAPREP from other worksheets. Only values are permitted in DATAPREP. Copy data into DATAPREP through ***Edit>Paste Special: Values or Text***

*****Note -** You must open the DATAPREP Excel file and your data file in the same run of Excel for ***Paste Special: Values or Text*** to be enabled e.g. open one file and then go to ***File>Open*** to locate and open the second file.

Files in the same Data input cells are marked in a blue font. Cells absent of blue indicate that DATAPREP automatically calculates the values. Please note that the numbers shown in these spreadsheets are only for reference to help you understand how they will be used.

Employment Worksheet

For this section you need to have already determined the four to eight employment types, how many workers employed by each type, and how many employees work in each zone. This data is necessary for the current year as well as the lag year (T-1), which is defined in ***TELUM*** as approximately five years prior. Once your data is correctly imported, **your zonal household, population, and employment numbers will appear** in the worksheet. An example of these worksheets as you will first see them before data entry into the *DOPU* workbook follows:

Employment: 2000									
Zone	Employment 1	Employment 2	Employment 3	Employment 4	Employment 5	Employment 6	Employment 7	Employment 8	Total Employment 2000
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0

Figure 1- ***TELUM*** DATAPREP - Employment Worksheet for Current Year

Employment: 1995									
Zone	Employment 1	Employment 2	Employment 3	Employment 4	Employment 5	Employment 6	Employment 7	Employment 8	Total Employment 1995
						0	0	0	0
						0	0	0	0
						0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0

User Tips
Cells marked with a small red corner indicate a User Tip is available. Tips may include column directions and/or functions.

Figure 2- ***TELUM*** DATAPREP – Employment Worksheet for Lag Year

Households Worksheet

Determine the number of households by income group, previously defined by you, that are located in each zone. For the lag year you need only to specify the total number of households for each zone.

Employment: 2000									
Zone	Employment 1	Employment 2	Employment 3	Employment 4	Employment 5	Employment 6	Employment 7	Employment 8	Total Employment 2000
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0

Information
Clicking on the TELUM Information button easily accesses a comment box describing table function(s) and user instructions.

Figure 3- ***TELUM*** DATAPREP – Households Worksheet for Current Year Zonal Data

*****Note -** The Household Percentages table is automatically calculated in ***TELUM*** DATAPREP.

Households: 1995		
Total Households 1995	Total Population 1995	Average Population per Household 1995
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000
0	0.000	0.000

Household - Percentages 2000								
Zone	HH1 2000	HH2 2000	HH3 2000	HH4 2000	HH5 2000	HH6 2000	HH7 2000	HH8 2000
1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 4- Households Lag Year **Figure 5-** Household Percentages as Calculated by ***TELUM***

*****Note -** The Household Percentages table is automatically calculated in ***TELUM*** DATAPREP.

Land Use Worksheet

Each variable below defines the amount of area per zone occupied by each category.

Land Area per Land Use								
Zone	Residential	Industrial	Commercial	Streets	Vacant Developable	Unusable Land	Total Land Area	Proportion of Usable Land Developed
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 6- ***TELUM*** DATAPREP – Land Use Worksheet

Land Area per Land Use - Percentages						
Zone	Residential	Industrial	Commercial	Streets	Vacant Developable	Unusable Land
1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
7	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Figure 7- Land Use Percentages as calculated by ***TELUM***

Projections Worksheet

Regional projections are used in ***TELUM*** to control the sum of forecasted zonal employment and population. Determine and enter regional **forecasts** for employment and population numbers in each forecast period.

Household size, as it appears in the yellow box below, is the average size for all household types. This number is calculated automatically by ***TELUM*** from the data in your current year Households worksheet.

	Population	Employment								
Year	Total Population	Employment 1	Employment 2	Employment 3	Employment 4	Employment 5	Employment 6	Employment 7	Employment 8	Total Employment
1995	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0

Household Size:	0.0000

Figure 8- ***TELUM*** DATAPREP – Projections Worksheet

The Employment-to-Households Conversion Matrix

In the following section we describe the purpose of the Conversion Matrix, after which you will see a sample of the worksheet template. You can learn more about the conversion procedure by reviewing the numerical example at the end of this chapter in the Appendix section.

The ***TELUM*** system uses two models in a recursive sequence to forecast the location of activity. The employment model, ***TELUM*-Emp**, begins the sequence by producing a forecast of the spatial distribution of employment. This is followed by the residential model, ***TELUM*-Res**, which produces a forecast of the spatial distribution of households given the forecast location of employment. Thus, the output of ***TELUM*-Emp**, the forecast of the spatial distribution of employment, is used as an input to ***TELUM*-Res**.

The core of location forecasting in ***TELUM*-Res** is done of households, by household type. In general, the household types are specified by socioeconomic class or group. ***TELUM*-Emp** specifies employment by industry type, such as manufacturing or retail. Thus, the employment forecasts from ***TELUM*-Emp**, which yield spatial distributions of employment at place of work by employment type, are converted to households by income group at place of work. This conversion is accomplished by multiplying the matrix of employment forecasts by a set of conversion ratios that are derived from regional statistics. This procedure provides the user with unique advantages. Perhaps of greatest importance, is that as the regional mix (proportions) of employment types varies, so does the region's household income distribution. For example, a region experiencing a long-term shift from manufacturing employment to service employment will have, built into the model system, the appropriate shift in the distribution of household incomes as a consequence of the different labor mixes of the different employment types. This matrix of conversion ratios is constructed from Public Use Microdata Sample (PUMS) data provided by the U.S. Census Bureau. Since there are thousands of observations in a PUMS data file, a computer program must be written to compute this cross tabulation.

While using PUMS data is suggested for building your conversion ratio matrix, agencies unable to access PUMS data may use a default matrix. The default matrix replaces the PUMS data with an even distribution of total persons employed by industry between each household type. Default values have produced reasonable results when measured against matrices produced using PUMS data. Calculate your default employment-to-household matrix by dividing the industry employment totals (Employment worksheet; cells B503 to I503) by the total number of household income sectors in your region. Enter the numbers in the corresponding cells of Input Table 1 in the DATAPREP Conversion Matrix worksheet.

*****Note -** The unique feature of capturing regional employment and household shifts is lost when industry employment is evenly distributed between all household income sectors.

There are five different types of regional conversion ratio used in the ***TELUM*-Emp** to ***TELUM*-Res** connection. These regional ratios are:

- Regional estimates of the number of **jobs per employee**
- Regional estimates of the **net** (into or out of the region) **commutation rate**
- Regional **unemployment rates** for each employment type
- Regional **employee-to-household conversion matrices**
- Estimates of the number of **employees per household** for each household type.

Regional control totals of employment by type are inputs to ***TELUM*-Emp**, and no regional totals of households are input to ***TELUM*-Res**. The regional totals of households by income group are completely determined by the conversion of employees to heads-of-households. This conversion procedure must be consistent with the actual numbers of households observed within a region if accurate forecasts of residential location are to be made.

The Conversion Matrix

After ***TELUM*** forecasts the location of employees, at their place-of-work, it calculates the resulting numbers and types of households, which are then allocated to their places of residence. This is the forecast of households at their place-of-residence. Use the sample spreadsheet shown below, which is in the Workbook *DATAPREP* to input the *number of heads of household by income group* that are employed in each industry. Also fill in the *number of employees per household*. You will find these numbers, using guidelines in the US Census as a basis if you choose. This number will typically fall within the range of 0.99 to 2.31. A default value of 1.00 may be substituted if the data based values are not available for your ***TELUM*** project. The spreadsheet will calculate the percentage of households in each income group whose employed person works in each industry.

When converting from employees to households, ***TELUM*** must account for households associated with persons currently unemployed. An *unemployment rate* is used under the assumption that unemployed individuals made their location decisions while employed, and therefore located like others in their income class. If you do not have estimates of unemployment rates by employment type, then use a default value of 0.0 for the percentage of unemployment.

The regional ratio of *net commutation* measures the extent of work trip commuting into or out of the region. ***TELUM*** uses this rate to adjust the regional employment forecasts so they have the proper number of employees living in the region. A rate less than 1.00 indicates net inbound, and a rate greater than 1.00 indicates net outbound commuting. In the absence of actual data, a default value of 1.00 should be used, which indicates no net in or outbound commuting is occurring.

The *regional rate of jobs per employee* is a simple calculation of total reported jobs in the region divided by the total number of persons working in the region. The number of total persons working in the region includes persons commuting into the region. This value will typically fall below 1.50. A default value of 1.00 should be used if actual data is not available.

When the estimated conversion ratios are used in ***TELUM*-Res**, the conversion procedure defined by equation (1) must be consistent (i.e., the total number of households in each income group generated by the conversion procedure should be very close to the observed number of households in each income group). In most cases[1], the DATAPREP.XLS conversion matrix spreadsheet computes an employee-to-household conversion matrix (CNV_{ij}) that guarantees consistency in the ***TELUM*-Res** conversion procedure.

Input Table 1: Employed Householders by Industrial Classification and Income Category

Industry	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	Total
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0

Input Table 2: Household Employment at Place of Residence

Employees per Household by Income Category

HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Number of *Households* by Income Category

HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	Total
0	0	0	0	0	0	0	0	0

Number of *Employees* by Income Category

HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	Total
0	0	0	0	0	0	0	0	0

Scaled Number of Employees by Income Category (Household Target)

HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	Total
0	0	0	0	0	0	0	0	0

Figure 9- *TELUM* DATAPREP – Conversion Matrix Worksheet 1

[1]Extreme values of the other conversion ratios (RNCR, RJPE, $UNEMP_i$ and $EMPHH_j$) may make it impossible to compute an employee-to-household conversion matrix (CNV_{ij}), which ensures consistency. In these cases, it is likely that errors were made in the estimation of one or more of the conversion ratios.

Input Table 3: Employment at Place of Work

Industry	Emp	UNEMP	Adjusted Emp (Industry Target)
1	0	**0.0000**	0
2	0	**0.0000**	0
3	0	**0.0000**	0
4	0	**0.0000**	0
5	0	**0.0000**	0
6	0	**0.0000**	0
7	0	**0.0000**	0
8	0	**0.0000**	0
Total	0		0

Output Table: Employment-to-Household Conversion Matrix

☐ Data Consistency Check

Industry	HH1	HH2	HH3	HH4	HH5	HH6	HH7	HH8	Total
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Maximum Absolute Deviation from Targets

Industry:	0.00E+00
Households:	0.00E+00
Rescaling Factor:	#DIV/0!

Figure 9- ***TELUM*** DATAPREP – Conversion Matrix Worksheet 1

5. Data Check and Consistency Report

Once you have finished entering all of your region's zonal data inputs, you must return to the first worksheet in your DOPU workbook, labeled Data Check. Data Check provides instruction on how to 'Run Data Check' for your IDEU and DOPU zonal inputs. Data Check completes a few statistical calculations that will tell you how strong the relation is between your data inputs. ***TELUM*** reads these calculations and prepares a Data Consistency Report for you to review. We **strongly recommend** you print this report and keep it on file for your agency.

Appendix for Data Preparation

Simple Numerical Example of the Conversion Procedure

Consider the following numerical example. First assume that we have a region where the reported employment in the region, i.e. the number of jobs, is 132.The number of households resident in the region is given as 70. Of the employed residents, 90 work in the region. Further, there is net in-commuting to work of 10 employees, with 20 who live outside the region commuting in to work, and 10 who live inside the region commuting out to work. Finally, there are five residents of the region who are unemployed, but who would work if they had a job.

First we calculate the regional ratio of jobs per employee – RJPE. We divide the total number of jobs in the region, i.e. the total reported employment in the region, 132, by the total persons working in the region. This is the 90 residents who work in the region plus the 20 who live outside, but commute into the region to work, or a total of 110. This gives 132/110 or 1.2 jobs per employee.

Next, in terms of persons, employees, we recall that 110 employees work in the region, 20 of which commute in. Ten other persons live in the region but commute out to work. The regional net commuting rate – RNCR, equals 1.0 plus the ratio of the net commutation to the total employed persons at work in the region. This ratio is therefore, outbound commuters minus inbound commuters, or (10 - 20), or -10, divided by 110, to yield -0.0909, which when added to 1.0 gives 0.9090 for RNCR.

Working back through the numbers we get 110 persons employed in the region if we divide the region's 132 jobs by the RJPE of 1.2. We may then multiply that 110 by the RNCR of 0.9090 to get the 100 employed residents of the region.

The unemployment rate – UNEMP, is calculated by dividing the number of unemployed workers by the total labor force, or 5 divided by (100+5), yielding 0.0476. If we multiply the 100 employed residents by 1.0 divided by 1.0 minus the unemployment rate, UNEMP, we get 100 times 1.05 or 105, as the total of employed plus employable residents.

Finally, we note that if we go back to the original numbers, we had 100 employed residents, 5 unemployed but employable residents, and 70 households. This gave 105 employable employees per 70 households, for a ratio of 1.5 employees per household - EMPHH. If we divide our 105 employed plus employable from the previous step, we close the loop by getting our original 70 households.

Formulation of the ***TELUM*-Res** Conversion Procedure uses the following equation to convert employees (at place of work) to households by income group (at place of work):

$$HH_j = \sum_i \left[EMP_i \times \left(\frac{RNCR}{RJPE} \right) \times \left(\frac{1.0}{1.0\text{-}UNEMP_i} \right) \times CNV_{ij} \times \left(\frac{1.0}{EMPHH_j} \right) \right]$$

where:

HH_j = the number of households in income group j,

EMP_i = the number of employees in industry type i,

RNCR = the regional net commuting rate,

RJPE = the regional ratio of jobs per employee,

$UNEMP_i$ = the unemployment rate for industry type i,

CNV_{ij} = the percentage of employees in industry type i who belong to household income group j (Note: CNV_{ij} is an element of the employee-to-household conversion matrix.),

$EMPHH_j$ = the ratio of employees per household for income group j.

It should be noted that:

1. The purpose of multiplying by the regional net commuting rate is to insure that when the final conversion procedure is applied to the employment forecasts from ***TELUM*-Emp**, the proper number of *employees living in the region* is used.
2. The purpose of dividing by the ratio of jobs per employee is to adjust the "employment" figures to account for *persons holding more than one job*.
3. The purpose of multiplying by 1.0 divided by 1.0 minus the unemployment rate, is to adjust back up the numbers of employees to *account for the unemployed*, who it is assumed will have made location decision while employed, and will therefore have located as others in their income (when employed) class.

Methods for Calculation of the *TELUM*-Res Conversion Ratios

Estimates of the conversion ratios can be calculated from data collected by regional planning agencies and the U.S. Bureau of the Census. The number of jobs per employee (RJPE), regional net commuting rate (RNCR), unemployment rates in each industry ($UNEMP_i$), and the number of employees per household by income group ($EMPHH_j$) can usually be estimated from regional planning agency surveys.

The employee-to-household conversion matrix (CNV_{ij}) is calculated by:

1. Computing the number of heads-of-household, by income group, employed in each industry.
2. Entering the results from step (1) into the conversion matrix spreadsheet in DATAPREP.XLS, along with estimates of the number of jobs per employee (RJPE), the regional net commuting rate (RNCR), unemployment rates in each industry ($UNEMP_i$), the number of employees per household by income group ($EMPHH_j$), the number of households by income group (HH_j), and the number of employees by industry (EMP_i).

J Brugger Oct. 25
C:\jeannette's/intheworks/4edit_dataprep.doc

5. *MAP IT*

1. What you can do with *MAP IT*

With the *MAP IT* function you can view the location of your regional data and model forecast outputs. You can keep track of where the ***TELUM*** models over and under estimate zonal employment and household location, decide if your region is more or less sprawled in future time periods, and track how regional employment and households change their location over time and/or with policy influence. In this chapter you will learn about the various mapping tools provided by *MAP IT* how to use ***TELUM*** data outputs in mapping software other than *MAP IT*.

2. How to Run *MAP IT*

To use the *MAP IT* function, you must have an installed version of ArcView 8x on your operating system. If ArcView 8.3 is not available on your computer, you can not use this function and must indicate "**NO**" in the first *MAP IT* screen that reads, "Will you be using the *MAP IT* function?"

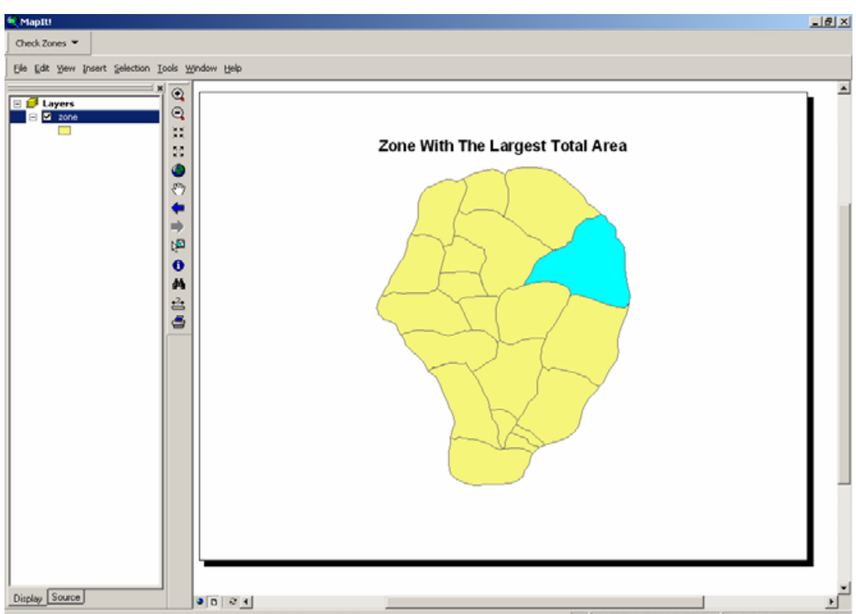
If ArcView 8.3 is available on your PC, then you must have a GIS compatible shapefile of your region.

1. Begin by confirming that you have a shapefile column with a numbering scheme that matches your regional "zone" inputs from *IDEU* and *DOPU*.
2. Name your region shapefile(s), **ZONE**.
3. Place your "**ZONE**" labeled shapefiles inside your ***TELUM*** folder. (C:\TELUM)
4. Answer "**Yes**" when ***TELUM*** asks if you will be using the *MAP IT* function.

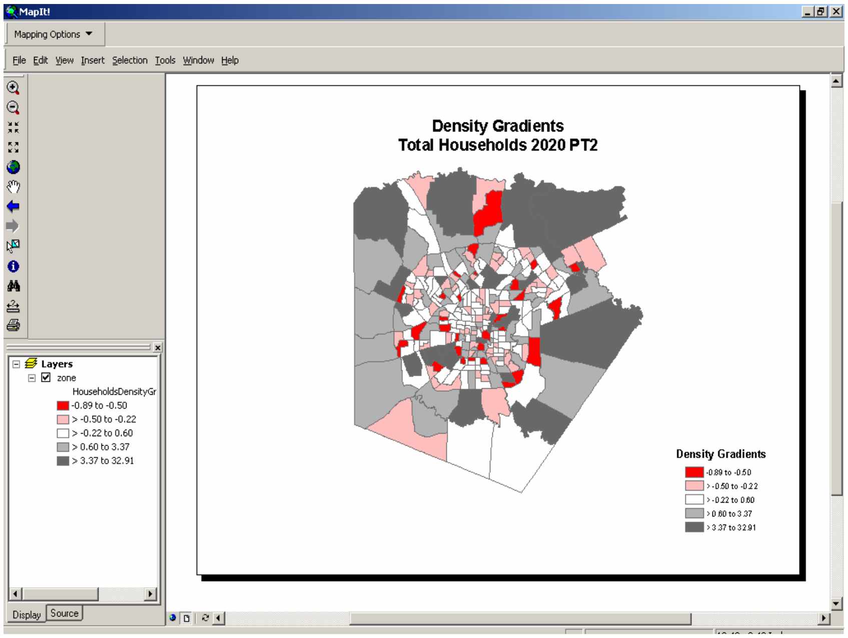
3. What can *MAP IT* do for you?

GIS is a powerful computer mapping system, and much more. It is a tool for managing information of various types according to where it is located. *MAP IT* uses ESRI's ArcMap technology to produce maps that will:

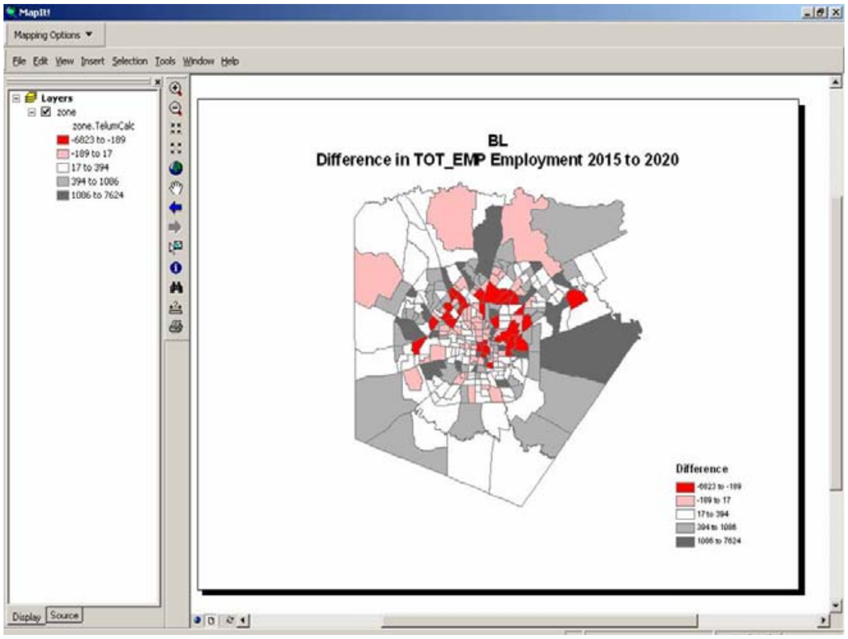
1. Display your model data inputs and outputs. An example of a Rancho Carne *MAP IT* output follows:



2. Measure regional sprawl



3. Display the spatial location of forecasted growth/decline.



4. What if you do not have ArcView 8x mapping software?

While we strongly promote the use of *MAP IT*, we recognize you may not have ArcView 8x available for your use. Inside your ***TELUM*** project folder is a folder labeled GIS. (C:\TELUM\GIS) Your GIS folder contains a copy of all the text outputs ***TELUM*** generates and reads into the ArcMap software. These text files may be formatted for use in your agency's mapping application

GIS Folder Contents

Your GIS folder contains the following set of files after you complete *DOPU*:

GIS_EMP.PRN - A space delimited text file containing the data you entered into your *DOPU Employment worksheet*.

GIS_HH.PRN - A space delimited text file containing the data you entered into your *DOPU Household worksheet*.

GIS_LU.PRN - A space delimited text file containing the data you entered into your *DOPU Land Use worksheet*.

The following files are added once you complete *MCPU*:

EMPRESE1.TXT, EMPRESE2.TXT, EMPRESE3.TXT, etc – Comma delimited text files containing model calibration residuals for each of your corresponding regional employment categories.

DRMRESH1.TXT, **DRMRESH2.TXT**, **DRMRESH3.TXT**, etc **-** Comma delimited text files containing model calibration residuals for each of your corresponding regional household categories.

The following files are added to your ***TELUM*** GIS folder after *MCPU*. The **xxxx** in the file names indicate the year in each file name by forecast year.

EMPFCSTxxxx.TXT - Comma delimited text files containing model forecast outputs for each regional employment category, by forecast year and forecast name.

DRMFCSTxxxx.TXT - Comma delimited text files containing model forecast outputs for each regional household category, by forecast year and forecast name.

EMPLBL05.TXT – Comma delimited text file containing baseline forecast outputs for

Building a Shapefile

Unfortunately we are unable to provide directions for building a shapefile. We recommend you consult your mapping application and/or ESRI's ArcMap documentation for assistance.

6. ***TELUM*** Travel Impedance Preparation

1. Introduction to the Travel Impedance Preparation Unit (*TIPU*)

Impedance is a term referring to the travel time, travel cost, or composite of both, calculated by travel models to describe differences in zone-to-zone difficulty of interaction. An agency transportation department typically builds impedance files and should be consulted for this section of ***TELUM***.

The ***TELUM*** model requires an input data file containing zone-to-zone travel times and/or costs for the region. Several recent applications have made use of composite travel times/costs developed from multimodal travel models and are often described in terms of "impedos" or some such other unit name. The time point of these travel times should be the common "current year" for both models.

The issue of "peak" versus "off-peak" travel times is important here. The best solution, when it is available, is to use the afternoon peak travel times, as these are the best inputs for location modeling. In the issue of time versus cost for impedance values, the most common choice is time. To use cost would be perfectly acceptable, except for the issues of inflation for the future year costs. In addition, it is sometimes possible to consider a generalized cost, which can be calculated by combining travel time and travel cost. In that case, there is the problem of estimating the "value of time" not only for the different locator types (such as income levels) but for future time periods as well. Finally, if there are several modes involved, all of the above issues are important, as well as the question of how to calculate a composite multi-modal cost.

If your ***TELUM*** forecasts are intended to be used in a model configuration linked to a traffic assignment package, there is also the question of whether to aggregate the networks to match the ***TELUM*** zone system, or take aggregated skim tree outputs as inputs to subsequent ***TELUM*** model forecasts.

Note that the preparation of the zone-to-zone travel times, costs or composite impedances is not an integral part of ***TELUM***. We expect these data to have been developed by your agency during normal activities. In this chapter emphasis is placed only on the organization of your impedance file. ***TELUM*** must be able to read your IMPD.TXT file so the values can be converted into a form suitable for use in the model calibration and forecasting units. Because there are numerous travel model software packages, and because many MPO's have customized the software they have, it has not been possible to develop direct software links for the travel models to TELUM. What we have done is develop a simple procedure for making this connection that we believe can be used with any travel model software package.

2. How to Organize Your Travel Impedance Data

Your travel impedance file must have two columns. The first column contains an assigned identification number. The second column contains your regional impedance zones, starting with the impedance value of Zone 1 to Zone 1, followed by the impedance from Zone 1 to Zone 2, then Zone 1 to Zone 3 and so forth. When you are finished you will have one long column of impedances from each regional zone to all other zones in the region. A pictorial example is provided below.

1. Organize your IMPD.txt file

In this example you see two tables of impedance numbers. The first table shows your impedances in a matrix format where the impedances are read from left to right and top to bottom. The second table shows how these impedance values are organized from the matrix table into your IMPD.txt file.

Table 1

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Zone 1	4.40	12.70	14.80	23.20	33.20
Zone 2	21.00	21.40	27.20	28.60	45.30
Zone 3	26.00	26.70	26.10	26.00	27.90
Zone 4	31.50	33.30	33.30	33.40	33.40
Zone 5	50.50	40.50	40.50	42.30	42.30

Table 2

1	4 4 0
2	1 2 7 0
3	1 4 8 0
4	2 3 2 0
5	3 3 2 0
6	2 1 0 0
7	2 1 4 0
8	2 7 2 0
9	2 8 6 0
1 0	4 5 3 0
1 1	2 6 0 0
1 2	

Example 1 Organize your IMPD.txt file

2. Create the IMPD.txt

Your **IMPD.txt** will have two 10 space columns, as pictured in Example 1. The first column contains an identification number of your choice. The second column contains your impedance values.

If your impedance table is developed in a Microsoft Excel spreadsheet you can format the columns and export the table into a text file following this procedure:

1) In your Excel spreadsheet select the two columns with data (usually the first two columns - A and B) and set the column width to 10.
2) While columns are still selected go to "*Format -> Cell -> Number*" tab and select "*Number*" from the Category list. Click OK.
3) Click on "*File -> Save As*". Choose the file name and in the drop-down menu in the "*Save as type*" box select "*Formatted Text (Space delimited)*".
4) Click "*Save*" and confirm on the following two screens.

5) Locate your saved text file - it should have an extension .prn. Open it in the *Notepad*.
6) In the Notepad click on "*File* -> *Save as*". Click Save (If you wish change the file name). The file should be saved with the .txt extension.
7) Close the Notepad.
8) Open the saved file and check if your data is saved as described in the TELUM Manual, page 6.2 (two 10-space columns). If yes, you are good to go further. Save the file in the "Data" folder inside TELUM directory and rename the file to "*IMPD.TXT*".

3. Enter Your IMPD.txt File into *TELUM*

1. Place your completed IMPD.txt file inside the ***TELUM*** project folder labeled *DATA*. (C:\TELUM\DATA)

2. *TIPU* performs an impedance file check to evaluate and confirm the format of your zonal impedance values. In order to perform this check, you must gather the follow data inputs for ***TELUM***:

a. Average Zone-to-Zone Impedance
The average is a simple algebraic mean of your region's zone-to-zone travel impedances.

b. Smallest Zone-to-Zone Impedance
Find your region's smallest zone-to-zone impedance value.

c. Largest Zone-to-Zone Impedance
Find your region's largest zone-to-zone impedance value.

d. Top 4x4 Impedance Values
Collect the 16 impedance values from the top left corner of your travel impedance matrix, as pictured above in Table 1.

e. Bottom 4x4 Impedance Values
Collect the 16 impedance values from the bottom right corner of your travel impedance matrix.

4. Complete the Travel Impedance File Check

With all of your impedance inputs entered, ***TELUM*** will ask you to run the Impedance File Check. File Check begins by looking for your IMPD.txt inside the DATA folder. If your IMPD.txt is not inside the DATA folder or ***TELUM*** is unable to read your IMPD.txt then *TIPU* will stop File Check and provide you with troubleshooting instructions. You must complete *TIPU* before you can continue into model calibration.

3. Future Year Travel Impedance

Forecast Travel Impedances provide you with the option to include your Transportation Department's impedance files for future time periods. Adding impedance file(s), in addition to your current *TIPU* impedance file, is strictly optional. Forecasts can be made based on your current year zonal impedances.

However, if you use the current year impedances for long range forecasting you are assuming that there will be no change in your region's transportation infrastructure.

How to Add Future Year Travel Impedance

Future Year Impedance files are entered into your model forecast(s) from within *MFCU*. Each time you prepare to re-run or run a new model forecast, *MFCU* will ask if you wish to enter IMPD files for future time periods. If you indicate that you wish to add future year impedances, you may enter as few as one or a number of impedance files equivalent to your forecast time periods.

1. Prepare your Future Year Travel Impedance (FY-*TIPU*) files in the same format as your **TIPU IMPD.txt** file, except this time you will include the forecast year in the impedance label. (e.g. An impedance file for year 2010 is saved as, **IMPD10.TXT**.)

2. Place your FY-*TIPU* file(s) inside your ***TELUM*** *DATA* folder.

3. When you enter *MFCU* for your Baseline model forecast, and/or for new or re-run model forecasts, select "Yes" when ***TELUM*** asks if you would like to add Future Year Impedance file(s).

4. For your FY-*TIPU* impedance files you must collect the same five data inputs for each additional impedance file, as described for *TIPU* File Check earlier in this chapter. ***TELUM*** will prompt you to enter your File Check inputs.

Upon successfully creating and File Checking your future impedance files, ***TELUM*** will move all of your FY-*TIPU* files in preparation for your model forecast.

4. Substituting Geometric Distance for Impedance

In some instances, especially for educational projects, it will be necessary to use geometric distances between zone centroids to approximate travel impedances. Here we provide notes on calculating the location of zone centroids in ArcView . Once the centroids are calculated, a matrix may be created by simply calculating the centroid-to-centroid distances. The diagonal elements of the matrix may be calculated by assuming that each geographic zone can be approximated by a circle. Then, ArcView can give you the zone's area, and you can calculate backwards using the formula for the area of a circle to get an implicit zone radius to use as the intrazonal distance, which is an acceptable approximation for the distance matrix diagonal values.

The centroid for a polygon is the geometric center, listed in terms of two points, the x coordinate, and the y coordinate. The calculation of the centroid in ArcGIS requires the addition of two fields in shapefile form containing the zones of your region and the use of a Visual Basic A script to calculate the two coordinates of the point.

1) **Add the fields that will hold the coordinates of the centroid for each zone**

- Open the attribute table in your regions shapefile. Click on the "Options" button (at the bottom of the attributes table window) and select "Add Field."
- Name the field "XCoord," set the type to "Double," click "OK"
- Repeat, naming the second field "YCoord"

2) **Start an "Edit Session" (Optional)**

- This step is optional. Calculating the centroid value in an edit session allows you to undo your changes, while doing so outside of an edit session is un-doable.
- To start an edit session, from the editor toolbar, click on the drop down menu “Editor” and select “Start Editing.”

3) **Calculate the X Values**

- From the attribute table window in your shapefile, right click on the heading for the field you just created, “XCoord.” In the menu revealed by the right click, select “Calculate Values” this will bring up the “Field Calculator” window.
- Click the “advanced” checkbox in the middle of the “Field Calculator” window
- In the first text box, labeled “Pre-Logic VBA Script Code” type:

```
Dim dblX As Double
Dim pArea As IArea
Set pArea = [Shape]
dblX = pArea.Centroid.X
```

- In the second text box, labeled “Calc =” type:

```
dblX
```

- click OK

4) **Calculate the Y Values**

The calculation of the Y values is the same as calculating the X values, except that you use the field you made, “YCoord,” and in the “Pre-Logic VBA Script Code” box, you use the following script (which merely replaces X with Y):

```
Dim dblY As Double
Dim pArea As IArea
Set pArea = [Shape]
dblY = pArea.Centroid.Y
```

- In the second text box, labeled “Calc =” type:

```
dblY
```

- Click OK

You will now have the X, Y values for the centroid as fields in your shapefile. These can be used, along with the Pythagorean theorem to calculate the distances between the points.

7. Model Calibration

1. Introduction to Model Calibration

Each of your regional locator types will exhibit a different locating behavior in each region. A particular locator type, such as High-Income Households, may well exhibit different locating behavior in different regions. It is therefore necessary to estimate the equation coefficients of the model equations for each locator type in your region. The process of estimating these equation parameters is called model calibration. ***TELUM*** performs a model calibration for each locator type in your region.

Due to the nonlinear structures of the ***TELUM*** forecasting model equations it is necessary to use specialized parameter estimation procedures for calibration. The goal of calibration is to develop estimates of the parameters of a model's equations(s) which best fit the general model structure to your region's specific data set. Most planners are familiar with this process in the context of multiple (linear) regression analysis. ***TELUM***'s model calibration is analogous to regression analysis but uses different mathematics and a different computer program. The computer program used here, ***TELUM*-CALIB**, locates the optimum (best fit) parameter values by a method called gradient search.

This section provides an overview of the ***TELUM*** Model Calibration Preparation Unit. *MCPU* is a small but critical unit in the ***TELUM*** system. This unit provides three layers of consistency checking that assures the user that she is ready to proceed to forecasting. A failure in ***TELUM***'s ability to perform a File Check, Employment and Household Calibration, and/or Land Use Consumption Regression means there is a problem with your ***TELUM*** project and/or associated project data and forecasting cannot be attempted.

2. Start Model Calibration - File Check

File Check is a way for ***TELUM*** to check the consistency of your data files in preparation for model calibration and later forecasting. If ***TELUM*** detects a problem with one of your files or finds a file is missing, you will not be able to run model calibration. An error in File Check is typically associated with your *DOPU* and *TIPU* data inputs. In most cases, users are asked to review and re-run the *DOPU* Data Check and *TIPU* impedance program before attempting to re-run File Check.

3. Begin Model Calibration – Employment and Household Location

Once File Check is complete, you can continue directly into model calibration. Begin your model calibration by clicking on the *GO* button when prompted by ***TELUM***. Calibration may take several minutes to finish. The length of time depends on the size of your region and the ability of the equations to reach an optimum parameter value, as well as the computing power of your PC.

4. Analysis of Results for Model Calibration

Immediately following the conclusion of your model calibrations, ***TELUM*** provides an Analysis of Results to summarize the model's fit to your data inputs. One of the first measures used for best fit analysis is the Best/Worst Likelihood Ratio, φ, which is a normalized maximum likelihood criterion (see the Chapter Appendix for more details). In linear multiple regression analysis the best fit is measured by the R^2 criterion. In addition to the best fit criterion, the Analysis of Results shows the statistical significance of the parameters obtained. The statistical significance here is measured with asymptotic t-tests. If the absolute values of the t-statistics are too low, they indicate that an equation coefficient is not statistically significant. If the t-values are sufficiently large (generally greater than 2.00 for most data sets) , they indicate that the equation coefficient is likely to be statistically significant. The formulas associated with these measures are provided in the Appendix to this Chapter.

Analysis of MAPE and MARMO Results

Another set of goodness-of-fit measures examines the distribution of residuals (or errors) between the observed data and the models' current best-fit estimates. A commonly seen form is the Mean Absolute Percent Error, or **MAPE**. This is the average (mean) of the absolute values of percent error between an observed set of say, household data and the values that would be estimated by DRAM. Unfortunately the value of MAPE can be easily distorted by large percentage errors in small zones. For example, if a zone with an observed ten households is estimated to have fifteen, it is a 50% error. If a second zone with 1000 observed households is estimated to have 1050, it is a 5% error. The value of MAPE for these two zones taken together is 27.5%, a value that exaggerates the forecast error of the model.

One way to deal with this bias is to state the value of MAPE for just the smallest and largest observations (zones) in the data set along with the MAPE for all the zones taken together. In that comparison, we might see a MAPE of 500% in the smallest zones (which account for 2% of the region's low-income households) and a MAPE of 12% for the largest zones (which account for 87% of the region's low-income households).

The **MARMO** measure is another way to give error measures that are weighted by the size of the observation and is a good summary measure of likely forecast error levels. The best, and unachievable, value for MARMO is 0.0, which would indicate a perfect fit of model to data. **Normal values of MARMO vary from 10.0 to 40.0 for each locator type.**

Analysis of Location Elasticity Results

Location elasticity measures the sensitivity of household and employment location to changes in the specific attractiveness variables of the ***TELUM*** models. The location elasticity values are calculated both for individual employment or residential zones, and for the regional average values for each variable for each locator . For a 1% increase in an attractiveness variable in a zone, the location elasticity measures the resulting percentage change in the number of households or employees in that zone. For example, suppose that for low-income households in Zone 12 the location elasticity for residential land is equal to 0.2500. This means that a 1% increase in residential land in Zone 12 will result in 0.25% increase in the attractiveness of Zone 12 to low-income households.

The location elasticity values are static measures of model sensitivity. This means that when a location elasticity value is calculated for a specific attractiveness variable in a zone all other attractiveness variables remain fixed. In the example above, the only variable that is allowed to change is the quantity of residential land in Zone 12. All other attractiveness variables in Zone 12 are assumed to be fixed, as are the attractiveness variables (including residential land) in all other zones. Because the location elasticity values are static measures of model sensitivity, they will change as the values of the ***TELUM*** model attractiveness variables change (e.g., the location elasticity values for forecast years will be different from the location elasticity values for the base year).

The value of location elasticity for a specific attractiveness variable and zone is a function of: 1) the value of the calibrated parameter for the attractiveness variable, 2) the numbers of households or employees in the zone, 3) the magnitude of the attractiveness variable, and 4) the relative attractiveness of other zones in the region. Location elasticity values will be larger when the calibrated parameter for the attractiveness variable is large (in absolute value), the number of households or employees is small (relative to other zones in the region), or the value of the attractiveness variable is small (relative to other zones in the region).

5. Land Consumption Calibration (LANCON)

In ***TELUM***, land use by locating activities is calculated *after* the completion of the *location demand* calculation. ***TELUM*-EMP** calculates location demand by employers, followed by the ***TELUM*-RES** calculation of location demand by households. LANCON takes both these calculated demands and estimates the actual change in the amount of land, by zone, that will be used by each of the demand categories. If there has been a decrease in demand by a particular category, then land currently in use by that category is released into a "pool" of land available for any use. If there has been an increase in demand by a particular demand category, then the addition of land to use by that category is calculated. After the calculations are done for each demand category, the sum of land used is adjusted, by an increase in density, to match the land available for such uses. ***TELUM*** produces a LANCON Statistical Analysis section to highlight your region’s land consumption reliability. Many regions find their land use reliability to be low. This is common and should not deter an agency from performing model forecast.

6. How to Run a LANCON Calibration Regression

1. When ***TELUM*** opens to LANCON, you will be asked to indicate which employment categories in your region are basic (industrial). Click all employment categories that apply as Basic employment for your region. **You must select at least one category.**

2. Next ***TELUM*** will ask you to check off all Household categories that are “low” income and “high” income within your region. The terms “low” and “high” refer to your regions bottom and top quartile/quintile category, respectively. **You must select at least one category for each.**

3. Begin LANCON by clicking the “**LANCON**” button. **This procedure requires you to have the Analysis ToolPak installed in Microsoft Excel and your Macro security set to “Low” before LANCON can operate. See the Installation Instructions for more details.** This process is highly sensitive and should not be interrupted.

Calibration Output Files

In addition to the summary information which is provided for the user, *TELUM* stores an detailed calibration output report in C:\TELUM. Many new users of the models will find the summaries to be adequate for their purposes. Our experience in Beta testing the system is that once users become familiar with the modeling process, they sometimes want more information than the calibration summaries. These files, which have the suffix **.out**, contain the full report on each locator’s calibration. It can be useful to review this output to check the accuracy of input data and diagnose any calibration problems. Two annotated sample calibration output files, one for employment and one for households, are included after the Appendix.

Model Calibration Appendix

Model Calibration and Goodness-of-Fit Theory

The following section introduces the mathematical method used in calibration. The calibration process involves "fitting" the ***TELUM*** equations to the data for a particular region. The better the fit of the model to the data, the more reliable the forecasts it produces. In all socio-economic data, there is a systematic, explainable component and a random, unexplainable component. The goal of model calibration is to adjust the model parameters so as to permit the model to explain as much as possible of the systematic component of the data.

To perform calibrations it is necessary to have one or more indicators of **Goodness-of-Fit** of the models to the data. The equation structures of the ***TELUM*** models are intrinsically nonlinear and the data from which their parameters must be estimated are not normally distributed. As such, standard multiple regression techniques cannot do the job. The parameters for the models are estimated by a computer program called CALIBTEL. CALIBTEL contains procedures for each of the two models ***TELUM*-EMP** and ***TELUM*-RES,** that are used to estimate model parameters for employment and household location, respectively. The procedure used for the estimation of parameters for these models in their current, aggregate, form is gradient search. In effect, the partial derivatives of a goodness-of-fit criterion with respect to each specific parameter are calculated. The values of these derivatives determine the direction of parameter search (Putman, 1983).

The appropriate goodness-of-fit measure for the calibration of ***TELUM*** CALIBTEL is the likelihood function, a measure derived from the notion of maximum likelihood as developed in econometrics. This measure has the general form:

$$L = \sum_i N_i \ln \hat{N}_i \quad (1)$$

where L is the computed likelihood measure, N_i is the observed value, and $\hat{N}i$ is the estimated value of the dependent variable. In ***TELUM*-RES** the dependent variable would be households of a particular type located in a particular zone, and in ***TELUM*-EMP**, the dependent variable would be employment of a particular type located in a particular zone. It is important to note that in this equation form, the magnitude of L is conditional on the magnitudes of the data being used. In a region with millions of households, L will be larger than it will be in a region with hundreds of thousands of households.

The "Best Fit" is when the difference between the models' estimate of the dependent variable and the observed values in the calibration data set is as small as possible. A perfect fit would be obtained if, for each independent variable observation, i.e. locator type and zone, the Estimated $\hat{N}i$ = the Observed N_i. This would give the following "Best Fit" value of likelihood:

$$L_b = \sum_i N_i \ln N_i \quad (2)$$

The "Worst Fit" occurs when all values of the dependent variable are estimated by the mean of that variable. For example, if the region's total of Type 1 employment were divided by the number of zones to get the mean of Type 1 employment per zone, and all zones were assigned an amount of Type 1 employment equal to the mean. This is also known as the uniform distribution assumption, where the Estimated $\hat{N}i$ = the Zonal Mean $\overline{N}$ and gives the following "Worst Fit" value of likelihood:

$$L_w = \sum_i N_i \ln \overline{N} \quad (3)$$

From these two extreme values of likelihood, we can construct a relative measure of goodness-of-fit which is analogous to the R^2 measure, but which is appropriate to the nonlinear equations of CALIBTEL, and to the non-normal distributions of the data. This measure of "Relative" goodness-of-fit is called a **Best/Worst Likelihood Ratio**, and takes the following equation form

$$\varphi = \frac{L - L_w}{L_b - L_w} \quad (4)$$

The computed value of this Best/Worst Likelihood Ratio, φ, has a range such that for a perfect fit, φ = 1.00, and for the worst fit, φ = 0.00. **Typical results obtained when fitting CALIBTEL give φ = 0.70~0.95.** The values taken by φ are independent of the magnitude of the dependent variables.

Asymptotic t-Statistics in DRAM and EMPAL Calibrations

In estimating nonlinear model parameters, it is necessary to develop ways of assessing statistical significance as a substitute for the measures more readily calculated in the estimation of parameters of linear models with normally distributed variables. The maximum likelihood estimator, when correctly calculated, is asymptotically normally distributed with a mean equal to the true parameter value and with a covariance matrix that can be calculated by use of second order partial derivatives. These derivatives are calculated as part of the parameter estimation procedure, and allow the computation of asymptotic t-statistics that yield an indication of the significance of the individual parameters in the models' equation structures. Since the ***TELUM*** application is applied mostly for regions with more than 100 zones, **a good rule of thumb is that an asymptotic t-value greater than 2.00 is an indication of a statistically significant parameter value.**

TELUM-RES Location Elasticity Values

Each of the ***TELUM*-RES** location elasticity values have the same mathematical definition except for travel time. For the percentage of developable land developed and the household percentage variables, the location elasticity values are defined for changes in one plus the value of the variable. (For example, if the percentage of developable land developed equals 66%, the ***TELUM*-RES** attractiveness variable is equal to 1.66. A 1% increase in this variable is equal to 0.0166.)

Location elasticity for any attractiveness variable (shown for residential land):

$$\varepsilon^{n}_{L^{r}_{i}} = \frac{\partial N^{n}_{i}}{\partial L^{r}_{i}} \frac{L^{r}_{i}}{N^{n}_{i}} = \sum_{j} \left[(\sum_{k} a_{k,n} E^{k}_{j}) \left(\frac{s^{n}}{N^{n}_{i}} \right) (p^{n}_{i,j}(1-p^{n}_{i,j})) \right] \tag{5}$$

where

$\varepsilon^{n}_{L^{r}_{i}}$ = elasticity of type n households to changes in residential land in zone i,

$a_{k,n}$ = a matrix of conversion coefficients of type n households per type k employees,

E^{k}_{j} = employment of type k (place-of-work) in zone j,

s^{n} = the calibrated ***TELUM*-RES** parameter for residential land,

L^{r}_{i} = residential land in zone i,

$p^{n}_{i,j}$ = the probability of a type n household, with an employed head-of-household in zone j, residing in zone i, and

N^{n}_{i} = households of type n residing in zone i.

For ***TELUM*-RES**, the location elasticity values for travel time are defined for a 1% increase in the travel time for trips from all employment zones to the specified residential zone.

The equation for the location elasticity for travel time is as follows:

$$\varepsilon^{n}_{c_{j.}} = \frac{\partial N^{n}_{i}}{\partial c_{j.}} \frac{c_{j.}}{N^{n}_{i}} = \sum_{j} \left[(\sum_{k} a_{k,n} E^{k}_{j}) \left(\left(\frac{\alpha^{n}}{c_{ij}} \right) + \beta^{n} \right) (p^{n}_{i,j}(1-p^{n}_{i,j})) \left(\frac{c_{ij}}{N^{n}_{i}} \right) \right] \tag{6}$$

where

$\varepsilon^{n}_{c_{j.}}$ = elasticity of type n households to changes in travel times from all employment zones to residential zone i,

c_{ij} = travel time between zones i and j, and

α^{n}, β^{n} = the calibrated DRAM parameters for travel time.

TELUM-EMP Location Elasticity Values

The ***TELUM*-EMP** location elasticity values are exactly analogous to the ***TELUM*-RES** location elasticity values. However, because ***TELUM*-EMP** has an additive lag term, the elasticity values must be multiplied by the potential term weighting parameter. Because the lagged employment variable appears in both the potential term and the lag term of

***TELUM*-EMP**, the location elasticity for lagged employment must be defined in terms of the values of the ***TELUM*-EMP** potential term and scaled lagged employment.

Location elasticity for any attractiveness variable other than lagged employment (shown for total land area) in ***TELUM*-EMP** is defined as:

$$\varepsilon^k_{L_j} = \frac{\partial E^k_{j,t}}{\partial L_j}\frac{L_j}{E_{j,t}} = \lambda \sum_i \left[(N_{i,t-1}) \left(\frac{b^k}{\tilde{E}^k_{j,t}} \right) (p^k_{i,j}(1-p^k_{i,j})) \right] \tag{7}$$

where

$\varepsilon^k_{L_j}$ = elasticity of type k employment to changes in land area in zone j,
λ = the calibrated ***TELUM*-EMP** potential weighting term,
b^k = the calibrated ***TELUM*-EMP** parameter for total land area,
L_j = total area of zone j,
$p^k_{i,j}$ = the probability of type k employment locating in zone j, with work-to-home trips terminating in zone i, and
$\tilde{E}^k_{j,t}$ = employment of type k in zone j at time t (un-weighted potential term).

The equation for location elasticity for lagged employment is as follows:

$$\varepsilon^k_{E^k_{j,t-1}} = \frac{\partial E^k_{j,t}}{\partial E^k_{j,t-1}}\frac{E^k_{j,t-1}}{E^k_{j,t}} = \left[\frac{\lambda \tilde{E}^k_{j,t} \sum_i \left[N_{i,t-1} \left(\frac{a^k}{\tilde{E}^k_{j,t}} \right) (p^k_{i,j}(1-p^k_{i,j})) \right] + (1-\lambda) E^k_{j,t-1}}{\lambda \tilde{E}^k_{j,t} + (1-\lambda) E^k_{j,t-1}} \right] \tag{8}$$

where

$\varepsilon^k_{E^k_{j,t-1}}$ = elasticity of type k employment to changes lagged employment,
a^k = the calibrated ***TELUM*-EMP** parameter for lagged employment, and
$E^k_{j,t-1}$ = employment of type k in zone j at time t-1 (scaled lag term).

For ***TELUM*-EMP**, the location elasticity for travel time is defined to a 1% increase in the travel time for trips from all residential zones to the specified employment zone. The equation for the location elasticity for travel time is:

$$\varepsilon^k_{c_{.j}} = \frac{\partial E^k_{j,t}}{\partial c_{.j}}\frac{c_{.j}}{E^k_{j,t}} = \lambda \sum_i \left[N_{i,t-1} \left(\left(\frac{\alpha^k}{c_{i,j}} \right) + \beta^k \right) (p^k_{i,j}(1-p^k_{i,j})) \frac{c_{i,j}}{E^k_{j,t}} \right] \tag{9}$$

where

$\varepsilon^{k}_{c_{\cdot j}}$ = elasticity of type k employment to equal changes in all of the impedances for work-to-home trips originating in zone j,

α^{k}, β^{k} = calibrated ***TELUM*-EMP** parameters for travel time, and

$c_{i,j}$ = impedance between zones i and j.

The purpose of all this is to provide a means for assessing, without the need for innumerable model runs, the relative sensitivities of the various locators in the various zones to the different independent variables in the model structure. This knowledge, in turn, provides a means for assessing the likely degree of impact of specific policy proposals on individual locator-zone combinations.

Sample Calibration Output Files: *TELUM*-EMP

```
    M    MM    EEEEE TTTTTTT RRRRRR    OOOO     PPPPP   I  L       U    U  SSSSS
   M M M M   E        T    R     R   O    OO   P     P  I  L      U     U  S
  M  M  M   EEEE     T    RRRRRRR   O     OO  PPPPPP  I  L      U     U  SSSS
 M     M   E        T    R   R     O     OO  P       I  L      U     U       S
M     M   EEEEE    T    R     RR    OOO    P       I  LLLLLL  UUUUU  SSSSS

                  CCCCC       A      LL       IIII  BBBBBB
                 CC    C     A A     LL        II   BB    B
                 CC         A   A    LL        II   BB    B
                 CC         A   A    LL        II   BBBBBB
                 CC        AAAAAAA   LL        II   BB    B
                 CC    C   A     A   LL        II   BB    B
                  CCCCC   A       A  LLLLLLL  IIII  BBBBBB

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                          University of Pennsylvania


                  CALIB V3.11 - EMPAL CALIBRATION PROCEDURE
                          VERSION OF 22 APR 1998


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*******************************************************************************

                  THIS RUN MADE ON  8-Nov-99 AT  9:17:59p

*******************************************************************************


  mycity - empal 1
  110899

*******************************************************************************

        THIS RUN FOR EMPLOYMENT TYPE   1 TRAVEL FUNCTION TYPE 0

        NUMBER OF ZONES   10

        NUMBER OF EMPLOYMENT-S.I.C.- GROUPINGS    4

        NUMBER OF HOUSEHOLD TYPES    4

        NUMBER OF LAND USE/ATTRACTIVENESS VARIABLES    1
```

Check the type of CALIB run.

Always check this to be sure it is the run you think it is.

Your input: use it to specifically identify your runs.

Confirm that this is what you wanted.

****
******

INPUT DATA-SET VARIABLES

****
******

ZONE	FCST YR EMP	BASE YR EMP	ZONE AREA
1	6.	30.	4.
2	1.	7.	5.
3	110.	89.	7.
4	92.	75.	6.
5	35.	35.	10.
6	18.	25.	9.
7	44.	27.	11.
8	53.	55.	8.
9	40.	52.	9.
10	1.	1.	7.
TOTL	400.	396.	75.
MEAN	40.	40.	8.
SDEV	37.	28.	2.

Is this the data you meant to use?

Does it match the other runs?

****

HOUSEHOLDS BY TYPE

****

ZONE	LI	LMI	UMI	UI
1	51.	72.	38.	40.
2	31.	87.	60.	48.
3	127.	89.	28.	30.
4	77.	100.	22.	30.
5	107.	116.	154.	77.
6	66.	107.	155.	80.
7	152.	147.	147.	93.
8	119.	107.	67.	30.
9	109.	131.	115.	74.
10	11.	10.	107.	190.
TOTL	850.	966.	893.	692.
MEAN	85.	97.	89.	69.
SDEV	45.	37.	53.	49.

Check these data too.

```
*******************************************************************************

 IMPEDANCE DATA (UPPER LEFT CORNER OF MATRIX, FIRST 10 X 10 ZONES)

*******************************************************************************
```

ZONE	1	2	3	4	5	6	7	8	9	10
1	176	171	363	278	498	565	960	836	514	756
2	171	199	346	299	402	394	822	762	393	597
3	363	346	241	620	739	577	704	485	286	599
4	278	299	620	185	303	569	1099	1061	688	845
5	498	402	739	303	233	404	1005	1085	683	719
6	565	394	577	569	404	237	606	757	378	315
7	960	822	704	1099	1005	606	283	415	449	293
8	836	762	485	1061	1085	757	415	232	403	547
9	514	393	286	688	683	378	449	403	222	314
10	756	597	599	845	719	315	293	547	314	216

```
                  MEAN VALUE OF UNSCALED IMPEDANCE =    540
                    THIS IS USUALLY IN TENTHS OF MINUTES.

                  THE ELEMENTS OF THE IMPEDANCE MATRIX
                  WILL BE DIVIDED BY   10.000 BEFORE CALIBRATION

  VALUE OF MAXIMUM LIKELIHOOD CRITERION FOR UNIFORM DISTRIBUTION
     C(W) =       -921.0340

  VALUE OF MAXIMUM LIKELIHOOD CRITERION FOR PERFECT FIT
     C(B) =       -751.8290

 WORST VALUE OF SEARCH CRITERION IS C(W)-C(B) =      -169.2050

 STARTING VALUES OF PARAMETERS

   Alpha        1.1325
   Beta        -2.2338
   Empl         3.6737
   Land         5.4202
   Lambda       2.5000

     ****** IMPEDANCE RESCALED x 0.10 *******

    GRADIENT SEARCH BEGINNING OVER AGAIN AT ITERATION 1

 ****** GRADIENT SEARCH PROCEDURE
         PARAMETERS ALLOW UP TO 20 OUTER ITERATIONS,
         EACH CONTAINING UP TO  3 LOOPS,
         EACH OF WHICH MAY HAVE UP TO  5 STEPS.
```

Do these impedance values make sense? (Look at your map.)

What is the relative distance between zones?

Are these impedance values consistent?

The statistical calculations begin here.

Does this number make sense?

```
OUTER                ITERATION             -                                   1
*****************************************************************
   LOOP     GRADIENT      FIRST STEP SIZE      CRITERION -OUTER ITERATION  1

    1          395.96      .18358830             -72.69
    2           26.58     1.13653300             -30.21
    3           27.13     1.08056700             -29.32

 PARAMETER    1 -- Alpha
                           LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES    1.1325      1.1274      1.0338
 NORMALIZED DERIVATIVES    -.0095      -.0280      -.0005
      DERIVATIVE VALUES      -3.8         -.7          .0

 PARAMETER    2 -- Beta
                           LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES   -2.2338     -2.2492     -2.6278
 NORMALIZED DERIVATIVES    -.0286      -.1132      -.0026
      DERIVATIVE VALUES     -11.3        -3.0         -.1

 PARAMETER    3 -- Empl
                           LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES    3.6737      3.6996      4.2891
 NORMALIZED DERIVATIVES     .0481       .1763      -.0004
      DERIVATIVE VALUES      19.0         4.7          .0

 PARAMETER    4 -- Land
                           LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES    5.4202      5.3928      4.8743
 NORMALIZED DERIVATIVES    -.0507      -.1551      -.0002
      DERIVATIVE VALUES     -20.1        -4.1          .0

 PARAMETER    5 -- Lambda
                           LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES     .9900       .4516       .0100
 NORMALIZED DERIVATIVES    -.9971      -.9650      1.0000
      DERIVATIVE VALUES    -394.8       -25.7        27.1
```

Meaning: decrease parameter.

Meaning: increase parameter.

Since X is greater in importance than Y, then lambda is a more important parameter.

This is a record of the calculations from the first iteration of the statistical procedure.

The procedure used for these calculations is called *gradient search*. It works by calculating the derivatives (a term from calculus) of the criterion (goodness-of-fit) with respect to each parameter in the model equation. A positive derivative value means that the parameter should be increased in the next calculation; a negative value means that the parameter should be decreased in the next calculation.

The normalized derivative values indicate the relative importance of each parameter at that step of the calculations. In this case, *lambda* dominates all three iterations (loops 1,2,3).

Note: Iterations 2 through 18 have been omitted

This is the next-to-last iteration:

Note:
The criterion is closer to zero than it was at the start, and the derivative values are also closer to zero.

```
OUTER                ITERATION                -                              19
***********************************************************
   LOOP     GRADIENT       FIRST STEP SIZE      CRITERION -OUTER ITERATION 19

    1             .27       .03241611              -18.21
    2            1.26       .01169534              -18.20
    3             .53       .04695823              -18.19

 PARAMETER    1 -- Alpha
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES         2.7275      2.7587      2.7638
 NORMALIZED DERIVATIVES          .5655       .2564       .5774
      DERIVATIVE VALUES             .2          .3          .3

 PARAMETER    2 -- Beta
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES        -4.8097     -4.8514     -4.8487
 NORMALIZED DERIVATIVES         -.7561       .1348       .2286
      DERIVATIVE VALUES            -.2          .2          .1

 PARAMETER    3 -- Empl
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES         7.4244      7.4271      7.4320
 NORMALIZED DERIVATIVES          .0494       .2485       .4444
      DERIVATIVE VALUES             .0          .3          .2

 PARAMETER    4 -- Land
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES         4.0013      4.0191      4.0187
 NORMALIZED DERIVATIVES          .3230      -.0208       .0600
      DERIVATIVE VALUES             .1          .0          .0

 PARAMETER    5 -- Lambda
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES          .5748       .5726       .5909
 NORMALIZED DERIVATIVES         -.0414       .9241      -.6429
      DERIVATIVE VALUES             .0         1.2         -.3

 APPARENT RIDGE BETWEEN PARAMETERS
```

Criterion values

Derivative Values

The gradient search technique may be thought of as a mathematical procedure for finding the highest point on a virtual mountaintop in a multidimensional space. It progresses by calculating the “direction” of steepest ascent up the mountain from a particular point. All the parameters are changed simultaneously (in proportion to their normalized derivatives) in order to move up the mountain. When a “step” is taken (having changed all the parameters), the criterion is re-evaluated in order to determine whether we are further up the mountain. If so, we take another number of steps in the same direction we may find (by recalculating the criterion) that we have gone too far and are over the “crest” of the mountain and are moving back down. In that case, we calculate a new direction of steepest ascent and move off in that direction. Even if the criterion does not decrease after a set number of steps in one direction, a new direction of steepest ascent is calculated.

It is possible to encounter a long curved steep-sided “ridge” on our way up the mountain. The gradient search procedure would slow down appreciably in such a case, as its search path would amount to numerous single steps back and forth over the ridge in a zig-zag pattern. CALIB can detect such a situation and will do the following: a) print a message “apparent ridge…” and b) use a different procedure to calculate the next direction of ascent, producing a new set of steps in a direction that is tangential to the previous zig-zag step pattern. This substantially increases the efficiency of the search process.

The “top” of the mountain is the point at which we will have found the values of the parameters to best fit the model to the equations. We will never get a perfect fit. The values of best/worst

```
 OUTER                ITERATION                 -                              20
************************************************************
   LOOP     GRADIENT       FIRST STEP SIZE      CRITERION -OUTER ITERATION 20

    1             .71      .04110083             -18.18
    2             .29      .03014674             -18.18
    3            1.38      .01877115             -18.17

 PARAMETER    1 -- Alpha
                           LOOP 1     LOOP 2     LOOP 3
       PARAMETER VALUES    2.7719     2.7799     2.8514
 NORMALIZED DERIVATIVES     .6439      .8063      .1450
      DERIVATIVE VALUES        .5         .2         .2

 PARAMETER    2 -- Beta
                           LOOP 1     LOOP 2     LOOP 3
       PARAMETER VALUES   -4.8455    -4.8419    -4.8724
 NORMALIZED DERIVATIVES     .2871     -.3440     -.1450
      DERIVATIVE VALUES        .2        -.1        -.2

 PARAMETER    3 -- Empl
                           LOOP 1     LOOP 2     LOOP 3
       PARAMETER VALUES    7.4383     7.4450     7.4771
 NORMALIZED DERIVATIVES     .5450      .3626      .0594
      DERIVATIVE VALUES        .4         .1         .1

 PARAMETER    4 -- Land
                           LOOP 1     LOOP 2     LOOP 3
       PARAMETER VALUES    4.0195     4.0198     4.0419
 NORMALIZED DERIVATIVES     .0210      .2495      .0352
      DERIVATIVE VALUES        .0         .1         .0

 PARAMETER    5 -- Lambda
                           LOOP 1     LOOP 2     LOOP 3
       PARAMETER VALUES     .5819      .5875      .5702
 NORMALIZED DERIVATIVES     .4533     -.1944      .9763
      DERIVATIVE VALUES        .3        -.1        1.3

******************************************
```

This is the final iteration.

SUMMARY OF RESULTS FROM GRADIENT SEARCH

****

SUMMARY OF CRITERION VALUES AT START OF EACH ITERATION

1	-72.6935
2	-25.0722
3	-20.5768
4	-19.2965
5	-19.1834
6	-19.1124
7	-18.9670
8	-18.9288
9	-18.9114
10	-18.8124
11	-18.7835
12	-18.7664
13	-18.7055
14	-18.6921
15	-18.6189
16	-18.2570
17	-18.2378
18	-18.2316
19	-18.2055
20	-18.1839

Criterion values show how well the estimated value fits the observed value for this locator type (Employment Type 1) by zone.

This shows the gradual movement of the raw (unscaled) goodness-of-fit measure towards zero over the twenty iterations of the parameter estimation calculations.

SUMMARY OF ITERATION COUNTS

```
     5   1  -1  -2   1   3  -2   1   5   1   1   5  -1   5   5  -2   1   5
     2  -1
     5  -1   2   1  -1   3   4   1  -1   1   1   1   2  -2   5   4   1   1
     2   5
    -1   1  -2   1   1  -1  -1   1   5  -1   1  -1   1   5  -1  -1   1   1
    -1   1
```

For the advanced user, this tells more about the search procedure results.

SUMMARY OF VALUES OF 5 PARAMETERS AT START OF EACH ITERATION

	ITER 1	ITER 2	ITER 3	ITER 4	ITER 5
PARAMETER 1	1.132500	1.033581	1.053970	1.002871	1.078082
	1.100167	1.229657	1.263458	1.289479	1.452845
	1.483281	1.523777	1.616717	1.640374	1.779006
	2.597689	2.623174	2.643204	2.727527	2.771924
PARAMETER 2	-2.233800	-2.628638	-3.670289	-3.891550	-3.920331
	-3.932977	-3.940356	-3.979645	-3.985618	-4.094076
	-4.081080	-4.096258	-4.154366	-4.168411	-4.252357
	-4.721851	-4.764874	-4.770424	-4.809712	-4.845478
PARAMETER 3	3.673700	4.288951	6.665297	6.538830	6.534572
	6.537230	6.583677	6.586141	6.600899	6.671438
	6.701462	6.728042	6.784080	6.798553	6.884093
	7.375297	7.374974	7.385520	7.424357	7.438279
PARAMETER 4	5.420200	4.874246	2.719082	2.794995	2.968087
	3.010081	3.201157	3.255280	3.279868	3.445621
	3.454069	3.477771	3.533909	3.546471	3.617007
	3.950011	3.967201	3.973132	4.001278	4.019510
PARAMETER 5	.990000	.334169	.630674	.588068	.538679
	.600212	.591147	.579781	.596933	.577096
	.599290	.575865	.595296	.587496	.585361
	.579696	.591322	.580765	.574838	.581872

This is a summary of the changing parameter values.

```
 **** FINAL CRITERION VALUE

           -18.1547


 **** FINAL VALUES

                     PARAMETER  DERIVATIVE

        Alpha        2.854080          .2
        Beta        -4.875161         -.2
        Empl         7.478262          .1
        Land         4.042548          .0
        Lambda        .588547         1.3


   EXIT ON CONDITION 0  NORMAL TERMINATION




********************************************************************************
******

                      SUMMARY OF COEFFICIENTS AND SIGNIFICANCE TESTS


********************************************************************************
******

 FINAL VALUES OF EMPAL PARAMETERS

 BETA VALUE ADJUSTED TO REFLECT INTERNAL SCALING
 USE THIS ADJUSTED VALUE AS INPUT TO EMPAL
 OR TO NEXT RUN OF CALIB.

                                ASYMPTOTIC
                     PARAMETER   STANDARD    ASYMPTOTIC
                      VALUES      ERRORS      T-VALUES
        Alpha         2.8541       .7312         3.90
        Beta          -.4875       .0237       -20.59
        Empl          7.4783       .3660        20.43
        Land          4.0425       .6187         6.53
        Lambda         .5885       .1091         5.40


 R SQUARED VALUE (FOR COMPARISON)

               RSQ= .8482

 BEST/WORST LIKELIHOOD RATIO

               B/W LR= .8927
 THE RANGE OF THE LIKELIHOOD RATIO IS BETWEEN 0.0000 AND 1.0000.
 FOR A PERFECT FIT, THE LIKELIHOOD RATIO WOULD BE EQUAL TO 1.0000.
```

These are the values you will type into the EMPAL control card for this employment

A goodness-of –fit measure. Statistically this is not as useful as the next one.

This is a better measure of goodness-of-fit of the EMPAL equation to this data.

```
*****************************************************************************

                   ZONAL LOCATION ELASTICITIES (1.0 = 1.0%)

******************************************************************************
```

ZONE	IMP	Empl	Land
1	-3.2397	1.1747	2.3497
2	-3.6369	1.0000	2.3792
3	-2.1575	1.6605	.6953
4	-1.6661	1.5197	.5776
5	-3.4684	2.7309	1.5734
6	-2.5448	2.5689	1.1762
7	-1.7645	1.7474	.6490
8	-2.0690	1.2934	.4829
9	-2.5825	2.1251	.8327
10	-5.8974	1.0000	2.3792
TOTAL	-29.0268	16.8208	13.0954
MEAN	-2.2348	1.7778	.8156
STD DEV	.5320	.4290	.4167

These are measures, zone-by-zone, of the sensitivity of this locator type (Employment Type 1) to each attractiveness variable.

```
******************************************************************************
******

                   REGIONAL LOCATION ELASTICITIES

******************************************************************************
******
```

	AVERAGE ELASTICITY	STANDARD DEVIATION
IMP	-2.2348	.5320
Empl	1.7778	.4290
Land	.8156	.4167

```
THE INTERPRETATION OF A LOCATION ELASTICITY IS:
FOR A CHANGE IN THE LISTED VARIABLE OF 1.00%
THE LOCATOR WOULD INCREASE OR DECREASE BY THE ELASTICITY
AMOUNT.  IF ELASTICITY = -0.4316, THEN FOR A 1.00%
INCREASE IN THAT SPECIFIC VARIABLE FOR THAT ZONE, THERE
WOULD BE A 0.4316% DECREASE IN THAT LOCATOR IN THAT
ZONE, (ALL OTHER THINGS BEING EQUAL).

THE REGIONAL ELASTICITY GIVES THE AVERAGE SENSITIVITY OF
THE SPECIFIC LOCATOR TO THE SPECIFIC VARIABLE.
```

Just as it says…

```
************************************************************************************

                   SUMMARY OF CALIBRATION RESIDUALS

************************************************************************************

    ZONE      OBSERVED         ESTIMATED          RESIDUAL          PCT.DIF

      1          6.00             12.82             -6.82        -113.6510%
      2          1.00              2.91             -1.91        -190.9278%
      3        110.00             83.53             26.47          24.0670%
      4         92.00             85.93              6.07           6.5946%
      5         35.00             25.91              9.09          25.9575%
      6         18.00             24.84             -6.84         -38.0065%
      7         44.00             39.91              4.09           9.2983%
      8         53.00             52.72               .28            .5364%
      9         40.00             71.02            -31.02         -77.5408%
     10          1.00               .42               .58          58.4391%

     MEAN ABSOLUTE PERCENT ERROR =    36.957%
     (ZONES WITH 0 OR 1 OBSERVED ARE OMITTED)

     MINIMUM OBSERVED LOCATOR VALUE =       1.
     MAXIMUM OBSERVED LOCATOR VALUE =     110.

     MAPE FOR (   3) SMALLEST 25% OF ZONES =  100.000%
      THESE ZONES HAVE   2.00% OF THE REGION TOTAL

     MAPE FOR (   3) LARGEST 25% OF ZONES =    11.347%
      THESE ZONES HAVE  63.75% OF THE REGION TOTAL

     OF THE SMALLEST ZONES, ZONES WITH 0 OR 1
     OBSERVED ARE OMITTED FROM MAPE CALCULATION

     RATIO OF ABSOLUTE ERROR SUM TO MEAN OF OBSERVED VARIABLE

               MARMO =    22.669%

     THE MAPE AND MARMO STATISTICS ARE ALWAYS GREATER THAN OR EQUAL TO 0.000%.
     FOR A PERFECT FIT, ALL OF THESE STATISTICS WOULD BE EQUAL TO 0.000%.
```

These are alternative measures of goodness-of-fit.

This is the most general of these measures. 20-30% represents a good fit.

```
*******************************************************************************

                    REGRESSION OF OBSERVED VS ESTIMATED

*******************************************************************************

     A =      -3.10     B =  1.0710

     F - TEST          F =     50.46   DF =   8

     STD. ERR. B =      .4076     T FOR B = 2.63

     STD. ERR. A =     12.988     T FOR A = -.24
```

Another way of comparing the model estimate to the actual data is by using a simple linear regression of one vs. the other. Here the estimated vs. observed data are plotted.

```
        Y
  85.933..                                                 *
         .                                                           *
         .
         .
         .
  73.716..
         .                    *
         .
         .
         .
  61.499..
         .
         .
         .
         .                            *
  49.283..
         .
         .
         .
         .                       *
  37.066..
         .
         .
         .
         .
  24.849..        *         *
         .
         .
         .
         .
  12.632..  *
         .
         .
         .
         .*
         ............................................................X
        1.000      22.800      44.600      66.400      88.200     110.000

              PLOT OF OBSERVED (X-AXIS) VS ESTIMATED (Y-AXIS)
```

Sample Calibration Output Files: *TELUM*-RES

```
    M     MM    EEEEE  TTTTTTT  RRRRRR     OOOO      PPPPP    I   L       U     U   SSSSS
   M M M M    E         T     R      R   O    OO    P     P  I   L       U     U   S
  M   M   M    EEEE      T     RRRRRRR   O     OO  PPPPPP   I   L       U     U   SSSS
 M     M    E         T     R    R       O    OO   P        I   L       U     U         S
M      M    EEEEE     T     R      RR     OOO    P        I   LLLLLL   UUUUU   SSSSS

                  CCCCC        A       LL        IIII   BBBBBB
                 CC     C     A A      LL         II    BB     B
                 CC          A   A     LL         II    BB     B
                 CC          A   A     LL         II    BBBBBB
                 CC         AAAAAAA    LL         II    BB     B
                 CC     C   A     A    LL         II    BB     B
                  CCCCC    A       A   LLLLLLL   IIII   BBBBBB

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                   Department of City and Regional Planning

                          University of Pennsylvania


                  CALIB V3.11 - DRAM CALIBRATION PROCEDURE
                          VERSION OF 22 APR 1998


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********************************************************************************

                  THIS RUN MADE ON  8-Nov-99 AT  9:28:07p

********************************************************************************

 mycity - dram 1
 110899

********************************************************************************
```

Check the type of CALIB run.

Always check this to be sure it is the run you think it is.

Your input: use it to specifically identify your runs.

```
THIS RUN FOR HOUSEHOLD INCOME GROUP   1 TRAVEL FUNCTION TYPE 0

NUMBER OF ZONES   10

NUMBER OF EMPLOYMENT-S.I.C.- GROUPINGS    4

NUMBER OF HOUSEHOLD TYPES    4

NUMBER OF LAND USE/ATTRACTIVENESS VARIABLES    3
```

Confirm that this is what you wanted.

```
ADDITIVE LAG TERM INCLUDED IN DRAM MODEL STRUCTURE:
TOTAL LAGGED HOUSEHOLDS
```

See notes on model formulation.

```
EMPLOYMENT TO HOUSEHOLD HEAD CONVERSION MATRIX

.1216  .0322  .2412  .6050
.0522  .0521  .3285  .5672
.2747  .3215  .2901  .1138
.3000  .3635  .2311  .1054
```

Based on regional data, converts employees by type at place-of-work to households by type at place-of work.

FIRST FOUR EMPLOYMENT TYPES IN FIRST TEN ZONES

1	6.	13.	145.	151.
2	1.	7.	153.	204.
3	110.	27.	50.	77.
4	92.	27.	56.	90.
5	35.	65.	176.	163.
6	18.	22.	198.	202.
7	44.	31.	189.	176.
8	53.	13.	35.	65.
9	40.	60.	148.	152.
10	1.	1.	156.	149.

Is this data correct?

Does it match the “target year” in the EMPAL calibration?

THIS PRINTOUT OF A PORTION OF THE EMPLOYMENT INPUT
IS TO VERIFY THAT THE CORRECT INPUT FILES WERE USED.

****

RESIDENTIAL ATTRACTIVENESS VARIABLES

****

ZONE	VACANT LAND	PER.DEV	RES.LAND
1	0.	.975	2.
2	0.	.980	2.
3	1.	.923	1.
4	1.	.891	2.
5	1.	.920	4.
6	1.	.889	4.
7	0.	.964	5.
8	1.	.850	1.
9	1.	.856	3.
10	0.	.957	5.
TOTL	6.	9.20	28.
MEAN	1.	.920	3.
SDEV	0.	.048	1.

Are these correct?

****

HOUSEHOLDS BY TYPE

****

ZONE	LIHH	LMIHH	UMIHH	UIHH
1	51.	72.	38.	40.
2	31.	87.	60.	48.
3	127.	89.	28.	30.
4	77.	100.	22.	30.
5	107.	116.	154.	77.
6	66.	107.	155.	80.
7	152.	147.	147.	93.
8	119.	107.	67.	30.
9	109.	131.	115.	74.
10	11.	10.	107.	190.
TOTL	850.	966.	893.	692.
MEAN	85.	97.	89.	69.
SDEV	45.	37.	53.	49.

Are these correct?

Do they match the EMPAL calibration output?

```
*******************************************************************************

 TOTAL HOUSEHOLDS (T-1)

*******************************************************************************

    1       175.
    2       215.
    3       289.
    4       243.
    5       424.
    6       378.
    7       472.
    8       354.
    9       382.
   10       298.


 TOTL      3230.


 MEAN       323.


 SDEV        95.
```

Are these zonal total households correct for the lag year?

```
****************************************************************************

 IMPEDANCE DATA (UPPER LEFT CORNER OF MATRIX, FIRST 10 X 10 ZONES)

****************************************************************************
```

ZONE	1	2	3	4	5	6	7	8	9	10
1	176	171	363	278	498	565	960	836	514	756
2	171	199	346	299	402	394	822	762	393	597
3	363	346	241	620	739	577	704	485	286	599
4	278	299	620	185	303	569	1099	1061	688	845
5	498	402	739	303	233	404	1005	1085	683	719
6	565	394	577	569	404	237	606	757	378	315
7	960	822	704	1099	1005	606	283	415	449	293
8	836	762	485	1061	1085	757	415	232	403	547
9	514	393	286	688	683	378	449	403	222	314
10	756	597	599	845	719	315	293	547	314	216

```
                  MEAN VALUE OF UNSCALED IMPEDANCE =   540
                    THIS IS USUALLY IN TENTHS OF MINUTES.

                  THE ELEMENTS OF THE IMPEDANCE MATRIX
                  WILL BE DIVIDED BY  100.000 BEFORE CALIBRATION.


  VALUE OF MAXIMUM LIKELIHOOD CRITERION FOR UNIFORM DISTRIBUTION
     C(W) =      -1957.1980

  VALUE OF MAXIMUM LIKELIHOOD CRITERION FOR PERFECT FIT
     C(B) =      -1830.2000


 WORST VALUE OF SEARCH CRITERION IS C(W)-C(B) =      -126.9972

 STARTING VALUES OF PARAMETERS

   ALPHA        7.2966
   BETA        -5.3177
   VACDEV       2.4646
   PERDEV       -.5314
   RESLND       1.0938
   LIHH        10.7542
   LMIHH         .7892
   UMIHH         .0529
   UIHH        -3.1115
   LAGHH         .5800


 ****** GRADIENT SEARCH PROCEDURE
         PARAMETERS ALLOW UP TO 20 OUTER ITERATIONS,
         EACH CONTAINING UP TO  3 LOOPS,
         EACH OF WHICH MAY HAVE UP TO  5 STEPS.
```

Does this match the EMPAL calibration input? Check consistency again.

The statistical calculations begin here.

```
 OUTER ITERATION -    1
************************************************************
   LOOP     GRADIENT      FIRST STEP SIZE      CRITERION -OUTER ITERATION  1

    1           33.63     2.01660100              -67.82
    2           18.49      .33019340              -63.88
    3           16.62     1.08013100              -48.28

 PARAMETER    1 -- ALPHA
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES         7.2966      7.3398      7.6558
 NORMALIZED DERIVATIVES          .2382       .3254       .1234
      DERIVATIVE VALUES            8.0         6.0         2.1

 PARAMETER    2 -- BETA
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES        -5.3177     -5.2050     -4.3761
 NORMALIZED DERIVATIVES          .6211       .8535       .5378
      DERIVATIVE VALUES           20.9        15.8         8.9

 PARAMETER    3 -- VACDEV
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES         2.4646      2.4619      2.4347
 NORMALIZED DERIVATIVES         -.0147      -.0281      -.2984
      DERIVATIVE VALUES            -.5         -.5        -5.0

 PARAMETER    4 -- PERDEV
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES         -.5314      -.5310      -.5276
 NORMALIZED DERIVATIVES          .0020       .0035       .0477
      DERIVATIVE VALUES             .1          .1          .8

  PARAMETER    7 -- LMIHH
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES          .7892       .7926       .8175
 NORMALIZED DERIVATIVES          .0187       .0257      -.0809
      DERIVATIVE VALUES             .6          .5        -1.3

 PARAMETER    8 -- UMIHH
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES          .0529       .0408      -.0554
 NORMALIZED DERIVATIVES         -.0665      -.0991       .0373
      DERIVATIVE VALUES           -2.2        -1.8          .6


 PARAMETER    9 -- UIHH
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES        -3.1115     -3.1245     -3.2237
 NORMALIZED DERIVATIVES         -.0718      -.1021      -.0639
      DERIVATIVE VALUES           -2.4        -1.9        -1.1
 PARAMETER   10 -- LAGHH
                                LOOP 1      LOOP 2      LOOP 3
       PARAMETER VALUES          .5800       .4518       .6474
 NORMALIZED DERIVATIVES         -.7064       .2014      -.7579
      DERIVATIVE VALUES          -23.8         3.7       -12.6

APPARENT RIDGE BETWEEN PARAMETERS
```

Check as for EMPAL

```
OUTER ITERATION -  20
***********************************************************
  LOOP     GRADIENT      FIRST STEP SIZE      CRITERION - OUTER ITERATION 20

   1            5.88       .02230959             -19.48
   2            2.21       .05937040             -19.41
   3            4.43       .02957990             -19.37

PARAMETER   1 -- ALPHA
                             LOOP 1     LOOP 2     LOOP 3
      PARAMETER VALUES       8.6992     8.7003     8.7095
NORMALIZED DERIVATIVES        .0465      .1551      .2491
     DERIVATIVE VALUES           .3         .3        1.1

PARAMETER   2 -- BETA
                             LOOP 1     LOOP 2     LOOP 3
      PARAMETER VALUES      -2.3607    -2.3653    -2.3957
NORMALIZED DERIVATIVES       -.2053     -.5117      .4829
     DERIVATIVE VALUES         -1.2       -1.1        2.1

PARAMETER   3 -- VACDEV
                             LOOP 1     LOOP 2     LOOP 3
      PARAMETER VALUES        .1964      .1956      .1890
NORMALIZED DERIVATIVES       -.0349     -.1109     -.0084
     DERIVATIVE VALUES          -.2        -.2         .0

PARAMETER   4 -- PERDEV
                             LOOP 1     LOOP 2     LOOP 3
      PARAMETER VALUES       -.2818     -.2819     -.2819
NORMALIZED DERIVATIVES       -.0011     -.0001     -.0150
     DERIVATIVE VALUES           .0         .0        -.1

PARAMETER   5 -- RESLND
                             LOOP 1     LOOP 2     LOOP 3
      PARAMETER VALUES       1.4949     1.4956     1.5110
NORMALIZED DERIVATIVES        .0311      .2588     -.4917
     DERIVATIVE VALUES           .2         .6       -2.2

PARAMETER   6 -- LIHH
                             LOOP 1     LOOP 2     LOOP 3
      PARAMETER VALUES       9.9982     9.9954     9.9688
NORMALIZED DERIVATIVES       -.1242     -.4479     -.1064
     DERIVATIVE VALUES          -.7       -1.0        -.5

PARAMETER   9 -- UIHH
                             LOOP 1     LOOP 2     LOOP 3
      PARAMETER VALUES      -3.6630    -3.6647    -3.6736
NORMALIZED DERIVATIVES       -.0755     -.1499     -.1298
     DERIVATIVE VALUES          5.5        -.2        2.7
```

This is the final iteration.

```
************************************************************************

 SUMMARY OF RESULTS FROM GRADIENT SEARCH

************************************************************************

 SUMMARY OF  CRITERION VALUES   AT START OF EACH ITERATION

       1        -67.8204
       2        -47.2688
       3        -43.8512
       4        -42.3540
       5        -36.2668
       6        -32.5154
       7        -27.0187
       8        -23.8358
       9        -23.5824
      10        -23.4119
      11        -22.7344
      12        -22.0719
      13        -21.9351
      14        -21.8798
      15        -21.6940
      16        -21.1974
      17        -19.8936
      18        -19.7399
      19        -19.6486
      20        -19.4840
```

Criterion values show how well the estimated value fits the observed value for this locator type (Household Type 1) by zone.

This shows the gradual movement of the raw (unscaled) goodness-of-fit measure towards zero over the twenty iterations of the parameter estimation

```
SUMMARY OF ITERATION COUNTS

       -2   -1   -1    5    3    2    1   -2   -1    5    5   -1   -3    2    1    1   -2   -1
        1    1
        5    1    1   -1    1   -1    1    1    1   -1    1    1    5   -1    3    4    1    1
        1    1
       -2   -1    1    1    1    1   -1    1    1    1   -1    1    5    5    1   -1   -1    1
        1    1
```

```
 SUMMARY OF VALUES OF 10 PARAMETERS AT START OF EACH ITERATION

                  ITER 1      ITER 2      ITER 3      ITER 4      ITER 5
 PARAMETER 1    7.296600    7.667818    7.855647    7.863288    7.897797
                8.021053    8.072397    8.156564    8.169782    8.189485
                8.266637    8.337057    8.361495    8.362821    8.384958
                8.496555    8.630968    8.639703    8.657081    8.699234
 PARAMETER 2   -5.317700   -4.323781   -3.803317   -3.740408   -3.433186
               -2.755781   -2.555497   -2.254523   -2.277145   -2.265309
               -2.268482   -2.300696   -2.293999   -2.295932   -2.305396
               -2.313066   -2.372806   -2.370031   -2.366431   -2.360747
 PARAMETER 3    2.464600    2.405665    2.293798    2.142106    1.500416
                 .934908     .799049     .529587     .490653     .469181
                 .387740     .380421     .360463     .358949     .341801
                 .289722     .234142     .227865     .216898     .196363
 PARAMETER 4   -.531400    -.522979    -.506926    -.484966    -.391446
               -.312310    -.295433    -.262035    -.259717    -.259604
               -.260107    -.267642    -.267803    -.267786    -.268232
               -.273778    -.281328    -.281168    -.281120    -.281832
```

For the advanced user, this tells more about the search procedure results.

This is a summary of the changing parameter values.

```
PARAMETER 5   1.093800    .789592    .685564    .762948   1.083357
              1.281465   1.399435   1.685125   1.715214   1.704325
              1.683857   1.632733   1.627708   1.629245   1.630114
              1.568497   1.512721   1.513424   1.510949   1.494942
PARAMETER 6  10.754200  10.952020  11.065630  11.094220  11.203920
             11.239230  11.213190  11.136970  11.089880  11.052950
             10.878330  10.712470  10.664970  10.660850  10.608870
             10.385180  10.097560  10.085070  10.059680   9.998181
PARAMETER 7    .789200    .809661    .804563    .775293    .652908
               .594173    .598858    .616039    .650503    .683216
               .829563    .969021   1.009469   1.012404   1.054193
              1.251672   1.507669   1.520983   1.548171   1.615023
PARAMETER 8    .052900   -.051780   -.093617   -.073611    .027421
               .171774    .218433    .328122    .363993    .390786
               .519930    .646869    .684789    .688113    .729788
               .911153   1.150730   1.163430   1.188834   1.250084
PARAMETER 9  -3.111500  -3.229865  -3.295389  -3.307671  -3.361204
             -3.426301  -3.433320  -3.441918  -3.445487  -3.451411
             -3.475634  -3.502177  -3.510425  -3.510799  -3.518382
             -3.562999  -3.624335  -3.629215  -3.638989  -3.663047
PARAMETER10    .580000    .573710    .510216    .578353    .599995
               .485382    .634541    .729087    .744735    .760461
               .785842    .793476    .807624    .801687    .768293
               .746164    .795101    .818305    .834210    .808646

 **** FINAL CRITERION VALUE

           -19.3167


 **** FINAL VALUES

                  PARAMETER  DERIVATIVE

        ALPHA      8.716844        1.1
        BETA      -2.381420        2.1
        VACDEV      .188751         .0
        PERDEV     -.282303        -.1
        RESLND     1.496458       -2.2
        LIHH       9.965671        -.5
        LMIHH      1.651811        1.1
        UMIHH      1.284517         .5
        UIHH      -3.677471        -.6
        LAGHH       .842352        2.7


   EXIT ON CONDITION 0  NORMAL TERMINATION
```

If we “know” where people work and we “know” where people live, then, implicitly, we “know” what length work-to-employment trips are being made.

```
******************************************************************************

                IMPLIED TRIP FREQUENCY DISTRIBUTION STATISTICS
                            (NOTE: TIMES ARE IN MINUTES)

 **************************************************************

     MAXIMUM OBSERVED IMPEDANCE VALUE = 109.9000
     AVERAGE ZONE-TO-ZONE IMPEDANCE (INCLUDING INTRAZONAL VALUES) =   54.0320
     STANDARD DEVIATION OF IMPEDANCE =   24.9670
     AVERAGE LENGTH OF IMPLICIT TRIPS =  39.8587

     MEDIAN TRIP LENGTH IS IN THE INTERVAL    40.2967 TO    42.1283


        Y
   9.184..              ***
         .                    ***
         .
         .
         .
   7.872..
         .
         .
         .
         .
   6.560..
         .
         .
         .
         .
   5.248..
         .
         .
         .
         .
   3.936..
         .
         .                 ***
         .
         .
   2.624..                       ***
         .                              ***
         .           ***
         .                                 ***
         .                          ***
   1.312..
         .
         .                                    ***
         .                                       ***
         .***********                               *****************
         ............................................................X
        1.832      23.445      45.059      66.673      88.286     109.900

           PLOT OF TRIP FREQUENCY IN PERCENTS (Y-AXIS) VS TRIPLENGTH (X-AXIS)
               NOTE THAT DATA ARE GROUPED BECAUSE DATA SET HAS 10 ZONES.
```

Time or distance between the two zones that are farthest apart.

Does this make sense?

****

SUMMARY OF COEFFICIENTS AND SIGNIFICANCE TESTS

****

FINAL VALUES OF DRAM PARAMETERS

These are the values you will type into the DRAM control card for forecasting.

Equation Parameters/Trip Function

HH to HH Att

		PARAMETER VALUES	ASYMPTOTIC STANDARD ERRORS	SYMPTOTIC T-VALUES
	ALPHA	8.7168	.4158	20.97
	BETA	-2.3814	.1020	-23.36
3	VACDEV	.1888	.1807	1.04
	PERDEV	-.2823	1.7797	-.16
	RESLND	1.4965	.1105	13.55
	LIHH	9.9657	.5301	18.80
	LMIHH	1.6518	.9808	1.68
	UMIHH	1.2845	.4955	2.59
	UIHH	-3.6775	1.0772	-3.41
	LAGHH	.8424	.0559	15.06

R SQUARED VALUE (FOR COMPARISON)

RSQ= .7792

A goodness-of –fit measure. Statistically this is not as useful as the next one.

BEST/WORST LIKELIHOOD RATIO

B/W LR= .8479

This is a better measure of goodness-of-fit of the EMPAL equation to this data.

THE RANGE OF THE LIKELIHOOD RATIO IS BETWEEN 0.0000 AND 1.0000.
FOR A PERFECT FIT, THE LIKELIHOOD RATIO WOULD BE EQUAL TO 1.0000.

****

ZONAL LOCATION ELASTICITIES (1.0 = 1.0%)

****

ZONE	IMP	VACDEV	PERDEV	RESLND	LIHH	LMIHH
1	-1.1046	.1445	-.2161	1.1457	7.6296	1.2646
2	-.2468	.1497	-.2240	1.1872	7.9062	1.3105
3	-1.0412	.1117	-.1670	.8854	5.8963	.9773
4	.1633	.1272	-.1903	1.0087	6.7173	1.1134
5	-.3258	.1206	-.1804	.9561	6.3671	1.0554
6	-.7788	.1385	-.2071	1.0978	7.3105	1.2117
7	-.3357	.1105	-.1652	.8759	5.8328	.9668
8	-1.2731	.1225	-.1832	.9709	6.4659	1.0717
9	-.5908	.1341	-.2005	1.0628	7.0779	1.1732
10	.1452	.1577	-.2359	1.2503	8.3263	1.3801
TOTAL	-5.3884	1.3169	-1.9696	10.4407	69.5300	11.5246
MEAN	-.6190	.1246	-.1864	.9881	6.5805	1.0907
STD DEV	.4342	.0126	.0189	.1000	.6659	.1104

These are measures, zone-by-zone, of the sensitivity of this locator type (Household Type 1) to each attractiveness variable.

****

ZONAL LOCATION ELASTICITIES (1.0 = 1.0%)

****

ZONE	UMIHH	UIHH	LAGHH
1	.9834	-2.8154	.2643
2	1.0191	-2.9175	.3597
3	.7600	-2.1758	.0836
4	.8658	-2.4788	.1840
5	.8207	-2.3496	.1596
6	.9423	-2.6977	.1937
7	.7518	-2.1524	.1824
8	.8334	-2.3860	.1922
9	.9123	-2.6119	.1844
10	1.0732	-3.0725	.3006
TOTAL	8.9620	-25.6575	2.1047
MEAN	.8482	-2.4283	.1755
STD DEV	.0858	.2457	.0613

```
*******************************************************************************
******

                    REGIONAL LOCATION ELASTICITIES


*******************************************************************************
******

                      AVERAGE     STANDARD
                    ELASTICITY   DEVIATION

          IMP         -.6190       .4342
        VACDEV         .1246       .0126
        PERDEV        -.1864       .0189
        RESLND         .9881       .1000
        LIHH          6.5805       .6659
        LMIHH         1.0907       .1104
        UMIHH          .8482       .0858
        UIHH         -2.4283       .2457
        LAGHH          .1755       .0613

    THE INTERPRETATION OF A LOCATION ELASTICITY IS:
    FOR A CHANGE IN THE LISTED VARIABLE OF 1.00%
    THE LOCATOR WOULD INCREASE OR DECREASE BY THE ELASTICITY
    AMOUNT.  IF ELASTICITY = -0.4316, THEN FOR A 1.00%
    INCREASE IN THAT SPECIFIC VARIABLE FOR THAT ZONE, THERE
    WOULD BE A 0.4316% DECREASE IN THAT LOCATOR IN THAT
    ZONE, (ALL OTHER THINGS BEING EQUAL).

    THE REGIONAL ELASTICITY GIVES THE AVERAGE SENSITIVITY OF
    THE SPECIFIC LOCATOR TO THE SPECIFIC VARIABLE.
```

Just as it says…

This table compares the input data to the model estimate and calculates both absolute and percent differences.

```
***********************************************************************

                    SUMMARY OF CALIBRATION RESIDUALS

***********************************************************************

    ZONE      OBSERVED          ESTIMATED          RESIDUAL          PCT.DIF

      1         51.00              38.85             12.15          23.8267%
      2         31.00              33.33             -2.33          -7.5295%
      3        127.00             165.83            -38.83         -30.5786%
      4         77.00              79.98             -2.98          -3.8729%
      5        107.00             113.87             -6.87          -6.4198%
      6         66.00              85.88            -19.88         -30.1164%
      7        152.00             123.48             28.52          18.7634%
      8        119.00              85.57             33.43          28.0933%
      9        109.00             107.18              1.82           1.6743%
     10         11.00              16.03             -5.03         -45.7355%

     MEAN ABSOLUTE PERCENT ERROR =    19.661%
     (ZONES WITH 0 OR 1 OBSERVED ARE OMITTED)

     MINIMUM OBSERVED LOCATOR VALUE =      11.
     MAXIMUM OBSERVED LOCATOR VALUE =     152.

     MAPE FOR (   3) SMALLEST 25% OF ZONES =   26.252%
      THESE ZONES HAVE 10.94% OF THE REGION TOTAL

     MAPE FOR (   3) LARGEST 25% OF ZONES =    25.857%
      THESE ZONES HAVE  46.82% OF THE REGION TOTAL

     OF THE SMALLEST ZONES, ZONES WITH 0 OR 1
     OBSERVED ARE OMITTED FROM MAPE CALCULATION
```

These are alternative measures of goodness-of-fit.

```
     RATIO OF ABSOLUTE ERROR SUM TO MEAN OF OBSERVED VARIABLE

               MARMO =    17.865%

     THE MAPE AND MARMO STATISTICS ARE ALWAYS GREATER THAN OR EQUAL TO 0.000%.
     FOR A PERFECT FIT, ALL OF THESE STATISTICS WOULD BE EQUAL TO 0.000%.
```

This is the most general of these measures. 20-30% represents a good fit.

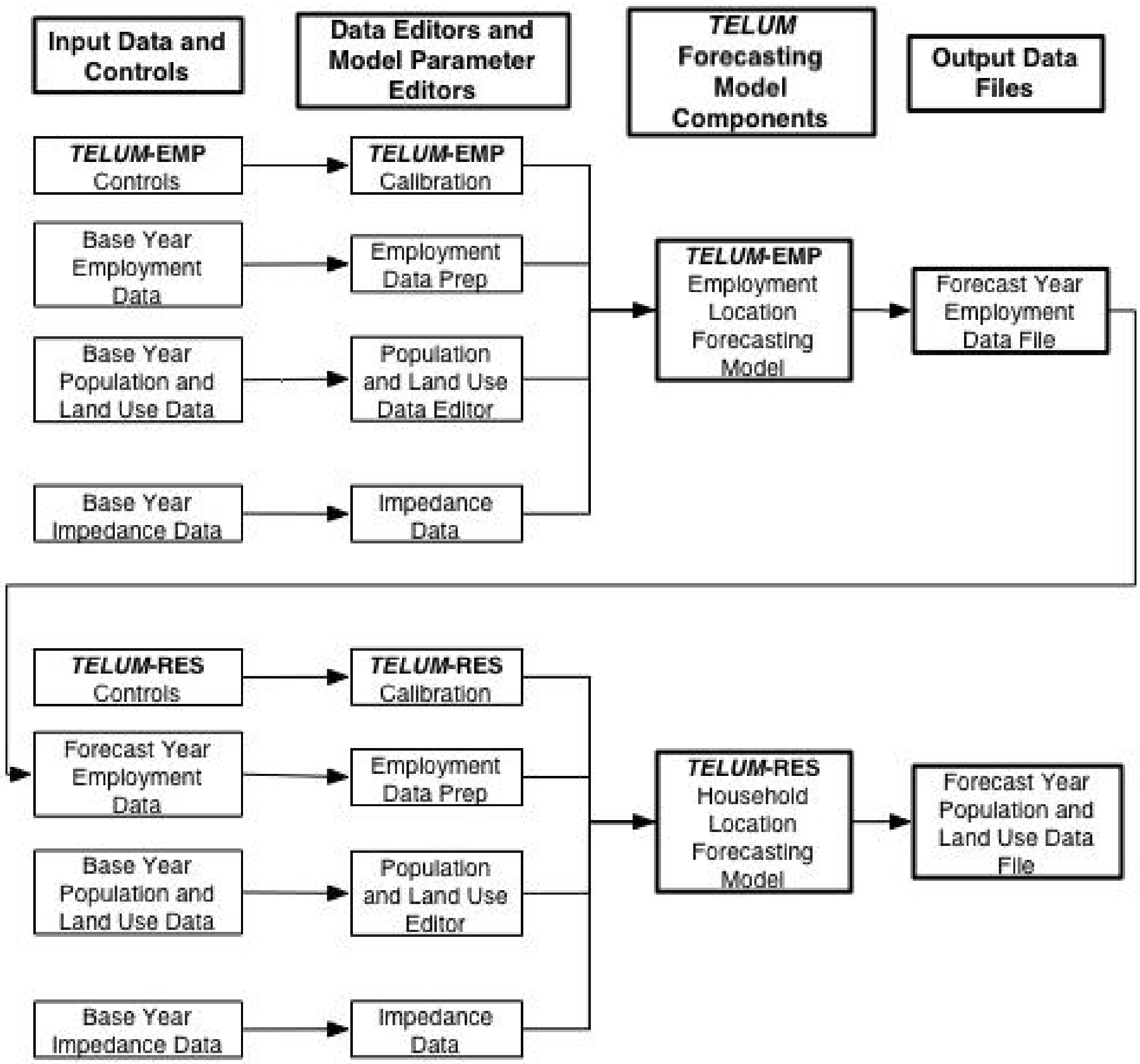
```
********************************************************************************

                    REGRESSION OF OBSERVED VS ESTIMATED

********************************************************************************


     A =      10.23     B =    .8797

     F - TEST           F =     30.84   DF =   8

     STD. ERR. B =      .3490     T FOR B = 2.52

     STD. ERR. A =     15.183     T FOR A =  .67

             Y
      165.835..                                                *
              .
              .
              .
              .
      144.434..
              .
              .
              .
              .
      123.034..                                                           *
              .
              .                                        *
              .
              .                                         *
      101.633..
              .
              .
              .
              .                      *                      *
       80.233..                           *
              .
              .
              .
              .
       58.832..
              .
              .
              .
              .
       37.431..                *
              .        *
              .
              .
              .*
              ............................................................X
            11.000      39.200      67.400      95.600     123.800     152.000

                    PLOT OF OBSERVED (X-AXIS) VS ESTIMATED (Y-AXIS)

                                    The End
```

Another way of comparing the model estimate to the actual data is by using a simple linear regression of one vs. the other. Here the estimated vs. observed data are plotted.

8. Model Forecasting

1. ***TELUM*** Program Overview

The diagram below is an overview of your work thus far in preparation for your first model forecast. This diagram shows the strong interconnections of each ***TELUM*** component. It is critical as you begin model forecasting that you keep this linear connectivity in mind. If you change your base year *DOPU* zonal data or *TIPU* impedance values, you must also complete a rerun of calibration parameters before proceeding to a new round of model forecasting.



2. Model Forecasting Unit Overview

This chapter discusses the process of model forecasting with ***TELUM***. The formulations of the models, ***TELUM*-EMP** and ***TELUM*-RES**, are discussed in detail in the chapter Appendix. In this section you will learn how to run a Baseline model forecast and new (Policy) forecasts, rerun your model forecasts, and include aspects of local planning knowledge into your forecasts.

Analysis of phenomena as complex as the location of jobs and people in a large region, requires complex tools. ***TELUM*** contains a formal structure consisting of two modified versions of singly-constrained spatial interaction models, referred to here as ***TELUM*-EMP** and ***TELUM*-RES**. These are followed by a multiple regression model, which reconciles the competing employment and household demand for land. The whole set of models run behind the ***TELUM*** interface.

The overall structure of the ***TELUM*** model forecasting process is rather straightforward. Beginning with regional trends, transportation facility descriptions, and data on the current location of employment (jobs), population, and households, ***TELUM*** can forecast future location of jobs and households. The forecasts are done in five-year steps. For example the 2000 data becomes the input for the next forecast, 2005, and, in turn, 2005 becomes the input to 2010. The equation structure of the models is complex. It is briefly described in the Appendix to this chapter. The models are described in more detail in Putman, S. Integrated Urban Models (1983, Pion Limited, London, Chapter 6). It is important to note that in embedding the models into a streamlined user-friendly interface, a certain amount of user discretion had to be sacrificed. ***TELUM*** *MFCU* is a linear modeling structure which, for example, a seasoned modeler may find limiting in that, if a user decides it is necessary to rerun a forecast she must rerun all time periods.

In *MFCU*, ***TELUM*** begins by running a set of Baseline (BL) forecasts. This first forecast is performed using your *DOPU* data inputs, *TIPU* impedance file, and a set of statistical outputs, the equation coefficients, generated by ***TELUM*** during *MCPU*. *MFCU* begins by telling you the name of your model forecast, in subsequent forecasts you will assign your own name. ***TELUM*** will then provide you with an opportunity to revise or add the following:

- Employment and Population projections
- Add travel impedance files for future forecast time periods
- Add constraints
- Change the number of time periods you wish to forecast for the region

Next, ***TELUM*** will begin the internal File Check in preparation for the model forecast. Similar to *MCPU*, begin Forecasting by clicking the “GO” button. Once you click “GO” ***TELUM*** immediately begins forecasting your region’s future employee and household locations for each forecast time period. This process can take several minutes and should not be interrupted for any reason.

Once *MFCU* has completed the model forecast, you are immediately provided with an option to view a summary of your forecast outputs by policy and forecast year. This report summarizes regional change in employee and household location and land use consumption. For a more detailed, graphical, view of your region’s zonal changes, we recommend using *MAP IT*.

3. The Baseline Forecast

The Baseline Forecast is the initial set of regional forecasts made from your *DOPU* data, *TIPU* impedance file, and *MCPU* calibration parameters. During future policy runs, you will use your Baseline forecasts for a comparative analysis against your region's policy forecast(s).

Running a Baseline Model Forecast

In preparation for the baseline forecast, ***TELUM*** provides you with an opportunity to do one or all of the following:

- Reduce the number of forecast time periods you wish to use
- Add an impedance file for a future time period(s)
- Change your regional employment and population projects for your forecast time periods
- Add zonal constraints

Each of these options is described in more detail in the following sections. For your first baseline forecast you may or may not wish to use the above options. It is important to know that whatever you do in your baseline forecasts will be reflected in any of the policy forecasts you attempt later. For instance, if you decide to make a baseline forecast with only four forecast time periods, all subsequent policy forecasts can only have four or fewer time periods.

We recommend that you run your first baseline forecast with the data inputs you have provided in *IDEU*, *DOPU*, and *TIPU*. If you don't agree with this first set of baseline forecasts, you can always return to *MFCU* to rerun the baseline with any changes in data.

How to Run a Baseline Forecast

Remember, a Baseline forecast can only be made after you have successfully completed a model calibration run in *MCPU*. This is because forecasting requires both the equation coefficients calculated by CALIB, and the calibration residuals. Use the following steps as a guide:

1. When you enter *MFCU*, the system will display **BL** as your first model forecast. As you continue ***TELUM*** will ask you to change or add data as described above.

2. Soon you will arrive at a screen asking you to Run a Model Forecast. Click "GO."

3. ***TELUM*** will announce when it has completed your Baseline forecast.

Immediately following your first forecast, your Spatial Analysis reports appear. Carefully review your reports, as well as your maps in *MAP IT*. Here you will decide whether to **keep** your Baseline forecasts or **rerun** your baseline before proceeding to a "new model forecast."

Re-Run a Baseline Model Forecast

At times, users tend not to agree with their Baseline forecasts. Typically, a user will find that they must make changes to the data. In this case, users may rerun their Baseline forecast. A rerun is **required** when any of your starting data inputs change. A user **must rerun** when one or all of the following apply:

- A change is made to the zonal and/or regional *DOPU* data inputs
- A new or modified impedance file is added to *TIPU*
- A change is needed in the region's Employment and/or Population projects
- The agency wants to add future forecast time period impedance files

How to Re-run a Baseline Forecast

Rerun your Baseline forecast by doing the following:

1. Open ***TELUM*** and click "*Skip to MFCU"*.
2. Upon re-entering *MFCU*, you will receive a screen asking "What you would like to do next in model forecasting." Select "Rerun Model Forecast."
3. ***TELUM*** will ask you which forecast you would like to rerun. Select **Baseline**.
4. Next, ***TELUM*** will ask you to indicate the change(s) you wish to make for your new forecast. Select the data component(s) you wish to change. If you do not make a change, there is no reason to rerun the Baseline forecast.
5. ***TELUM*** will automatically transport you to the section where you have indicated that changes are necessary. Make your data changes and proceed back through the system to *MFCU*. During this time, we suggest you **do not exit *TELUM*** until you have completed your new set of Baseline Forecasts.
6. Once you re-enter *MFCU*, continue through the ***TELUM*** screens until you see Run Model Forecast. Select "GO."
7. Once you have completed the Baseline rerun, you can review your Spatial Analysis and *MAP IT* Forecasting maps. You may continue to rerun your Baseline forecast until you find a set of forecasts your agency believes accurately reflect the location of activity for the region.

4. Running a New Model Forecast

A new model forecast, also referred to as a **Policy Forecast**, can be run in the ***TELUM*** system after the baseline forecast. Agencies typically run a new forecast when:

- A change in policy is planned for one or more zones in the region
- A transit improvement or highway project changes impedance values in one or more zones
- Updates in the regional employment and population projections become available
- The agency wishes to analyze the "What if we did this?", or "What if the region doesn't grow as rapidly as we now expect?" that come along with policy changes

How to Run a New Model Forecast

Begin the New Model Forecast by gathering your new data inputs. New data typically includes updated household, employment or impedance data, policy constraints in the form of impedance value changes, maximums and minimums on household and employment data, or absolute parameter values. Please see the proceeding section for directions to change regional projections, *DOPU* and *TIPU* data, and impose household and employment constraints by zone.

To run a new model forecast:

1. Open ***TELUM*** and click "Skip to MFCU."

2. *MFCU* will ask you to select whether you wish to perform a "New" or "Rerun" model forecast. Select "New" model forecast.

3. Enter the name and a description of your new model forecast.

4. ***TELUM*** will ask you to indicate the change(s) and/or data you wish to add for your new model forecast. Select all options that apply. You can choose to change employment and household projections, add future year impedance files, or impose constraints on regional employment and household data by zone. You **must** make a change otherwise there is no reason for you to be running a new model forecast.

5. ***TELUM*** will automatically transport you to where you have indicated changes are necessary. Make your data changes and proceed back through the system to *MFCU*. During this time, we suggest you **do not exit *TELUM*** until you have completed your new model forecast.

6. Once you return to *MFCU*, continue through the ***TELUM*** screens to Run Model Forecast. Select "GO."

7. You have completed a "New" model forecast. Now you can review your Spatial Analysis and *Map It* Forecasting maps.

Changing Your Model Forecast Inputs

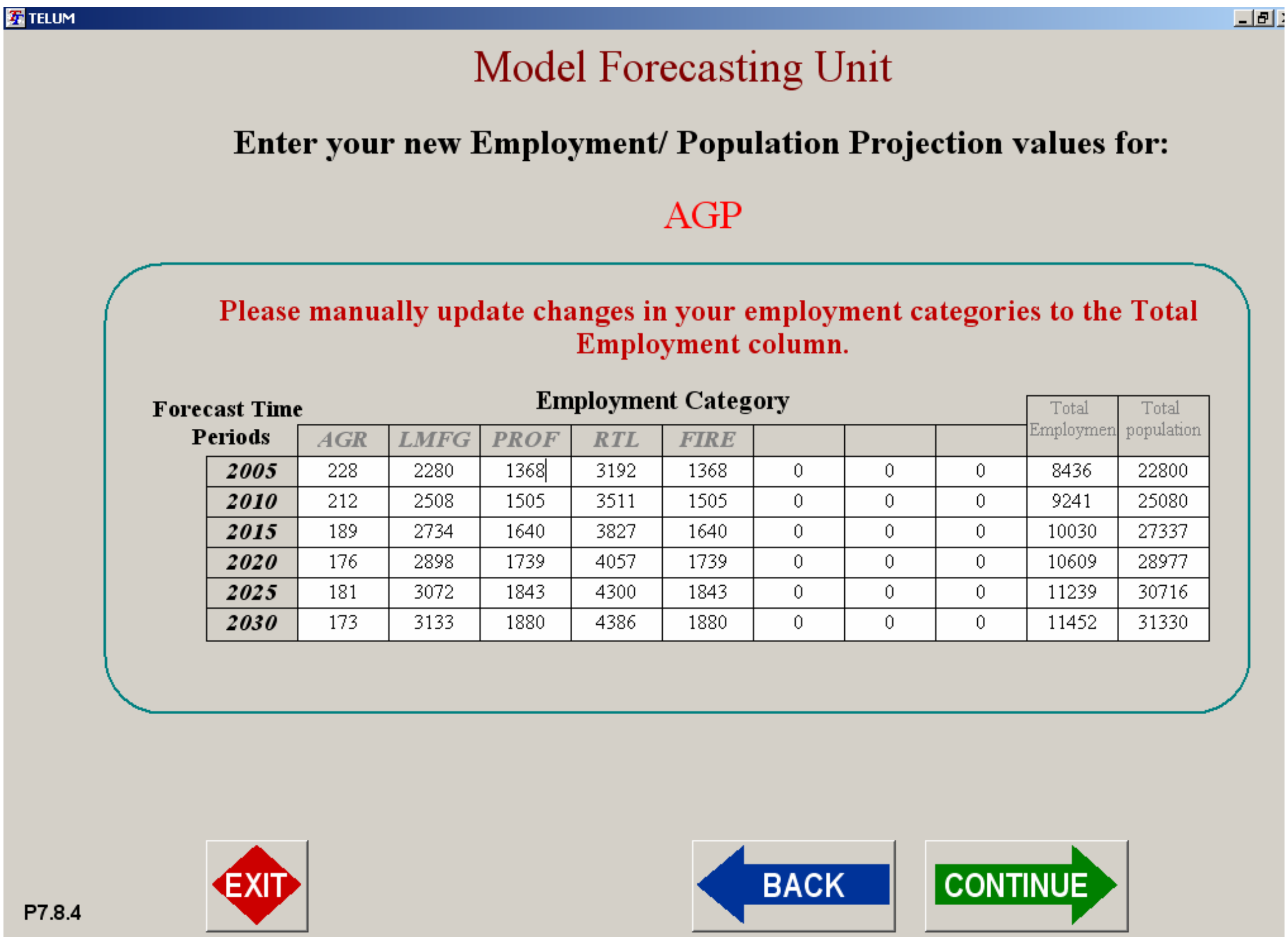
Your model forecast inputs, as you will recall, are the *DOPU* zonal data, *TIPU* impedance file, and *MCPU* model parameter values. Often agencies must change and/or add data inputs to reflect a policy or updated data that becomes available within their modeling region. This is a typical modeling function. A change is necessary when:

- A change is made to the zonal and/or regional *DOPU* data inputs
- A new or modified base year impedance file is added to *TIPU*
- A change is made in the region's Employment and/or Population projections
- The agency has impedance files to add for future forecast time periods

When running a new model forecast, ***TELUM*** provides the options to change regional employment and population projections, modify regional impedance files, and impose location constraints on household and employment locators. *DOPU* or *TIPU* changes must be made in the corresponding sections of ***TELUM***. Projection and impedance data can be updated by running a new model forecast, as described below.

Changes to Employment and Population Projections and Impedance Files

When new regional employment and population projections or impedance data becomes available, the regional ***TELUM*** forecasts should be updated to ensure accuracy. After viewing the baseline forecast and choosing to run a new model forecast, you can update projections and impedance files. By choosing to change regional employment and population projections, you can manually alter the population and employment projections in the supplied worksheet in screen P7.8.4, as shown below.

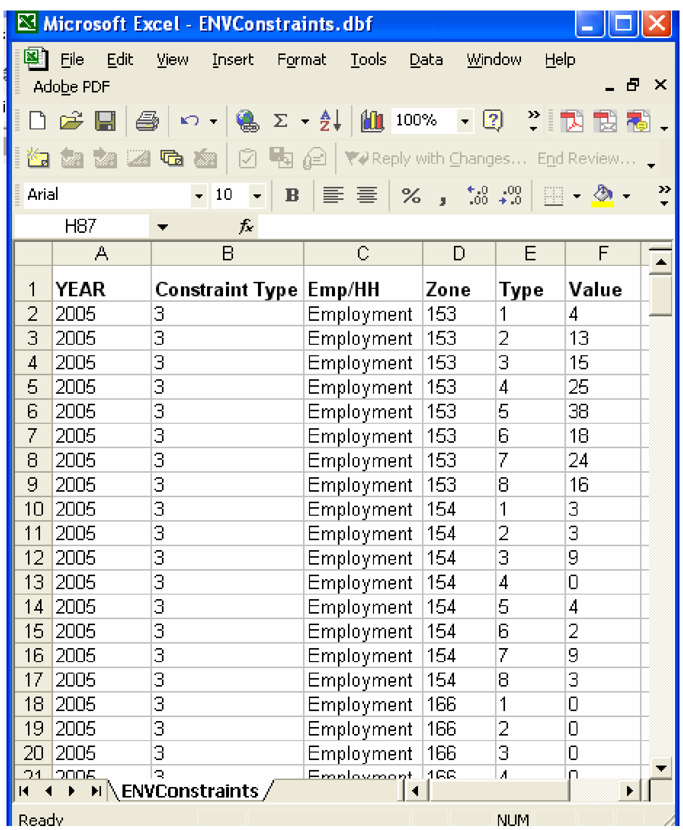


Employment and Household Constraints by Type and/or Zone

Any policy or infrastructure change expected to affect employee and household location and/or travel time can be forecasted for comparison with other policies and the baseline. These changes are reflected by ***TELUM*** when entered as new population or employment projections, updated impedance files, or household, employment and location constraints. Constraints and changes in impedance values reflect regional and zonal policies that can alter the pattern of employment and household location. Constraints serve two important roles in the forecasting process. They limit growth in zones that are either increasing too fast due to model errors or increasing at a rate that deviates grossly from local knowledge. Examples of local knowledge include the protection of environmentally sensitive or farm lands, future increases or limits on households or employment values due to planned development, or limits on infrastructure expansions. There are four types of Employment and Household Constraints: Absolute Constraints, Total Constraints, and Maximum and Minimum Constraints.

Constraint Data Entry Preparation

Before entering constraints, it is helpful to organize a sample input table that resembles the one below, with Zone, Type, and Value columns, as well as year, constraint type, and employment or household designation. The Type category reflects not the constraint type, as Type 1: Absolute Constraint, but the employment or household category number. For instance, with four household categories, Low-Income (LI), Middle-Income (MI), High Middle-Income (HMI) and High-Income (HI), LI is type 1, MI is type 2, HMI is type 3, and HI is type 4. The same concept applies to employment. In a student project in which there were eight employment types, the table below was used to organize a large number of constraints. The corresponding employment sequence numbers are noted in the Type category. The constraint type, value, and year were included to best facilitate accurate data entry into ***TELUM***.

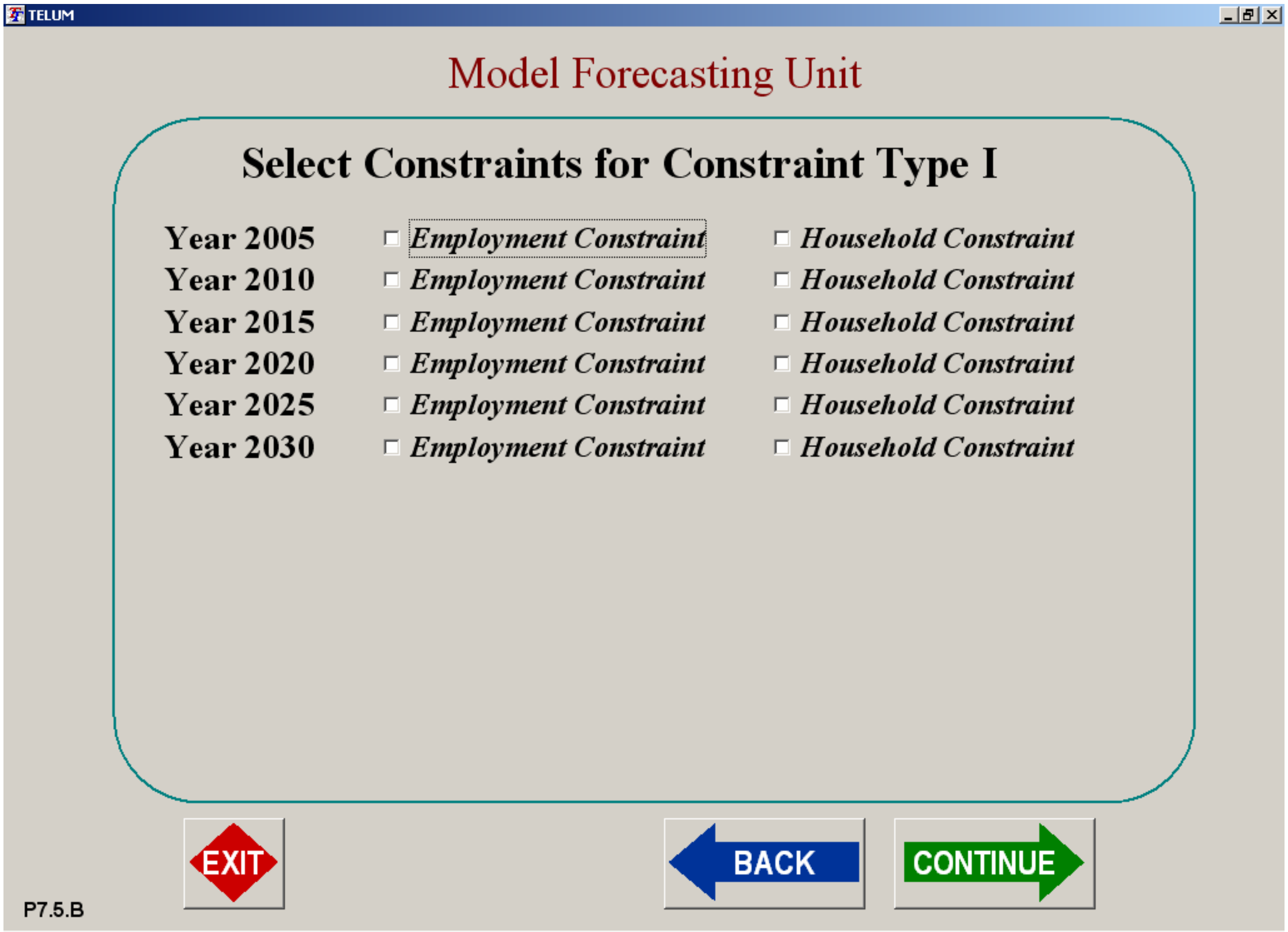


Microsoft Excel - ENVConstraints.dbf

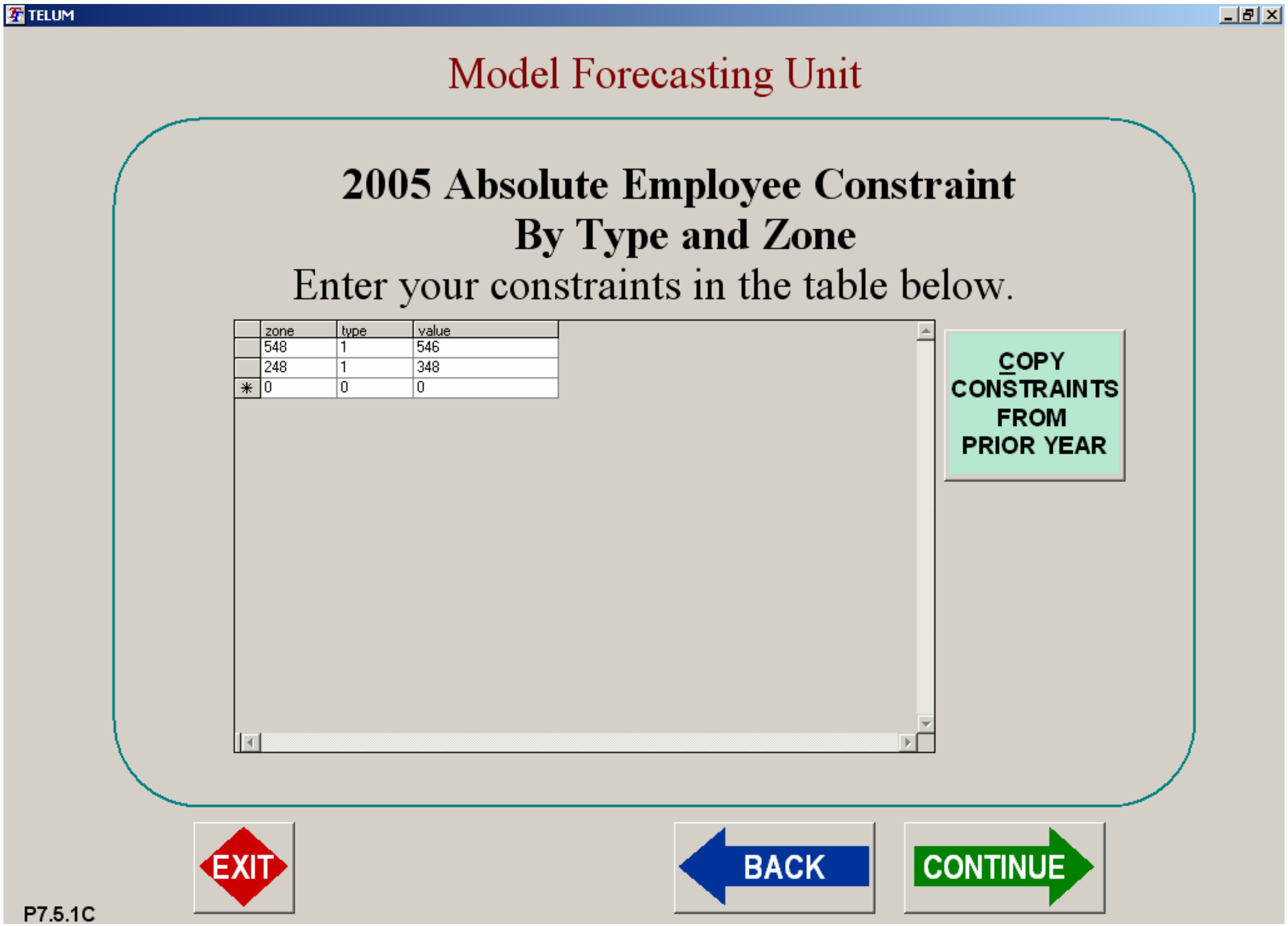
	A	B	C	D	E	F
1	YEAR	Constraint Type	Emp/HH	Zone	Type	Value
2	2005	3	Employment	153	1	4
3	2005	3	Employment	153	2	13
4	2005	3	Employment	153	3	15
5	2005	3	Employment	153	4	25
6	2005	3	Employment	153	5	38
7	2005	3	Employment	153	6	18
8	2005	3	Employment	153	7	24
9	2005	3	Employment	153	8	16
10	2005	3	Employment	154	1	3
11	2005	3	Employment	154	2	3
12	2005	3	Employment	154	3	9
13	2005	3	Employment	154	4	0
14	2005	3	Employment	154	5	4
15	2005	3	Employment	154	6	2
16	2005	3	Employment	154	7	9
17	2005	3	Employment	154	8	3
18	2005	3	Employment	166	1	0
19	2005	3	Employment	166	2	0
20	2005	3	Employment	166	3	0
21	2005	3	Employment	166	4	0

ENVConstraints

Type I: Absolute Constraint by Specific Parameter
An absolute constraint is a total zonal value that can be imposed for any employment or household variable. Specified zones will be forecasted with your total inputted number for that locator type. An example of an absolute employment or household constraint by type and zone is setting an employment value to a single zone. If the manufacturing employment category is set to a total of 100 jobs in a specific zone, ***TELUM*** will automatically forecast 100 manufacturing jobs to that zone. The location of other employment types within this zone will likely be effected by this constraint. To impose zonal constraints, choose the year and type of constraint as indicated in the screen shot below.

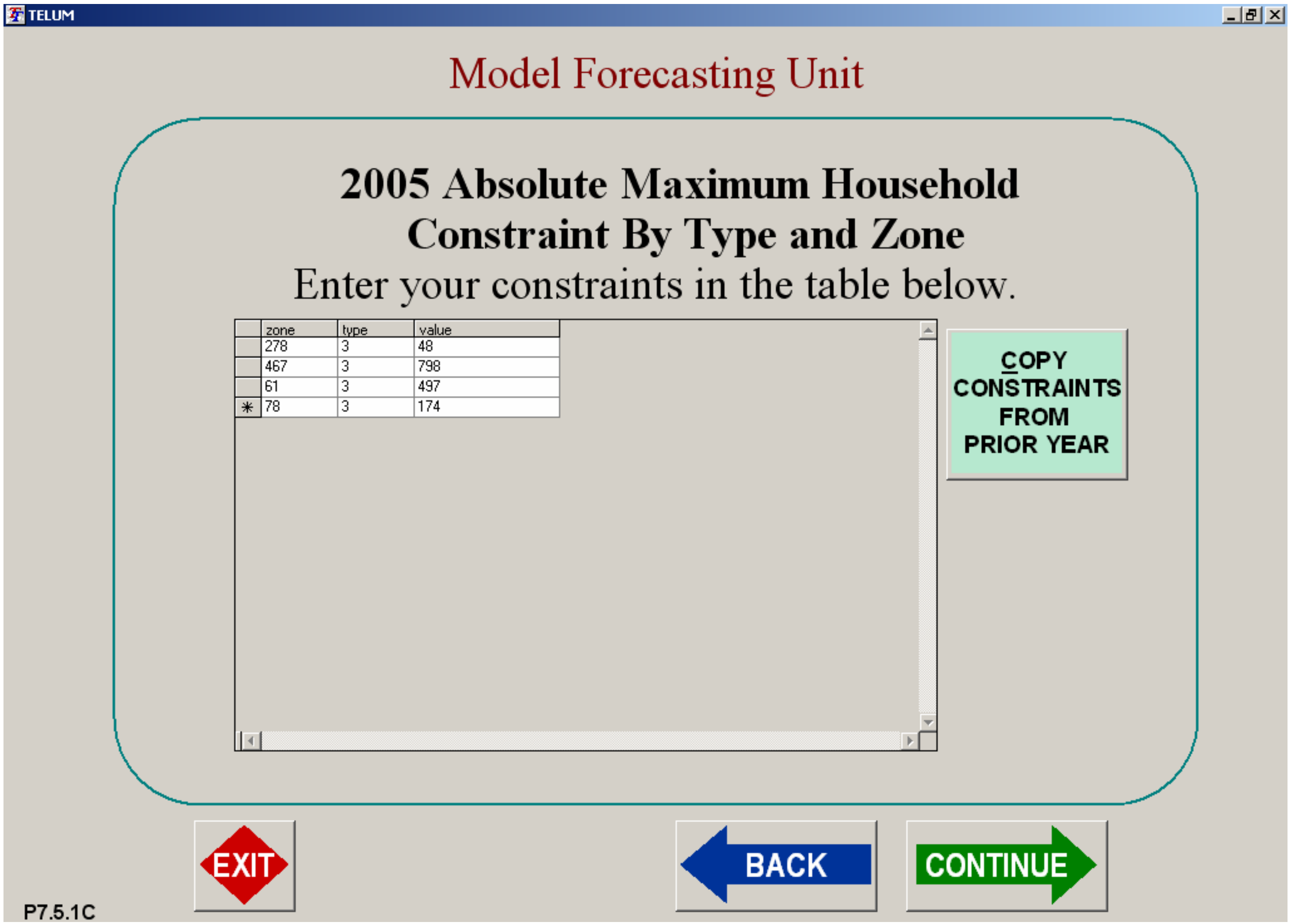


Using the constraint data preparation table, the constraints can be entered as shown in the table below. If the policy run requires constraints for more than one year, the constraint entry process can be facilitated by using the constraint copy button shown below on the right of the screen. This copies the exact zones, values, and types of constraint and must be modified if the project constraints change over time periods.



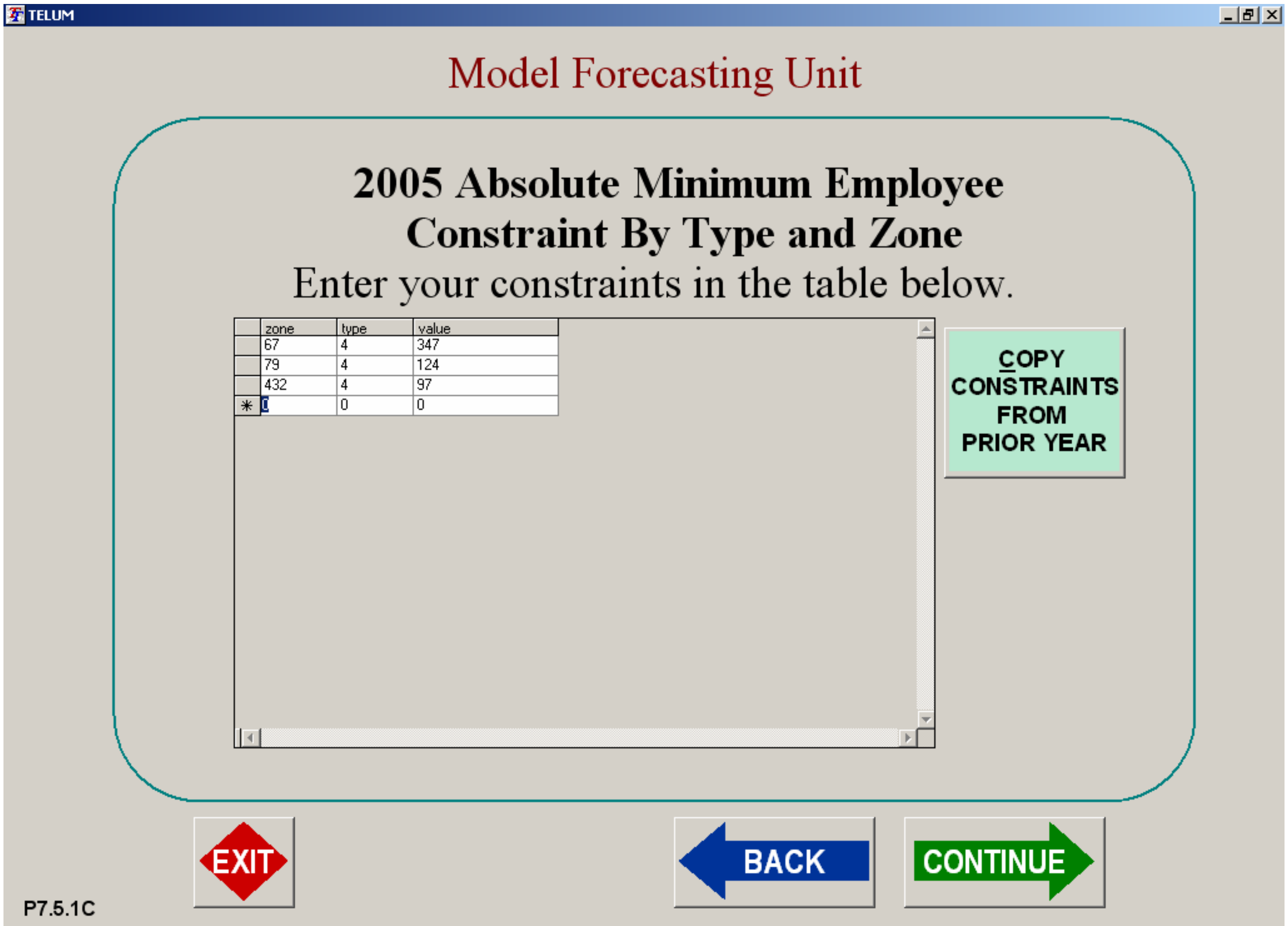
Type 2: Total Constraints by Employment or Households
The total constraint, Type 2, directs the model to automatically populate the specified zone with your input constraint household or employment value. For instance, if a zone is constrained to a total value of 10,000 jobs, ***TELUM*** forecasts 10,000 jobs to that zone. If one employment or household type in a zone is constrained by a total value, ***TELUM*** maintains the baseline proportion of employment types in that zone. Enter total constraints in the same manner as shown for the absolute constraints in the worksheet screen shown above.

Type 3: Maximum Constraints
A maximum constraint sets a maximum value of households or employment by type in a zone. A maximum constraint operates only when the forecasted value for a specific zone and type exceeds your employment or household constraint input value for that forecast period. An example of a Type III constraint occurs if high income households are constrained to a maximum of 2,000 in a given zone. When and only when the maximum is reached during forecasting will this constraint affect the distribution and number of other households locating in this zone as well as the distribution of high income households in other zones in the region. When the input value is exceeded, the constraint is applied and surplus households or jobs are distributed to the next more desirable zones. Enter maximum constraints in the same manner as prior type in the worksheet screen below.

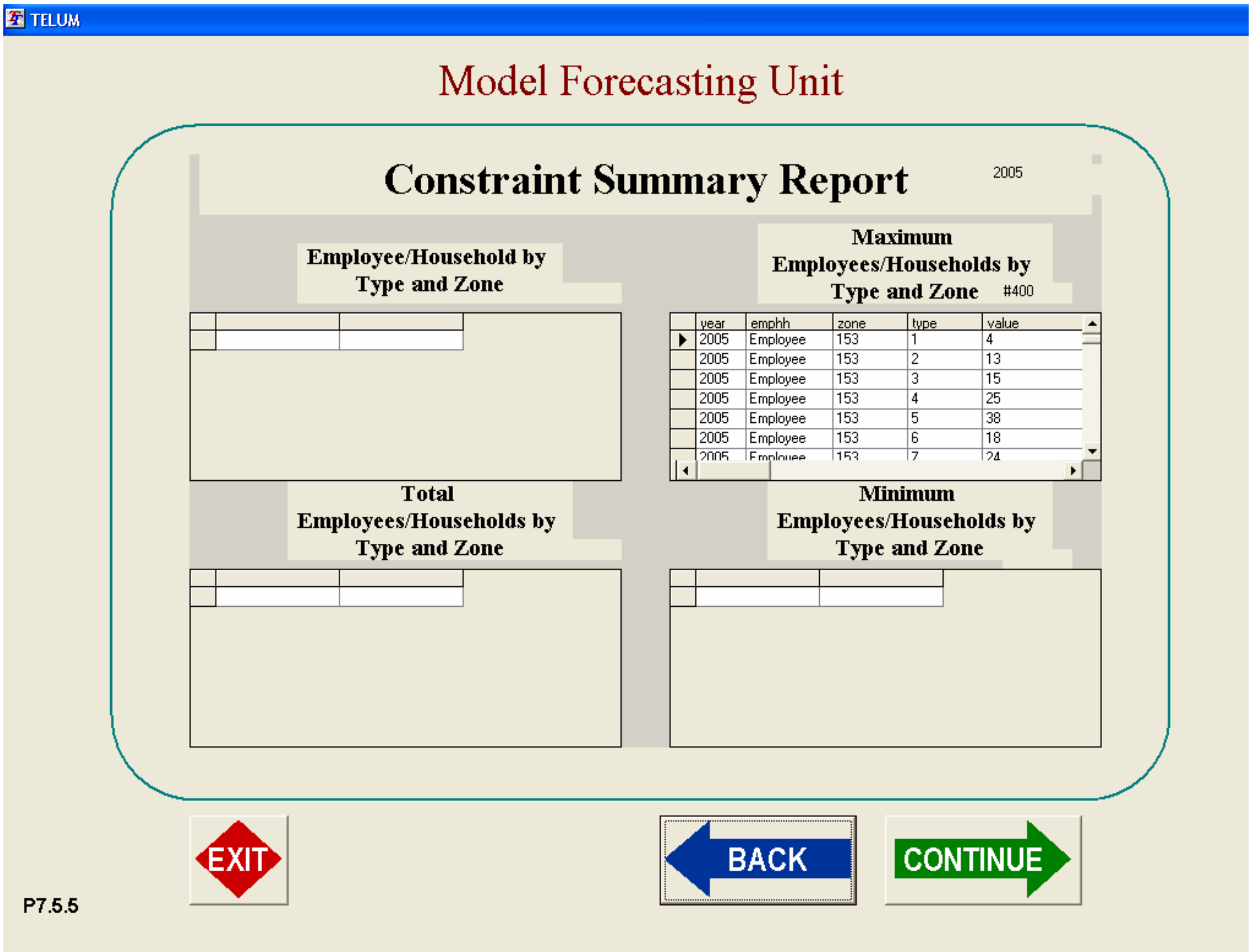


Type 4: Minimum Constraints

A minimum constraint sets a minimum value to the amount of employment or households forecasted in a zone by type. The amount of households or employment in that zone is affected by the constraint only when the value is less than the input minimum. The distribution of employees and/or households is thus limited and redistributed to other zones only when the household or employment value does not meet minimum constraints. Enter minimum constraints as before in the worksheet screen shown below.



After all desired constraint types are entered, ***TELUM*** will provide a Constraint Summary Report, as shown below. If there was an error in entering or applying a constraint, using the "BACK" button will enable you to re-entered or modify constraints for all time periods and types.



TELUM will then ask the you to verify a File Check in preparation for forecasting with the new constraint values. Click "GO" if constraint entry is accurate and complete.

5. Making Use of Unobserved Factors in Forecasting

Residuals represent unobserved factors that influence employment and household location, but are not captured in the ***TELUM*-EMP** and ***TELUM*-RES** model formulations. Residuals are a means to capture the information that is contained in errors made by ***TELUM*-EMP** and ***TELUM*-RES** when predicting the location of employment and households for the base year. In fact, the mathematical formulations of ***TELUM*-EMP** and ***TELUM*-RES** allow us to make perfect estimates of base year employment and household location when residuals are not attenuated (i.e., the attenuation parameter is set to 1.00 for a verification run). However, this does not mean that it is possible to make perfect forecasts of employment and household location in future time periods. Since residuals are determined from base year model calibrations, these unobserved factors have an implicit temporal specification.

As an example, suppose that ***TELUM* -RES** is calibrated for the base year 1990. Housing prices, which are not explicitly included in the ***TELUM*-RES** model formulation, are unobserved factors which influence household location. The ***TELUM*-RES** residuals, which are calculated for the ***TELUM*-RES** base year (2000) calibration, contain information about the influence of 2000 housing prices on household location. Over time, the influence of 2000 housing prices on household location will diminish. The location of households in 2005 may be strongly influenced by housing prices in 2000, but by the year

2015, the influence of 2000 housing prices on household location will be negligible. Therefore, it is logical to assume that the effect of residuals on household location will also diminish over time. For this reason, residuals are usually reduced in ***TELUM*-EMP** and ***TELUM*-RES** forecast runs.

APPENDIX

The Employment and Household Location Model Formulations

There are three special features of the ***TELUM*-EMP** equations: 1) a multivariate, multi-parametric attractiveness function is used, 2) a separate, weighted, lagged variable is included outside the spatial interaction formulation, 3) a constraint procedure is included in the model, allowing zone and/or sector specific constraints. The model is normally used for 4-8 employment sectors with individually estimated parameters. The equation structure is as follows:

$$E^k_{j,t} = \lambda^k \sum_i P_{i,t-1} A^k_{i,t-1} W^k_{j,t-1} c^{\alpha^k}_{i,j,t} \exp(\beta^k c_{i,j,t}) + (1-\lambda^k) E^k_{j,t-1} \qquad (1)$$

where

$$W^k_{j,t-1} = (E^k_{j,t-1})^{a^k} L^{b^k}_j \qquad (2)$$

and

$$A^k_{i,t-1} = \left[\sum_\ell (E^k_{\ell,t-1})^{a^k} L^{b^k}_\ell c^{\alpha^k}_{i,\ell,t} \exp(\beta^k c_{i,\ell,t}) \right]^{-1} \qquad (3)$$

where

$E^k_{j,t-1}$ = employment (place-of-work) of type k in zone j at time t-1

$E^k_{j,t}$ = employment (place-of-work) of type k in zone j at time t

L_j = total area of zone j

$c_{i,j,t}$ = impedance (travel time or cost) between zones i and j at time t

$P_{i,t-1}$ = total number of households in zone i at time t-1

$\lambda^k, \alpha^k, \beta^k, a^k, b^k$ = empirically derived parameters

The Residential Location model - *TELUM*-RES

***TELUM*-RES** is an aggregate form of a multinominal logit model of location choice. When translated into computational form, this yields a modified version of a singly-constrained spatial interaction model. There are two major modifications: 1) a multivariate, multiparametric attractiveness function is used, 2) a consistent balanced constraint procedure is included in the model, allowing zone and/or sector specific constraints. The multivariate zonal attractiveness term enables the inclusion of knowledgeable professionals' input to the model structure in a consistent and replicable fashion. The model is normally used for 3-5 (the current maximum is 8) household categories whose parameters are individually estimated. The model is described in more detail in Putman (1983, 1991) as well as in numerous journal articles and reports. For reference, the equation structure is given here.

$$N^n_i = \eta^n \sum_j Q^n_j B^n_j W^n_i c^{\alpha^n}_{i,j} \exp(\beta^n c_{i,j}) + (1.0 - \eta^n) N^T_{i,t-1} \qquad (4)$$

where

$$Q_j^n = \sum_k a_{k,n} E_j^k \tag{5}$$

and

$$B_j^n = \left[\sum_i W_i^n c_{i,j}^{\alpha^n} \exp(\beta^n c_{i,j}) \right]^{-1} \tag{6}$$

and

$$W_i^n = \left(L_i^v\right)^{q^n} \left(x_i\right)^{r^n} \left(L_i^r\right)^{s^n} \prod_{n'} \left(1 + \frac{N_i^{n'}}{\sum_n N_i^n} \right)^{b_{n'}^n} \tag{7}$$

where

E_j^k = employment of type k (place of work) in zone j

N_i^n = households of type n residing in zone i

$N_{i,t-1}^T$ = total households residing in zone i at time t-1

L_i^v = vacant developable land in zone i

x_i = 1.0 plus the percentage of developable land already developed in zone i

L_i^r = residential land in zone i

$a_{k,n}$ = regional coefficient of type n households per type k employee

$c_{i,j}$ = impedance (travel time or cost) between zones i and j

$\eta^n, \alpha^n, \beta^n, q^n, r^n, s^n, b_{n'}^n$ = empirically derived parameters

In the original formulation of ***TELUM*-RES** all variables had the same time subscript. Beginning in early 1994, with the more general availability amongst agencies of the necessary data, several new formulations were examined in an attempt to include a lag term and thus increase forecast reliability, which resulted in the current form of ***TELUM*-RES**.

Review of the ***TELUM*** Model Forecasting Process

Each five-year forecast step begins with the execution of ***TELUM*-EMP**. The model is normally used for 4 to 8 employment sectors whose parameters are individually estimated. To forecast the location of employment of type k in zone j at time t+1, ***TELUM*-EMP** uses the following input variables:

- employment of type k in all zones at time t
- population of all types in all zones at time t
- total area per zone for all zones
- zone-to-zone travel cost (or time) between zone j and all other zones at time t.

Following the employment location forecasts produced by ***TELUM*-EMP**, a set of residence location forecasts is produced by ***TELUM*-RES**. The model is normally used for 4 to 5 household types (usually income groups) whose parameters are individually estimated. A separate submodel within ***TELUM*-RES**, called LANCON, calculates land consumption using a multiple regression based procedure for making a simple reconciliation of the demand for location by employers and households with the supply of land in each zone.

To forecast the location of residents of type h in zone i at time t+1, ***TELUM*-RES** uses the following input variables:

- residents of all h types in zone i at time t
- land used for residential purposes in zone i at time t
- the percentage of the developable land in zone i that has already been developed at time t
- the vacant developable land in zone i at time t, zone-to-zone travel cost (or time) between zone i and all other zones at time t+1
- employment of all k types in all zones at time t+1.

The residence location forecasts produced by ***TELUM*-RES** may then be used (sometimes after a further step of spatial disaggregation) as input to procedures (exogenous to TELUM) that generate and distribute trips, split trips by mode, and then assign vehicle trips to the transportation network(s).

Many different configurations of land use and transportation linkages have been tested by the use of ITLUP and, more recently, ***TELUM***. While the current implementation of the model system does not permit all of these configurations to be examined, there is adequate scope for an agency to prepare accurate forecast inputs to the agency travel modeling system. Throughout this manual we present a mix of theory discussion with instructions for specific model operation. Our intent is to train thoughtful users to utilize this powerful analysis tool.

Model Forecasting Output Files

TELUM stores a large model report that contains a copy of data inputs used and outputs generated for both employment and households during a forecast. These reports are lengthy, and ***TELUM*** provides a summary of each report's contents in the Spatial Analysis section. As you become familiar with TELUM you may wish to review these detailed outputs for further insight into the forecasting process. Further, if you should later decide to rerun a model forecast, ***TELUM*** will store the original detailed output files in a folder inside your main project folder in case you decide to review them again at a later date. The next section contains a sample copy of a forecasting output file. Several of the more important sections are highlighted for you.

TELUM-EMP Forecasting Output

```
TELUM-EMP-V3.00 EMPLOYMENT ALLOCATION MODEL
VERSION OF 20 NOV 2004

(C) COPYRIGHT S.H.PUTMAN ASSOCIATES 1989-2006

THIS RUN MADE ON  6-Dec-00 AT  4:16:18p

This Copy Licensed for Use at

Urban Simulation Laboratory - Dept. CRPlng.
```

Always check the date and title to be sure this is the run you think it is.

```
Page 1

*******************************************************************

MyCity: 12.06.00
Baseline: 2000-2005
```

Always check the date and title to be sure this is the run you think it is.

```
******************************************************************
```

EMPLOYMENT ALLOCATION PARAMETERS

TYPE	ALPHA	BETA	EMPL. ATTR.	LAND	LAG. EMPL.
Light In	.092	.107	1.273	.326	.955
Heavy In	.169	.100	1.211	-.685	.210
Service	-.392	1.052	1.271	3.135	.990
Retail	-.032	.025	1.038	-.305	.648

Do these match calibration values?

REGIONAL CONTROL TOTALS

Light In	Heavy In	Service	Retail
430	450	1333	880

NO CONSTRAINTS IMPOSED ON MODEL OUTPUTS

Are these the correct new regional forecast values?

Page 2

****

IMPEDANCE MATRIX (UPPER LEFT 13 X 13 ENTRIES)

****

1	53	89	155	243	125	120	320	401	216	280
2	89	71	108	157	177	200	392	449	245	253
3	155	108	74	139	157	214	372	388	180	145
4	243	157	139	132	291	338	509	523	317	230
5	125	177	157	291	80	72	220	278	98	217
6	120	200	214	338	72	59	200	300	159	289
7	320	392	372	509	220	200	117	165	215	376
8	401	449	388	523	278	300	165	132	209	329
9	216	245	180	317	98	159	215	209	97	163
10	280	253	145	230	217	289	376	329	163	85

MEAN VALUE OF UNSCALED IMPEDANCE = 229
THIS IS USUALLY IN TENTHS OF MINUTES.

Page 3

****

BASE YEAR (2000) INPUT DATA

****

EMPLOYMENT TYPE

	Light In	Heavy In	Service	Retail	TOTAL
1	16.	0.	560.	201.	777.
2	82.	32.	76.	90.	280.
3	27.	12.	15.	12.	66.
4	180.	375.	32.	32.	619.
5	55.	16.	130.	98.	299.
6	36.	10.	169.	87.	302.
7	1.	0.	27.	35.	63.
8	3.	1.	48.	70.	122.
9	11.	4.	117.	82.	214.
10	31.	13.	129.	115.	288.
TOTAL	442.	463.	1303.	822.	3030.

Are these values correct?

Page 4

****

BASE YEAR (2000) INPUT DATA

****

HOUSEHOLD TYPE

	LI	LM	HM	HH	TOTAL
1	64.	64.	42.	41.	211.
2	109.	123.	38.	3.	273.
3	106.	151.	45.	14.	317.
4	73.	73.	3.	3.	152.
5	115.	224.	194.	71.	605.
6	48.	67.	118.	68.	301.
7	12.	21.	100.	165.	298.
8	33.	91.	109.	68.	301.
9	76.	134.	102.	49.	362.
10	38.	61.	95.	16.	211.
TOTAL	675.	1009.	848.	497.	3030.

Are these values correct?

****

NOTE: ATTRACTIVENESS K-FACTORS INCLUDED

K-FACTORS MULTIPLIED BY .60

****

Page 5

****

FORECAST YEAR (2005) OUTPUT DATA

****

EMPLOYMENT TYPE

	Light In	Heavy In	Service	Retail	TOTAL
1	12.	0.	601.	241.	855.
2	79.	28.	83.	103.	294.
3	17.	5.	9.	9.	40.
4	177.	377.	37.	36.	628.
5	66.	10.	144.	112.	332.
6	36.	14.	153.	89.	291.
7	1.	2.	25.	35.	63.
8	3.	3.	45.	68.	119.
9	9.	3.	102.	70.	183.
10	30.	8.	133.	117.	288.
TOTAL	430.	450.	1333.	880.	3093.

Page 6

****

BASE YEAR TO FORECAST YEAR PERCENT CHANGE (0.01 = 1.0%)

****

EMPLOYMENT TYPE

	Light-In	Heavy-In	Service	Retail	TOTAL
1	-.23	.00	.07	.20	.10
2	-.04	-.12	.10	.14	.05
3	-.39	-.60	-.38	-.23	-.40
4	-.02	.01	.17	.13	.02
5	.20	-.39	.11	.15	.11
6	.00	.36	-.09	.02	-.03
7	.16	.00	-.08	-.01	.00
8	-.09	1.74	-.06	-.03	-.03
9	-.20	-.25	-.13	-.15	-.14
10	-.02	-.41	.03	.02	.00

Page 7

****

SUMMARY OF BASE YEAR TO FORECAST YEAR CHANGES

****

TABLE OF GINI COEFFICIENTS OF DISPERSION

EMPLOYMENT	BASE YEAR	FORECAST YEAR
Light In	.565	.577
Heavy In	.714	.722
Service	.712	.726
Retail	.566	.596
TOTAL EMP	.547	.575

Is employment in your region dispersing or concentrating?

NOTE THAT 0.00 IS TOTALLY DISPERSED, 1.00 TOTALLY CONCENTRATED

****

TOTAL REGIONAL PERCENT CHANGE

EMPLOYMENT TYPE

Light In	Heavy In	Service	Retail	TOTAL
-.027	-.028	.023	.071	.021

Is this how you expected employment in your region to grow or decline?

****

ZONAL MEAN ABSOLUTE PERCENT CHANGE

EMPLOYMENT TYPE

Light In	Heavy In	Service	Retail	TOTAL
.134	.388	.122	.108	.088

NOTE THAT 0.01 IS 1 %

****

Page 7

TELUM-RES Forecasting Output

```
                    TELUM-RES-V3.10 HOUSEHOLD ALLOCATION MODEL
                            VERSION OF 08 JUN 2003


                      COPYRIGHT S.H.PUTMAN ASSOCIATES 1989-2006

                    THIS RUN MADE ON  6-Dec-00 AT  4:17:34p

                          This Copy Licensed for Use at

                     Urban Simulation Laboratory - Dept. CRPlng.



*********************************************************************************
*


MyCity: 12.06.00
Baseline: 2000-2005



*********************************************************************************
*

                  FORECASTS WILL BE MADE USING THE ADDITIVE LAG
                            FORMULATION OF TELUM-RES.
                     LOCATION SURPLUS WILL NOT BE CALCULATED.


             TRIP GENERATION NOT AVAILABLE WITH AN ADDITIVE LAG TERM



                                     Page 1
```

Check!

****

HOUSEHOLD ALLOCATION PARAMETERS

Check all parameters against calibration runs.

****

	TRIP FUNCTION		LAND USE VARIABLES		
HH. TYPE	ALPHA	BETA	V.DEV.	PER.DEV.DEV.	RES.
LI	-.516	-1.598	.218	-2.121	-.076
LM	-1.888	.555	.169	-.844	-.210
MH	.631	-.860	-.098	.336	.104
HH	.405	-.606	-.441	-.286	.523

HOUSEHOLD TO HOUSEHOLD ATTRACTION PARAMETERS
LOCATED HOUSEHOLDS

	LI	LM	MH	HH
LI	-.231	7.475	2.356	.145
LM	-4.511	13.031	2.891	1.737
MH	-5.996	7.774	5.417	3.786
HH	-1.604	1.811	2.979	5.861

Check all parameters against calibration runs.

LAGGED TOTAL HOUSEHOLD ATTRACTION PARAMETERS

1	.7801
2	.8866
3	.9988
4	1.0000

Check against land consumption regression results.

REGRESSION PARAMETERS FOR LAND CONSUMPTION EQUATIONS

	INTRCEPT	**% DVL DV**	**% BAS L**	**% COMM L**	**% LI HH**	**% HI HH**	**TOTLND**
RESIDENTIAL	1.12010	-.18930	.05130	-.59540	.18870	.88820	-.19530
	INTRCEPT	% DVL DV	TOT LND	% BAS EM	% BAS L	% RES L	
BASIC	-10.49670	-8.82340	-.20280	-2.21350	1.53870	6.77580	
	INTRCEPT	% DVL DV	TOT LND	% COM EM	% COM L	% RES L	
COMMERCIAL	-2.87890	-2.86670	-.12130	-.50120	.41490	1.56580	

Page 2

****

REGIONAL RATIOS - EMPLOYMENT, HOUSEHOLDS, ETC.

****

EMPLOYMENT TYPE	PERCENT UNEMPLOYED
LInd	.000
Hind	.000
Servi	.000
Retail	.000

HOUSEHOLD TYPE	EMPLOYEES PER HOUSEHOLD
LI	1.00
LM	1.00
MH	1.00
HH	1.00

Do these match the spreadsheet?

EMPLOYMENT - HSHOLD CONVERSION MATRIX

HOUSEHOLD TYPE

	LI	LM	MH	HH
LInd	.2649	.4921	.1359	.1071
Hind	.3867	.4221	.1166	.0745
Servi	.1882	.3057	.3332	.1729
Retail	.1630	.2411	.3644	.2315

JOBS PER EMPLOYEE (REGIONAL) 1.000

NET COMMUTING RATE (REGIONAL) 1.000

****

Page 3

****

LAGGED TOTAL HOUSEHOLD INPUT DATA

****

1	211.
2	273.
3	317.
4	152.
5	605.
6	301.
7	298.
8	301.
9	362.
10	211.
TOTAL =	3030.
MEAN =	303.

Page 4

****

BASE YEAR (2000) INPUT DATA

****

HOUSEHOLD TYPE

Correct?

	LI	LM	MH	HH	TOTAL
1	64.	64.	42.	41.	211.
2	109.	123.	38.	3.	273.
3	106.	151.	45.	14.	317.
4	73.	73.	3.	3.	152.
5	115.	224.	194.	71.	605.
6	48.	67.	118.	68.	301.
7	12.	21.	100.	165.	298.
8	33.	91.	109.	68.	301.
9	76.	134.	102.	49.	362.
10	38.	61.	95.	16.	211.
TOTAL	675.	1009.	848.	497.	3030.

Page 5

****

BASE YEAR (2000) INPUT DATA

****

SUPPLEMENTARY POPULATION VARIABLES

	RESIDENT POPULATION	GROUP QUARTERS POPULATION	EMPLOYED POPULATION	NONWORKING POPULATION	TOTAL POPULATION
1	488.	0.	211.	277.	488.
2	630.	0.	273.	357.	630.
3	733.	0.	318.	416.	733.
4	350.	0.	151.	199.	350.
5	1396.	0.	604.	791.	1396.
6	695.	0.	301.	394.	695.
7	688.	0.	298.	390.	688.
8	695.	0.	301.	394.	695.
9	837.	0.	362.	475.	837.
10	489.	0.	212.	277.	489.
TOTAL	7001.	0.	3030.	3971.	7001.

Page 6

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BASE YEAR (2000) INPUT DATA

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DEVELOPED LAND USE

	TOT DVLPD	BASIC	% BASIC	RETAIL	% RETAIL	RESIDENTIAL	% RESDNTL
1	1.	0.	.01	1.	99.94	0.	.05
2	4.	0.	1.10	4.	98.32	0.	.58
3	4.	1.	14.31	3.	61.42	1.	24.27
4	19.	14.	70.37	5.	27.56	0.	2.07
5	6.	2.	27.28	4.	72.42	0.	.30
6	2.	0.	.03	2.	99.72	0.	.25
7	14.	0.	.08	13.	95.03	1.	4.89
8	16.	0.	.14	15.	96.09	1.	3.77
9	11.	0.	.07	11.	97.39	0.	2.53
10	12.	0.	1.38	12.	97.52	0.	1.09
TOTAL	90.		16.	70.		3.	

Page 7

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BASE YEAR (2000) INPUT DATA

****

OTHER LAND USE

	TOT AREA	UNUSBLE	STREETS	VACANT	% VACANT	DEVELPBL	% DVPL DEV
1	2.	0.	0.	1.	50.00	2.	50.00
2	5.	0.	0.	1.	20.00	5.	80.00
3	6.	0.	0.	2.	30.40	6.	69.60
4	20.	0.	0.	1.	3.19	20.	96.81
5	7.	0.	0.	1.	14.29	7.	85.71
6	3.	0.	0.	1.	33.33	3.	66.67
7	15.	0.	0.	1.	6.67	15.	93.33
8	17.	0.	0.	1.	5.88	17.	94.12
9	12.	0.	0.	1.	8.33	12.	91.67
10	13.	0.	0.	1.	7.69	13.	92.31
TOTL	100.	0.	0.	10.		100.	

Page 8

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IMPEDANCE MATRIX (UPPER LEFT 13 X 13 ENTRIES)

****

1	53	89	155	243	125	120	320	401	216	280
2	89	71	108	157	177	200	392	449	245	253
3	155	108	74	139	157	214	372	388	180	145
4	243	157	139	132	291	338	509	523	317	230
5	125	177	157	291	80	72	220	278	98	217
6	120	200	214	338	72	59	200	300	159	289
7	320	392	372	509	220	200	117	165	215	376
8	401	449	388	523	278	300	165	132	209	329
9	216	245	180	317	98	159	215	209	97	163
10	280	253	145	230	217	289	376	329	163	85

MEAN VALUE OF UNSCALED IMPEDANCE = 229
THIS IS USUALLY IN TENTHS OF MINUTES.

NOTE: K-FACTORS FOR SCALING FORECASTS READ IN

K-FACTORS MULTIPLIED BY .90

Page 9

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FORECAST YEAR (2005) INPUT DATA

****

EMPLOYMENT TYPE

	LInd	Hind	Servi	Retail	TOTAL
1	12.	0.	601.	241.	855.
2	79.	28.	83.	103.	294.
3	17.	5.	9.	9.	40.
4	177.	377.	37.	36.	628.
5	66.	10.	144.	112.	332.
6	36.	14.	153.	89.	291.
7	1.	2.	25.	35.	63.
8	3.	3.	45.	68.	119.
9	9.	3.	102.	70.	183.
10	30.	8.	133.	117.	288.
TOTAL	430.	450.	1333.	880.	3093.

Does this match the output of the TELUM-EMP run?

Page 10

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2 EMPLOYMENT TYPES WERE GROUPED AS "INDUSTRIAL" FOR LAND USE CALCULATIONS

THE TYPES WERE 1 2
THE CATEGORIES WERE LInd Hind

2 EMPLOYMENT TYPES WERE GROUPED AS "COMMERCIAL" FOR LAND USE CALCULATIONS

THE TYPES WERE 3 4
THE CATEGORIES WERE Servi Retail

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NO CONSTRAINTS IMPOSED ON MODEL OUTPUTS

Page 11

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REGIONAL EMPLOYMENT - HOUSEHOLD RECONCILIATION
CHANGE IN HH DISTRIBUTION DUE TO CHANGE IN REGIONAL EMPLOYMENT MIX

****

BASE YEAR REGIONAL POPULATION TO HOUSEHOLD RATIO 2.311
FORECAST YEAR REGIONAL POPULATION TO HOUSEHOLD RATIO 2.264

REGIONAL SUMS OF INPUT VALUES OF ZONAL EMPLOYMENT FORECASTS

LInd	**Hind**	**Servi**	**Retail**
430.	450.	1333.	880.

REGIONAL SUMS OF ZONAL FORECASTS OF HOUSEHOLDS
(ADJUSTED FOR UNEMPLOYMENT, AND EMP/HH RATES)

LI	**LM**	**MH**	**HH**
682.	1021.	876.	514.

FORECAST REGIONAL SUM OF EMPLOYED RESIDENTS 3093.

INPUT VALUE OF REGIONAL POPULATION FORECAST 7001.

****

COMPARISON OF OUTPUT YEAR INCOME GROUPS TO INPUT YEAR INCOME GROUPS

INPUT YEAR INCOME GROUPS

	LI	LM	MH	HH
GROUP TOTALS	675.	1009.	848.	497.
GROUP SHARE	.2229	.3332	.2798	.1642

OUTPUT YEAR INCOME GROUPS

	LI	LM	MH	HH
GROUP TOTALS	682.	1021.	876.	514.
GROUP SHARE	.2206	.3302	.2831	.1661

Page 12

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FORECAST YEAR (2005) OUTPUT DATA

****

HOUSEHOLD TYPE

	LI	LM	MH	HH	TOTAL
1	98.	83.	41.	50.	272.
2	108.	123.	39.	4.	275.
3	124.	148.	51.	25.	348.
4	51.	53.	4.	7.	115.
5	109.	226.	198.	76.	610.
6	58.	81.	116.	66.	320.
7	12.	22.	105.	161.	300.
8	34.	100.	107.	54.	295.
9	55.	124.	112.	51.	341.
10	34.	60.	103.	21.	217.
TOTAL	682.	1021.	876.	514.	3093.

Page 13

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BASE YEAR TO FORECAST YEAR PERCENT CHANGE
(** IS PRINTED IF BASE YEAR WAS 0.0)**

****

HOUSEHOLD TYPE

	LI	LM	MH	HH	TOTAL
1	52.	30.	-3.	22.	29.
2	-1.	0.	3.	46.	1.
3	17.	-2.	13.	75.	10.
4	-31.	-28.	34.	154.	-24.
5	-5.	1.	2.	7.	1.
6	20.	20.	-2.	-3.	6.
7	2.	3.	5.	-2.	1.
8	2.	10.	-2.	-20.	-2.
9	-28.	-7.	9.	2.	-6.
10	-11.	-2.	8.	25.	3.
TOTAL	1.	1.	3.	3.	

Page 14

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FORECAST YEAR (2005) OUTPUT DATA

****

SUPPLEMENTARY POPULATION VARIABLES

	RESIDENT POPULATION	GROUP QUARTERS POPULATION	EMPLOYED POPULATION	NONWORKING POPULATION	TOTAL POPULATION
1	616.	0.	271.	344.	616.
2	621.	0.	275.	346.	621.
3	789.	0.	349.	440.	789.
4	259.	0.	114.	145.	259.
5	1379.	0.	610.	770.	1379.
6	724.	0.	320.	404.	724.
7	679.	0.	300.	379.	679.
8	667.	0.	295.	372.	667.
9	773.	0.	341.	432.	773.
10	493.	0.	218.	275.	493.
TOTAL	7001.	0.	3093.	3908.	7001.

Page 14

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FORECAST YEAR (2005) OUTPUT DATA

****

DEVELOPED LAND USE

	TOT DVLPD	BASIC	% BASIC	RETAIL	% RETAIL	RESIDENTIAL	% RESDNTL
1	1.	0.	.00	1.	83.53	0.	16.47
2	4.	0.	.77	4.	98.69	0.	.54
3	4.	0.	8.64	2.	46.51	2.	44.85
4	19.	13.	65.89	6.	32.64	0.	1.47
5	6.	1.	22.25	5.	75.72	0.	2.03
6	3.	0.	.02	2.	71.47	1.	28.51
7	14.	0.	.43	13.	93.79	1.	5.78
8	15.	0.	.19	15.	95.96	1.	3.85
9	9.	0.	.07	9.	97.16	0.	2.77
10	12.	0.	1.17	12.	97.21	0.	1.63
TOTAL	87.	14.		68.		5.	

Page 15

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FORECAST YEAR (2005) OUTPUT DATA

****

OTHER LAND USE

	TOT AREA	UNUSBLE	STREETS	VACANT	% VACANT	DEVELPBL	% DVPL DEV
1	2.	0.	0.	1.	50.00	2.	50.00
2	5.	0.	0.	1.	20.00	5.	80.00
3	6.	0.	0.	2.	36.93	6.	63.07
4	20.	0.	0.	1.	5.00	20.	95.00
5	7.	0.	0.	1.	14.29	7.	85.71
6	3.	0.	0.	0.	12.08	3.	87.92
7	15.	0.	0.	1.	9.48	15.	90.52
8	17.	0.	0.	2.	9.56	17.	90.44
9	12.	0.	0.	3.	20.94	12.	79.06
10	13.	0.	0.	1.	5.72	13.	94.28
TOTL	100.	0.	0.	13.		100.	

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SUMMARY OF BASE YEAR TO FORECAST YEAR CHANGES

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TOTAL REGIONAL PERCENT CHANGE

LI	LM	MH	HH	TOTAL
1.02 %	1.17 %	3.30 %	3.29 %	2.08 %

ZONAL MEAN ABSOLUTE PERCENT CHANGE

LI	LM	MH	HH	TOTAL
16.88 %	10.46 %	8.17 %	35.57 %	8.21 %

****

REGIONAL PERCENT CHANGE IN LAND USE

TOTAL LAND AREA	.00%
UNUSABLE LAND	.00%
STREETS AND HIGHWAY	.00%
BASIC LAND	-10.31%
COMMERCIAL LAND	-3.52%
RESIDENTIAL LAND	54.32%
VACANT DEVELOPABLE	23.14%
TOTAL DEVELOPABLE	.00%

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GINI COEFFICIENTS OF SPATIAL DISPERSION

ACTIVITY	BASE YEAR	FORECAST YEAR
LI	.525	.577
LM	.494	.523
MH	.439	.436
HH	.546	.531
TOTAL	.428	.459

NOTE THAT 0.00 IS TOTALLY DISPERSED, 1.00 TOTALLY CONCENTRATED

Page 17

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