A Freight Analysis and Planning Model

Final Report

Grant/Cooperative Agreement
FHWA-BAA-HEPP-02-2007

July 2011

Prepared by

Genevieve Giuliano[1]
Jose-Luis Ambite[2]
Jiangping Zhou[1]
James Blythe[2]
[1]School of Policy, Planning and Development
and
[2]Information Sciences Institute
University of Southern California
Los Angeles, CA 90089-0626

Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. The document is disseminated under the sponsorship of the US Department of Transportation, Federal Highway Administration, in the interest of information exchange. The US Government assumes no liability for the contents or use thereof. The contents do not necessarily reflect the official views or policies of the US Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Acknowledgements

Abstract

This project links a newly developed method for estimating intra-metropolitan freight flows with a widely used transportation planning software to demonstrate its feasibility for sketch level regional transportation planning. We link the Argos planner, an automated computational workflow, with the TransCAD transportation planning software. The Argos planner was originally developed and tested with 2001 data for the Los Angeles Region; we updated to 2007 data. The updated model results were compared against the baseline model for the region. The linked system was used to test three different policy scenarios: reduction in international trade, shift of freight from truck to rail, and truck peak period pricing. The scenario results are plausible and demonstrate the utility of the model for sketch level planning. A user-friendly graphical interface was developed to allow easy use of Argos by practitioners. The linked model would require additional development to be useful in professional practice. The updating process is complex and requires expertise in both freight dynamics and regional economic modeling. The modeling approach is unconventional, so would require extensive training and technical assistance for use in public planning agencies.

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Introduction

The purpose of this research project is to link a newly developed method for estimating intra-metropolitan freight flows with widely used transportation planning software, and to demonstrate the model for regional transportation planning.

This project builds on National Science Foundation (NSF) research that developed a method for estimating freight flows using automated computational workflows, a computer science technique for automatically querying data and conducting computations to to produce freight flows from multiple data sources. The NSF funded work resulted in a working model, "Argos," that was applied using data for the Los Angeles region (Ambite and Kapoor, 2007a; Giuliano, Gordon, Pan, Park and Wang, 2008). In contrast to traditional methods of preparing model input data, Argos, automatically processes data from many different sources, greatly reducing the time a effort required for data preparation.

This research links the Argos workflow with TransCAD, a widely used commercial software package for metropolitan transportation planning. Linking with TransCAD allows practitioners easy access to Argos. The research also includes updating the data sources for the Argos model, generating an updated baseline, and using the updated modeling system for policy analysis.

This chapter provides a short overview of metropolitan freight modeling, a description of the Argos workflow, and summary results from the first application. Chapter 2 describes the process of linking Argos with TransCAD and validates the earlier results. Chapter 3 describes data sources and the updating process, and provides the updated baseline modeling results. Chapter 4 presents the policy analysis. Chapter 5 presents conclusions on the applicability of the modeling system for regional transportation planning.

1.2 Overview of Metropolitan Freight Modeling

A recent comprehensive review of freight modeling (Southworth, 2011) categorizes models of two main types: aggregate and disaggregate. Aggregate models estimate flows between geographic units; disaggregate models start with individual decision-makers and model the choices of mode, route, etc. Within the aggregate category, models are either vehicle trip based or economic activity based. Data availability continues to be a major constraint to model development, as most freight data are propriety and costly to collect.

Trip based models are the most widely used for metropolitan freight planning. They are a logical progression from the traditional 4-step urban transportation planning model. However, these models have some notable disadvantages: 1) they implicitly assume that the vehicle trip is the unit of demand, rather than the commodity being transported (Holguin-Veras and Zorrilla, 2006); hence they are not modeling the

underlying economic supply and demand; 2) they require extensive, highly detailed and place specific data; 3) because the underlying economic dynamics are not considered, they require extensive calibration and are not transferable. Economic activity based commodity flow models are generally not used for metropolitan freight modeling because of the lack of available commodity flow data for small spatial units.

In earlier work we described an adequate urban transportation model as having the following attributes: (a) solid behavioral foundations, (b) multi-modal, (c) able to analyze interactions between passenger and freight, (d) able to take feedback from policy changes, (e) detailed enough to capture small-area impacts, (f) use widely available (non-proprietary) and frequently updated data. Building on initial work by Gordon and Pan (2001), Giuliano et al (2008) developed an economic activity approach that minimizes reliance on proprietary or individualized survey data. The base is an economic input output model, and freight flows are generated from economic supply and demand. The major research steps involved are the following:

1. Estimate commodity-specific *interregional* and *international* trip attractions and trip productions for those locations where airports, seaports, rail yards or regional highway entry-exit points are located.
2. Utilize a regional input-output transactions table to estimate *intraregional* commodity-specific trip attractions and trip productions at the level of small-area units.
3. Create regional commodity-specific origin-destination matrices using estimates from steps (1) and (2).
4. Load the O-D matrices onto a regional highway network with known passenger flows.

We applied our model using 2001 data for the Los Angeles region, and our results are quite comparable to methods that rely on far more detailed data and model calibration (Giuliano et al, 2008). Because our approach uses widely available data sources and is economic activity based, it is transferable to other metropolitan areas. Variations of this model have been applied in research on Houston and Seattle by our research team. It is also scalable to higher levels, for example to statewide or region-wide planning and analysis.

1.3 The Argos Workflow

Commodity based models focus on supply and demand among economic sectors. The basic idea is to estimate inbound and outbound flows and then disaggregate the flows to an appropriate level of geography. Input/output tables are typically used to estimate the quantities of commodity supply and demand by geographic unit. Once allocated to origins and destinations, commodity flows are converted to truck trips. A truck origin-destination (O-D) matrix is then generated via some type of spatial interaction model (Holguin-Veras et al, 2001; Southworth, 2011). The focus on supply and demand helps

to capture truck flows more accurately, and thus leads to more robust models (Wisetjindawat et al, 2006).

As noted above, data availability is a major problem in metropolitan freight flow modeling. Ideally, such modeling requires data on commodity flows by industry sector, mode, origin and destination, all at a geographic scale sufficiently fine to identify specific flows on specific routes at specific times. Data are also needed on exports and imports to the region, as well as through traffic. Such a comprehensive data source does not exist. Analysts must either collect the necessary data directly, or develop a method based on available data. Because of the costs of direct data collection, and the rapidly changing nature of economic activity, our approach is based on using available data sources.

However, using existing data sources generates other challenges. Some is not available at the appropriate geographic scale, there is more data on some flows than others, and industry data uses various classification systems, making different data sources incompatible. Using many different data sources generates the need for an efficient way to combine the data and manipulate the various sources.

1.3.1 General Approach

Our approach is illustrated in Figure 1-1, using the Los Angeles region as a case study (see Giuliano et al, 2008 for a detailed description). The first row of boxes in the flow chart show the various data sources used. These are described in Table 1.   For interregional flows (imports/exports in Figure 1-1), we use a series of data sources to generate trip attractions and productions for the major import/export nodes. Regional input/output data and small area employment data are the basis for generating intraregional trip attractions and productions. Commodity attractions and productions are the basis for generating a freight flow O-D matrix. Control totals are used as checks at various points in the process.

Figure 1-1: Overview of Argos Data Process Steps
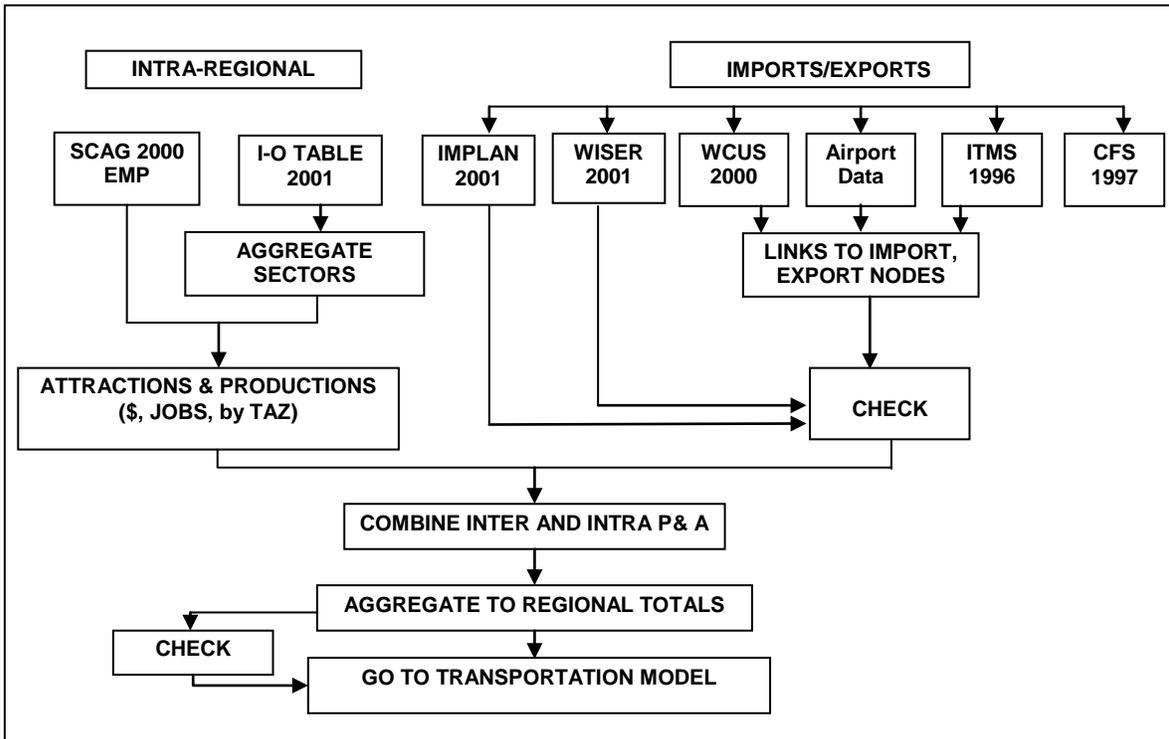
Our approach has some important advantages. First, the secondary data sources we use are widely available and regularly updated, hence the approach is easily transferable across metropolitan areas. Second, our approach avoids use of proprietary data (with two low-cost exceptions) and data obtainable only through metropolitan level surveys. Therefore data costs are low, relative to other more conventional approaches.

Table 1-1: Data Sources for the Los Angeles Application

Data Source	Code System	Year	Description
Commodity Flow Survey (CFS)	SCTG	1997	Provides commodity flows by 2 digit SCTG (Standard Classification of Transported Goods) sector for US regions, states, and MSAs. Flows in dollars, tonnage by mode. Level of detail varies by geographic unit. Based on sample of shipments; sample data available by 5 digit SCTG, zipcode origin and destination, tonnage, value, mode. CFS is conducted irregularly. Source: Bureau of Transportation Statistics, http://www.bts.gov/programs/commodity_flow_survey
IMPLAN	IMPLAN	2001	Provides county level input/output data by 509 IMPLAN sectors for US counties, county level inbound/outbound flows, state and national foreign imports/exports. Proprietary data source, updated annually. Source: Minnesota IMPLAN Group, Inc., http://www.implan.com/what.html
WISERTrade	HS, SITC	2001	Provides monthly imports and exports by HS (Harmonized System) code for customs districts, by mode; also provides annual imports and exports by SITC (Standard International Trade Classification) for world ports. Proprietary data source, updated monthly/annually. Source: WISERTrade, http://www.wisertrade.org/home/index.jsp
Waterborne Commerce of the US (WCUS)	WCUS	2001	Provides annual foreign and domestic trade by WCUS sector for major US ports, in tonnage. Updated annually. Source: http://www.iwr.usace.army.mil/ndc/data/dictionary/ddwcus.htm
SCAG	SIC	2000	The Southern California Association of Government provides small area employment data by SIC (Standard Industrial Classification). The data are generated from state employment and tax records and are used in regional modeling and forecasting. Source: Available by special request from Southern California Association of Governments

1.3.2 Computational Workflow: Argos Planner

Using widely available secondary data sources requires using multiple sources and developing methods to assure consistency across the sources. New computer science tools make it possible to generate the required computations efficiently. From the computer science perspective, the process of estimating freight flows is an instance of a scientific workflow (Taylor et al. 2006). A scientific workflow is an executable specification that describes a combination of data sources and algorithms that computes a desired dataset, such as the workflow of Figure 1-1.

There are many challenges in producing a data processing workflow such as the transportation model of Figure 1-1. Since the data comes from a variety of sources, it may be expressed in different schemas, formats, and units. Therefore, the workflow needs to include many operations that perform different types of data conversion, for example, to translate a given measurement into different units — from tons to dollars to jobs to ton-miles to container units to trucks to passenger-car-equivalents. Also

frequent is the need to translate economic data described in one industry/ sector classification to another, for example, from the North American Industry Classification System (NAICS) to the Standard Classification of Transported Goods (SCTG), or from different versions of these classifications, for example, from NAICS 1997 to NAICS 2002.

There are many details that the abstract workflow of Figure 1-1 does not show. The detailed workflow that estimates the truck traffic due to freight movements contains over 50 data access and data processing operations. Gordon and Pan (2001) implemented this estimation model by a combination of manual steps and custom-designed programs Argos automatically generates such a data processing workflow in response to a user data request, including all the necessary data integration and translation operations.

Argos is a general approach to construct data processing workflows, where the data sources and data processing operations are represented as web services. These services consume and produce relational tables, and thus are able to represent general computations. We describe the input/output signature of each service as relational formulas in an expressive logic (PowerLoom) using terms from an ontology of the application domain. These logical descriptions allow for a precise understanding of the data and enable the Argos planner to automatically construct a computational workflow in response to a user data request.

The Argos planner not only selects the relevant sources and data processing operations, but can also automatically insert adaptor services to connect the input an output of existing services. We have developed a set of domain-independent adaptor services that correspond to relational algebra operations (selection, projection, join and union), as well as some domain-dependent ones, such as product classification conversions. Figure 1-2 illustrates the insertion of an adaptor service. Assume that service Sc requires as input employment data according to the NAICS industry classification, but there is no source that produces such data. However, the system knows of a source Sp that contains a conversion table from SIC to NAICS industry codes and of a source Se for employment data that uses the SIC classification. Then, the system will automatically insert a Product Conversion service that adapts the data produced by Se to the data required by Sc as show in Figure 1-2. A more detailed description of the techniques for automatic workflow generation in Argos is available in (Ambite and Kapoor 2007a; Ambite and Kapoor 2007b).

Figure 1-2: Example of Adaptor Service
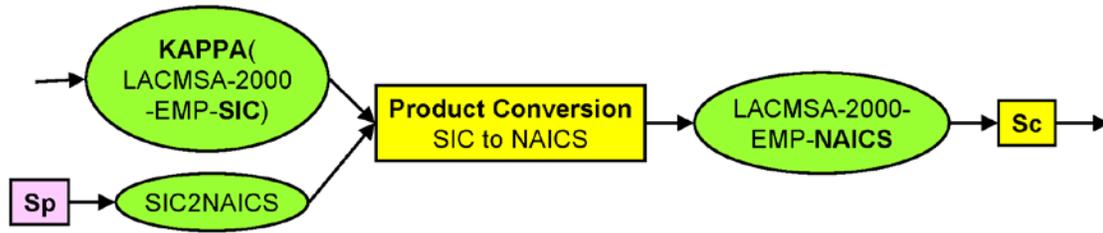
1.3.3 From Argos Planner to Transportation Model

The output of the Argos planner includes the productions and attractions, in dollars and tons, for both intraregional and interregional flows. In the previous application, the translation of tons to passenger car equivalents (PCEs), the distribution of PCEs to produce the O-D matrix, and the assignment of trips to the highway network were conducted using separate models developed by Prof. Qisheng Pan (see Gordon and Pan, 2001; Giuliano et al, 2008 for details). The process is shown in Figure 1-3 below.

We start with the matrix of productions and attractions by commodity code, by ton. We assume that all intraregional trips are by truck. Interregional trips include imports to the region, exports from the region, and through traffic. We use various data sources to factor out the portions of interregional flows that move by water, air or rail. For imports and exports, each flow (trip) starts/ends at an external node (a port, railroad yard, airport, interstate highway) and ends/starts at an internal zone. These local collection or distribution segments are also assumed to be truck. Port imports provide an example of how the factoring works. About 40% of all imports (as measured in dollars) are consumed within the region, and therefore travel on truck from the ports to distribution/warehousing locations. Of the 60% of imports destined for locations outside the region, about 7% travels entirely by rail or rail/truck combination, 6% by water or water/truck combination, 20% by air or air/truck combination and the remainder travel by truck only[1].

In the earlier application, we conducted a two stage trip distribution. The first was the intraregional distribution. The intraregional distribution was used to allocate the interregional trips to traffic analysis zones (TAZs). That is, interregional trips were assigned in proportion to intraregional trip attractions.

The conversion from tons to PCEs can be done in a number of ways. In this case we start with a control total of daily truck trips. Using state level factors, we calculate shares of truck trips/day by commodity sector, which yields tons/truck by sector. This method implicitly accounts for empty truck trips. The conversion to PCEs is based on vehicle classification data.

The final step in the process is the traffic assignment. In our earlier work, we started with the equilibrium assignment of all passenger trips (data provided by the Southern

---

[1] Source: Author calculations.

California Association of Governments). We then assigned the truck PCEs to the equilibrium network.

Figure 1-3: Original Flowchart for Traffic Assignment
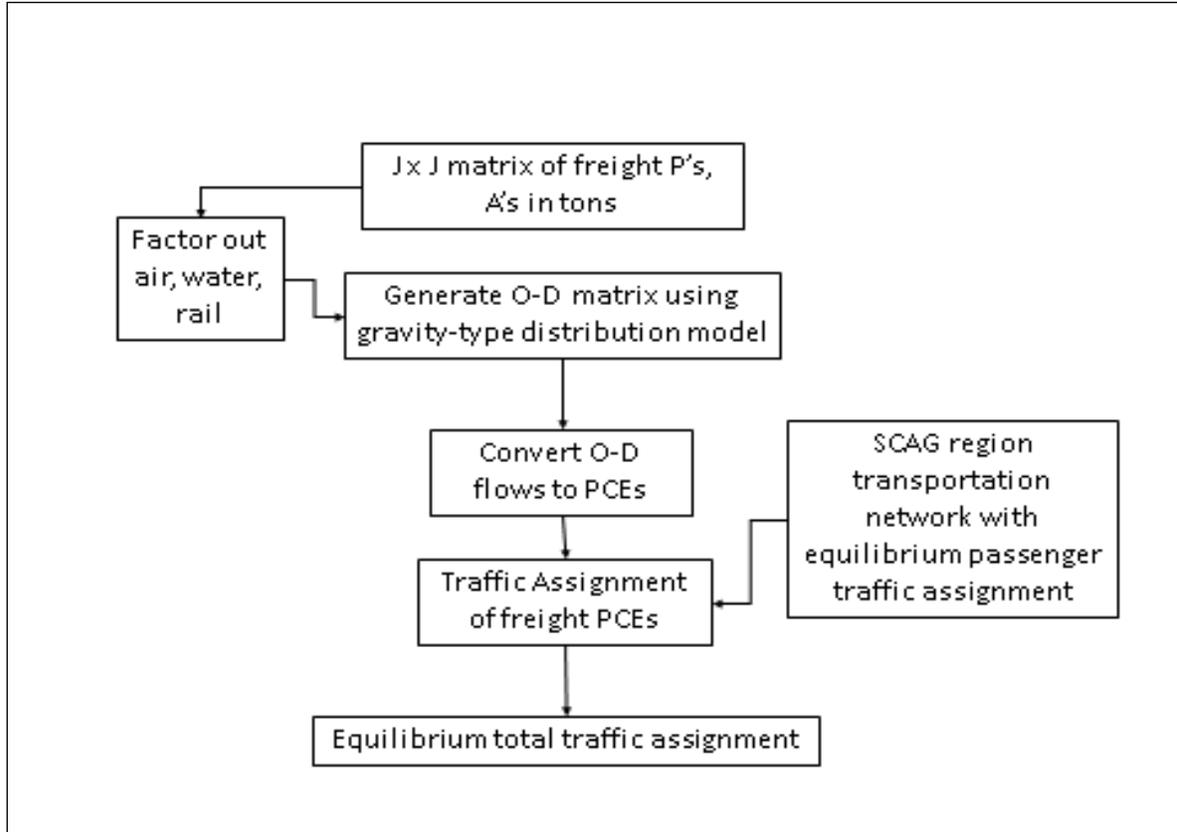
1.4 Test Empirical Application

The first empirical application was based on 2001 data for the Los Angeles region. We were able to compare our results with heavy duty truck (HDT) screenline data for 2003 provided by SCAG. We generated two traffic assignments, one with PCEs based on proportion of trucks by number of axles in the region; the other with PCEs unique to each screenline as calculated by SCAG. Both were compared with actual screenline data. Figure 1-4 shows our results using the proportion based PCEs. The average difference is 36%, the weighted average difference is 20%, and the regression R^2 is 0.80. These results are at least as good as SCAG's model results, and we did not use any data fitting techniques to adjust our model.

The next step in improving our model is to link the Argos planner to commercially available transportation planning software. We selected TransCAD for this purpose. TransCAD is a GIS based software with full transportation modeling capabilities. It can be used at varying levels of geography, and it has an easy to use graphical interface. In addition, it is capable of handling very large data sets, a

requirment for application to the Los Angeles region. The following chapter describes the process of linking Argos to TransCAD.

Figure 1-4: Comparison of Results

Estimated and Actual Screenline HDT, 24 Hr, in PCEs

Est = 0.9851 (Actual) + 27096
R² = 0.80
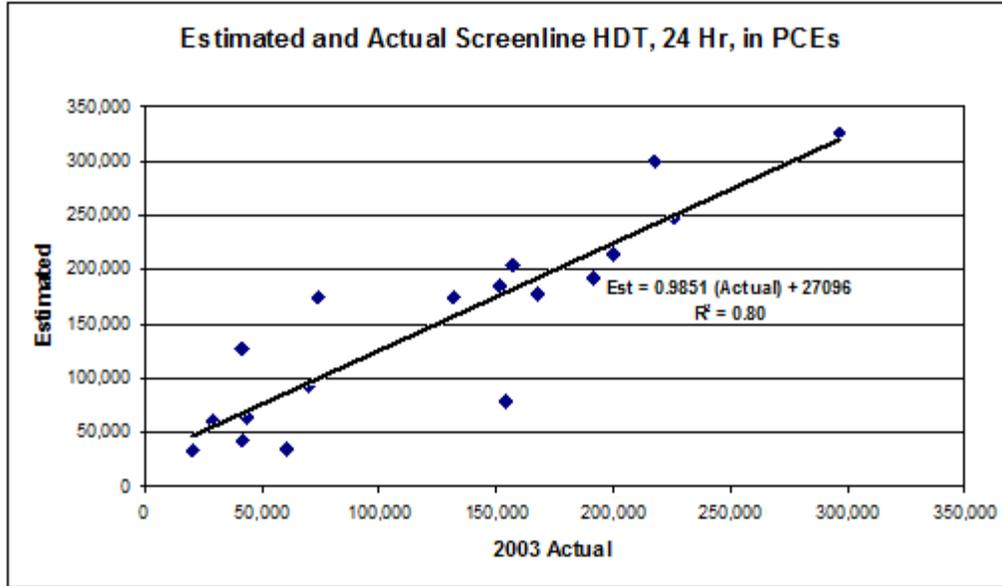
2. Task 1 -- Linking Argos to TransCAD

Task One of this project is to link the workflow ("Argos") to the TransCAD model. This chapter summarizes the Task One work and results. Linking the Argos model required replicating some steps of the workflow in TransCAD. Unless otherwise stated, all raw data used in the replication processes are the same as those detailed in (Giuliano et al. 2008). Those data are called base-case data hereafter.

We describe how TransCAD and other software packages can be used to complete the following modeling steps regarding regional traffic flow analysis:

- Balance and distribute intraregional freight trips
- Distribute freight trips between intraregional TAZs and regional entry-exit points
- Aggregate freight trips obtained from the above two steps and convert them into a data format compatible with TransCAD
- Combine the aggregated freight trips with appropriate passenger trips and convert them into a data format compatible with TransCAD
- Create a regional highway network file in TransCAD, using the raw base-case data in ArcView format
- Load the above trips onto the TransCAD network file and assign to different routes in the base-case network
- Aggregate traffic assignment results at pre-designated screenline locations and compare results with actual ground traffic counts at those locations, and
- Generate thematic maps that help the modeler visualize the trip assignment results, using the embedded graphic functions of TransCAD.

This chapter is organized as follows. Section 1 shows how freight trips in the Argos workflows can be categorized to facilitate the replication. Sections 2 and 3 detail how different categories of freight trips are estimated in the Argos workflow and how those trips can be read into TransCAD. Section 4 explains how to assemble freight trips of different categories into a master matrix file in TransCAD. Section 5 describes how the matrix file for freight trips can be combined with its counterpart for passenger trips in TransCAD. Section 6 reports how freight and passenger trips are assigned to the network in TransCAD. Section 7 compares the assignment results obtained from TransCAD with actual ground counts for the base case. The main conclusions of this document are that:

- The Argos workflow planner can be interfaced with widely–available commercial tools such as TransCAD.
- The Argos workflows can be extended to automate file conversion processes required to generate TransCAD compatible files
- TransCAD can be used to enhance the Argos workflows in modeling steps such as trip assignment and assignment result visualization.

2.1 Categorize Freight Trips in Argos: Base Case

Argos workflows and the original freight transportation model on which they are based use different data, procedures, methods and formulae to estimate freight trips with origins and destinations that are inside or outside the region in question (Pan 2003). Our case study area is the Los Angeles region, and the base case data is from 2001. The Los Angeles region is 35,000 square miles and includes the largest container port complex in the US and the third largest air cargo airport. Its 2000 population and employment are 16 million and 7 million respectively. Transportation modeling requires highly disaggregate data; we use traffic analysis zones (TAZs). There are 3,191 TAZs in the region.

The first step in generating the freight flow data is to enumerate all flows (trips) within and through the region. These trips can be grouped into four separate categories based on origins and destinations as shown in Table 2-1.

Table 2-1: Freight Trip Categories

Category 1: Internal to Internal Trips between 3,191 TAZs within the region	Category 2: Internal to External Trips from 3,191 TAZs within the region to 12 highway entry-exit points of the region
Category 3: External to Internal Trips from 12 entry-exit points of the region to 3,191 TAZs within the region	Category 4: External to External Trips between 12 highway entry-exit points of the region

To obtain these trips, one first needs freight trip productions and attractions for the different TAZs and entry-exit points. The 3,191 TAZs include 10 TAZs containing major seaports, airports and rail yards; in addition there are 12 highway entry-exit points. The Argos workflow automatically estimates freight trip productions or attractions measured in dollars and tons for all TAZs and entry-exit points, using data from multiple sources and computations developed by the Argos research team (Giuliano et al, 2008; Ambite and Kapoor 2007; Ambite and Kapoor 2007). After the test empirical application described in Chapter 1, the dollars to tons to PCEs conversion was added to the Argos planner.

It is important to note that PCE trips generated by Argos are the final product of multiple modeling steps. These steps start with the estimation of freight flows in dollars by commodity based on regional input-output data and point employment data. Flows are converted from dollars into tons by commodity based on regional freight flow data drawn from the Commodity Flow Survey (CFS). Tonnage flows are allocated to modes (air, water, rail, truck), also using CFS data. PCE values for the truck mode are obtained

using the estimated ton values and load factors by commodity (Pan 2003; Giuliano et al. 2008).

2.2 Estimate Intraregional Trips in TransCAD

2.2.1 Generate Input Data for Trip Distribution

The Argos workflow originally produced the attractions and productions in two separate .csv files. These files store the numbers of trips in a long-table format. Figure 2-1 provides an example of table format in Microsoft Access. Column #1 is the commodity ID assigned by the USC industry sector coding system (see (Pan 2003). Column #2 is the TAZ ID. Column #3 shows the factor shares produced ("Export") or attracted ("Import") by TAZ by industry sector. The unit of measurement in this example is dollars.

Figure 2-1: Argos-generated .csv files by Commodity by TAZ

There are 29 commodity types in the USC industry sector coding system.[2] Given 29 commodity types and 3,191 TAZs, there should be 92,539 rows (records) altogether in either .csv file. However, to save storage space, the original Argos workflow omits rows in sequence if numbers of productions or attractions are zero. The final .csv files generated by the original Argos workflows have 73,926 and 90,016 rows for attractions and productions respectively.

TransCAD uses .bin files for productions and attractions, and they are structured differently than the Argos .cvs files. An example is illustrated in Figure 2-2. There are three differences between them. First, .bin files do not distinguish commodity types. Second, .bin files do not omit TAZs even when there are zero productions or attractions. The third difference is that .bin files store attractions and productions in one file while .csv files store the attractions and productions in two separate files. By default, TransCAD uses .bin files as input for trip distribution. Therefore the original Argos .cvs files had to be converted to compatible .bin files.

Figure 2-2: TransCAD .bin Files

Initially the conversion into a format suitable for TransCAD was done outside of Argos in three steps described below. Now, an updated Argos workflow directly creates a file in the required format. This is implemented as a new step in the updated Argos workflow, which performs a join of the import and export tables along with a list of all TAZs so that there are no omitted rows.

---

[2] USC codes were developed at the University of Southern California to establish a common industry code system compatible with SIC, SCTG, and IMPLAN industry codes (Park et al, 2007).

Step 1: Generate a complete index list of trips by TAZ by commodity

As mentioned above, if visualized as a long table, a complete index list of trips by TAZ by commodity should have three columns and 92,539 rows, as shown in Table 2-2. Column #1 is used to store commodity type IDs 1, 2, 3, …,27, 28,29, and Column #2 to store TAZ IDs 1, 2, 3,…,3189, 3190, 3191. Column #3 is the concatenation of the values in Columns #1 and #2, which generates 92, 539 unique IDs for PCE trips produced or attracted by commodity type for each TAZ. We use a Visual Basic program in MS Excel 2007 and the embedded "concatenate" function to generate the complete index list as above.

Table 2-2: Complete Index List of Trips by TAZ by Commodity

Commodity ID	TAZ ID	Concatenated ID by Commodity by TAZ
1	1	1,1
1	2	1,2
1	3	1,3
…	…	…,…
1	3189	1,3189
1	3190	1,3190
1	3191	1,3191
2	1	2,1
2	2	2,2
2	3	2,3
…	…	…,…
2	3189	2,3189
2	3190	2,3190
2	3191	2,3191
…	…	…,…
29	1	29,1
29	2	29,2
29	3	29,3
…	…	…,…
29	3189	29,3189
29	3190	29,3190
29	3191	29,3191

Step 2: Generate unique IDs for Argos .csv files

The unique IDs are generated by concatenating Columns #1 and #2 in the .csv files. Again, the "concatenate" function and a VBA program in MS Excel 2007 were used. This step generates .csv files with unique IDs for each record.

Step 3: Link .csv files with unique IDs and the complete index list

Having the complete index list and .csv files with unique IDs, we use MS Access 2003 to link the list and the files together, using the unique IDs in the list and in the files as a common key. MS Access 2003 allows users to keep all records that the list has. All the omitted records that have zero trips in Argos .csv files are now padded, as shown in Table 2-3.

Table 2-3: Padded Argos .csv Files

Commodity ID	TAZ ID	Concatenated ID by Commodity by TAZ	IMPORTS	EXPORTS
1	1	1,1	0	0
1	2	1,2	10.45	10.00
1	3	1,3	10.00	20.00
…	…	…,…	…	…
1	3189	1,3189	0	0
1	3190	1,3190	10.45	10.00
1	3191	1,3191	10.00	20.00
2	1	2,1	0	0
2	2	2,2	10.45	10.00
2	3	2,3	10.00	20.00
…	…	…,…	…	…
2	3189	2,3189	0	0
2	3190	2,3190	10.45	10.00
2	3191	2,3191	10.00	20.00
…	…	…,…	0	0
29	1	29,1	10.45	10.00
29	2	29,2	10.00	20.00
29	3	29,3	…	…
…	…	…,…	0	0
29	3189	29,3189	10.45	10.00
29	3190	29,3190	10.00	20.00
29	3191	29,3191	0	0

Depending on whether different constant parameters are used to distribute trips by commodity type in TransCAD, the padded Argos .csv files can be exported to 29 separate .csv files with each file having 3,191 records, or to one .csv file with 92, 539 records. In our case, the same constant parameters are used to distribute trips of all commodity types, so only one .csv file is exported with 3,191 records by aggregating across all commodity types. The resulting file is now compatible with the TransCAD .bin file structure, and hence can be read into TransCAD.

2.2.2 Balance Trips Produced and Attracted by TAZ

Depending on whether total attractions equal total productions for all TAZs, an intermediate procedure called "trip balancing" is required before TransCAD is used to distribute attractions and productions. In travel demand models, trip balancing ensures that total attractions equals to total productions in the study area. Technical details of trip balancing can be found in (Caliper 2005). In our case, trip balancing is not performed since Argos workflows generate two .csv files that are constrained to have the same total intra-regional attractions and productions for all TAZs.

2.2.3 Distribute Argos-generated Intraregional Trips in TransCAD

The balanced trips produced and attracted by TAZ can be distributed with the embedded gravity model application in TransCAD. The gravity model is the most widely used trip distribution model. TransCAD also needs an input file of friction factors between TAZs. The factors represent the minimum generalized costs that trip makers bear when traveling between TAZs. The costs can be minimum monetary costs, travel distances, or time costs. We use shortest-path travel distances between TAZs. The distances are calculated in TransCAD using the 2000 Southern California Association of Government (SCAG) Regional Travel Model road network files in ArcView format, a TransCAD .net file, and TransCAD's embedded "multiple paths function". Technical details of generating .net file and finding shortest-path travel distances between TAZs (centroids) can be found in (Caliper 2006). With the balanced trip file and the friction factor file, one can now distribute the trips in TransCAD. Figure 2-3 is the screenshot of the user-interface for trip distribution in TransCAD.

The outcome of intraregional trip distribution is an N x N Origin-Destination (O-D) matrix (table) with N = number of TAZs. Each element in the matrix holds the number of trips between an origin and a destination within the study region. The row index value of the element is the ID of the origin (TAZ), and the column index value is the ID of the destination (TAZ). We do not include trips within the same TAZ in the traffic assignment, because there are so few such trips that travel on major roads.

Figure 2-3: Trip Distribution Interface in TransCAD
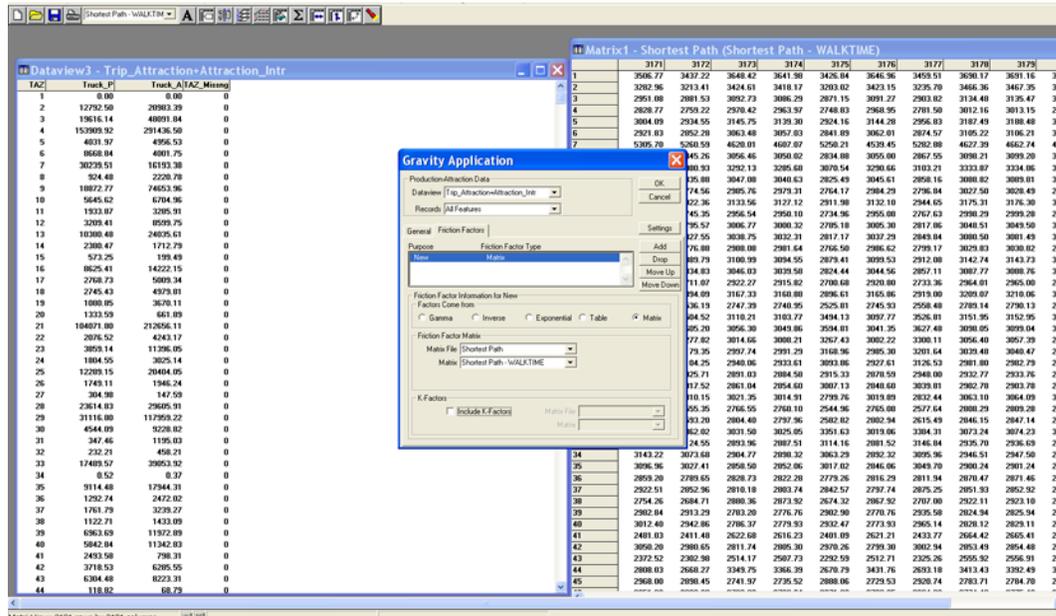
2.3 Distribute Interregional Trips

We now turn to Category 2, 3 and 4 trips, those with at least one end exiting or entering the region. Interregional trips travel by air, rail, water, or truck. Since we are interested in flows on the highway network, we must identify the portion of interregional trips that use the truck mode. The Argos workflow generates matrices of interregional flows by mode and commodity. The truck portion flows comprise the interregional trips used to generate the origin-destination matrix discussed here.

2.3.1 Balance trips attracted and produced at regional entry-exit points

The total number of freight trips attracted and produced at regional entry-exit points for modes of surface transportation (including 12 highway entry-exit points, 2 major seaports, 5 airports and 3 rail yards) generated by Argos do not equal each other, because attractions are regional imports and productions are regional exports. However, each import or export has a corresponding trip end within the region, so the total attractions and productions for imports are equal, as are the total attractions and productions for exports. In the case of through trips, the total number of attractions at entry/exit points equals the total number of productions at these points. Therefore no trip balancing is required for using Argos outputs.

2.3.2 Distribute trips between TAZs and regional entry-exit points

Freight trips between entry/exit points and TAZs within the region are assigned in proportion to commodity specific intra-regional attractions or productions using the following (Pan 2003):

$$F^{Eo,d} = \sum_i Inb_i^{Eo} \frac{A_i^d}{\sum_d A_i^d} \qquad (1)$$

$$F^{o,Ed} = \sum_i Outb_i^{Ed} \frac{P_i^o}{\sum_o P_i^o} \qquad (2),$$

where

$F^{Eo,d}$ = inbound freight trips from entry-exit point o to internal TAZ d;

$F^{o,Ed}$ = outbound freight trips from internal TAZ o to entry-exit point d;

Inb_i^{Eo} = inbound commodity i at entry-exit point o;

$Outb_i^{Ed}$ = outbound commodity i at entry-exit point d;

A_i^d = internal trip attraction of commodity type i at internal TAZ d;

P_i^o = internal trip production of commodity type i at internal TAZ o;

$\sum_d A_i^d$ = sum of attracted trips of commodity type i;

$\sum_o P_i^o$ = sum of trip productions of commodity type i.

The original Argos workflow generated values for Inb_i^{Eo}, $Outb_i^{Ed}$, A_i^d, and P_i^o, and the values of $\sum_d A_i^d$ and $\sum_o P_i^o$ could be calculated based on the values of A_i^d, and P_i^o. Thus, all variables in equations (1) and (2) were known and hence $F^{Eo,d}$ and $F^{o,Ed}$ could be calculated. However, manual calculations are extremely tedious and time-consuming. For instance, there are 12 highway entry-exit points and 3,191 internal TAZs. Similar calculations must be repeated 3,191*12 * 2=76,584 times to get all values for $F^{Eo,d}$ and $F^{o,Ed}$. We have modified the Argos workflow so that this assignment of external trips takes place within the workflow.

With the values of $F^{Eo,d}$ and $F^{o,Ed}$ calculated, only through trips for the study region remain to be considered. Through trips include the imports and exports that simply flow through the region. Examples include imports arriving at the ports and flowing to destinations outside the region, or exports from outside the region arriving at LAX for transport to international destinations. A large portion of through trips does not travel by truck, and hence are not relevant for highway network forecasting and analysis. As described in Chapter 1, we factor out the air, water and rail trips, leaving truck through trips to be distributed.

Through trips are allocated to the 12 highway entry/exit points based on interregional truck flow data for the State of California. That is, the through trips are assigned entry/exit nodes based on observed truck flows at those locations. Note that "through trips" include a truck trip from Northern California to Mexico, a trip from the ports to Arizona, etc. This step is calculated by a SQL query outside Argos planner.

2.4 Aggregate Freight Trips of All Categories

The process described above result in two separate data files that are either .bin files or .csv files. Before these files can be used as input for traffic assignment, they have to be aggregated into a single matrix file in TransCAD. In TransCAD, the O-D matrix file has to be associated with a standard geographic file to be used as input for traffic assignment. TransCAD uses standard geographic files to store spatial and attribute information of the transportation system.

In our case, the standard geographic file used to assign trips is based on the 2000 SCAG Regional Travel Model's road network files, which were created in ArcView. The SCAG network files do not have our 12 highway entry-exit points, so we add them to the network, yielding a total of 3,203 origins/destinations. The ArcView file is converted into a standard geographic file in TransCAD. TransCAD then can be used to generate a blank matrix file that has 3,203 origins or destinations. Step-by-step guides regarding how to generate a blank matrix file in TransCAD can be found in (Caliper, 2006). Figure 2-4 is a screenshot of the user-interface for generating a blank matrix file in TransCAD.

Figure 2-4: Generate Matrix File in TransCAD
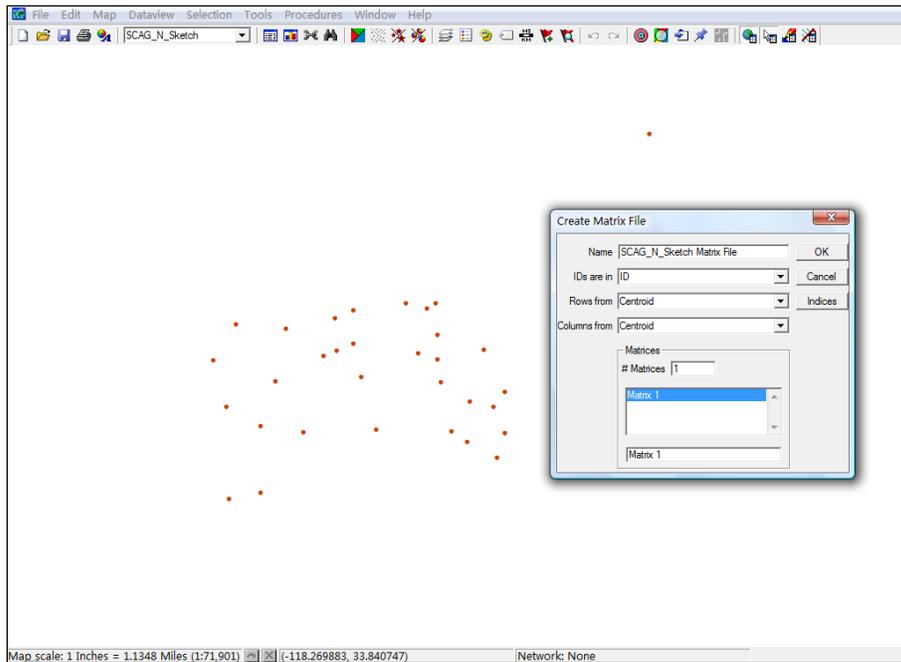
Data from the .bin files or .csv files mentioned above can be imported into the blank matrix file, using TransCAD's embedded Matrix-Import Tool. Figure 2-5 shows the user-interface in TransCAD that is seen when reading .bin or .csv files into a matrix file.

Figure 2-5: Import .csv and .bin Files into TransCAD
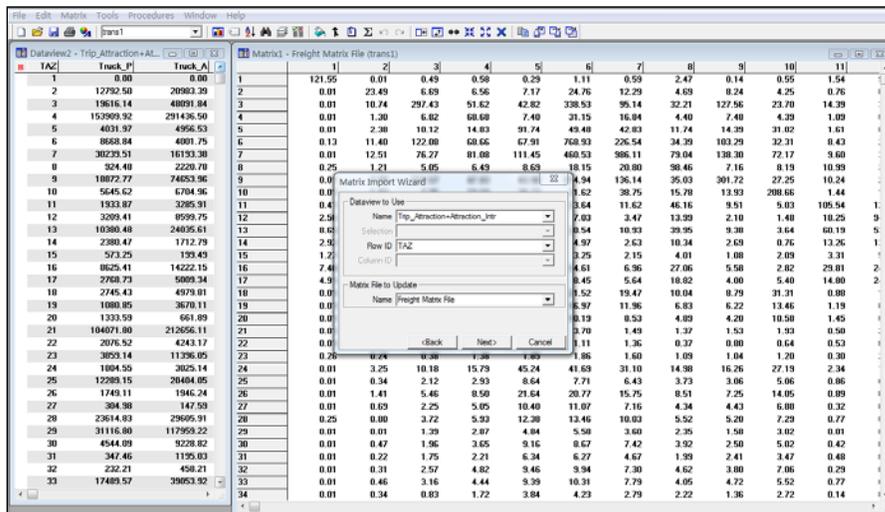
The first 3 columns of Figure 2-5 is a .bin file, and the remaining columns are in a matrix file, to which data have already been imported. Both files are not completely shown because both have thousands of rows or columns. Files are imported to the

matrix based on TAZ ID. In TransCAD, values in corresponding cells in matrix files that are associated with the same geographic file can be added, multiplied, divided, or subtracted using the Matrix Operation tool. This tool is used to aggregate freight trips of different categories after they have been imported from .bin or .csv files into appropriate matrix files. The aggregation generates a new matrix file, whose cells hold the sum of freight trips of different categories. At this point, freight trips are aggregated and are ready to be combined with corresponding passenger trips.

2.5 Combine Freight Trips and Passenger Trips

Freight trips are only a small portion of all trips using a region's road network. To perform traffic assignment of all trips in a study area, one needs origin-destination data for both freight and passenger trips for the same time period.

2.5.1 Prepare the Matrix File for Passenger Trips

Argos does not address passenger trips. Thus the origin-destination matrix for passenger trips is generated using different data and procedures. In our case study, we use the base case equilibrium traffic assignment (AM peak, 6 to 9 AM) produced by SCAG (Southern California Association of Governments, 2003). These data are originally in .pcu format, which minimizes file sizes by using low-level binary format to store information. Before TransCAD can use them as input for traffic assignment, the .pcu data have to be converted into a compatible matrix file. The conversion involves the following steps:

Step 1. Convert the data in .pcu format into data in .txt format

A short program called "bintotxt.exe" is used to convert the .pcu file into a .txt file. The new .txt file is an N x N table, where N = total number of origins/destinations.

Step 2. Reshape a wide table of .txt format into a long table of .csv format

Although the .txt file has the same dimensions of the TransCAD matrix file, it cannot be directly read into TransCAD. Rather, the .txt table must be converted to a long table (e.g. in .csv format, which has N rows and three columns. We used SPSS 15's Restructure Data Wizard to produce the long table as a SPSS .sav file. A .sav file can be directly exported to a .csv file. A portion of the .sav file is shown in Figure 2-6.

Figure 2-6: Example of a .sav File

Step 3. Import data from a .csv file into a matrix file

We import the .csv passenger trip data (file) into a blank matrix file, producing the passenger O-D matrix in TransCAD.

2.5.2 Combine Freight Trips and Passenger Trips
We now have two O-D matrix files, one for freight and one for passengers. The "Matrix-Pack" tool in TransCAD is used to merge the two files. Figure 2-7 is the screenshot showing both matrix files and the menu for Matrix-Pack.

Figure 2-7: Matrix-Pack Tool in TransCAD
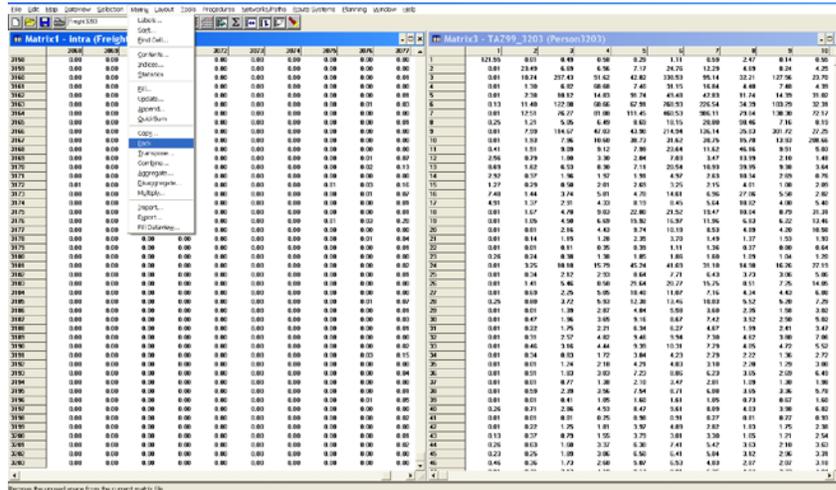
2.5.3 Allocate Freight Trips to a Given Time Period

Argos generates freight trips for a whole year. To get the freight trips for a given time period from the annual data i, the following formula is used

$$f_{ij}=F_{ij}/365 * \alpha \qquad\qquad\qquad (3),$$

where f_{ij} is the freight trips measured in PCEs between origin i and destination j in the time period of interest (in the base case, AM-peak period was studied), Fij is the annual freight trips measured in PCEs between origin i and destination j in the matrix file containing annual freight trip data, α. is the estimated ratio of freight trips occurring in the time period of interest. In the base case, a value of 0.1537028 was used for α. This value was estimated and given in (Pan 2003). In other cases, the values for α can be adjusted, depending on the temporal distribution of freight trip and the time period to be simulated. In all cases where the value of α is known, TransCAD allows the modeler to automatically implement (3) by using the "Fill-Matrix" tool. Figure 2-8 illustrates the Fill-Matrix user interface.

Figure 2-8: Fill-Matrix Tool in TransCAD

2.5.4 Aggregate Freight and Passenger Trips

TransCAD has a "Quicksum" function to automatically aggregate trips for the same time period in corresponding cells in matrix files that are linked together. It also generates a new matrix file that holds the aggregate trips. Figure 2-9 shows the screenshot of the Quicksum function. Once the aggregated file is created, traffic assignment can be performed.

Figure 2-9: Quicksum Function in TransCAD

2.6 Assign Freight Trips and Passenger Trips

2.6.1 Create a .net File

TransCAD needs three files to perform a traffic assignment: 1) a standard geographic file that represents the actual road network, 2) a matrix file that contains trips between all origins and destinations within the network, and 3) a .net file that is created based on the standard geographic network. A .net file contains algorithms that TransCAD uses to calculate the minimum-impedance paths between any two points in a standard geographic file. In TransCAD, a .net file is not visible and its source codes are locked to conventional users for proprietary reasons. An appropriate .net file has to be created and added before TransCAD can perform a traffic assignment. Where a standard geographic file is available, TransCAD allows the modeler to create the .net file by telling TransCAD which nodes in the file are treated as origins and destinations in traffic assignment and by executing a function called "Create Network". Figure 2-10 is the screenshot of the menu/function with which the modeler can create a .net file when a standard geographic file is opened in TransCAD. The .net file for our base case was created using the 2000 SCAG Regional Travel Model's geographic file for the road network.

Figure 2-10: Create a Network File in TransCAD
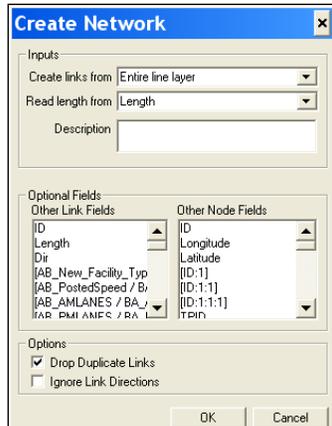
2.6.2 Assign Trips

Various types of assignments are available in Trans CAD, including all-or-nothing, STOCH, capacity constraints, user equilibrium, system equilibrium, etc. In addition, the user controls the convergence criteria. Figure 2-11 is a typical user-interface for traffic assignment. Beneath the interface are a standard geographic file and corresponding matrix file.

Figure 2-11: User-Interface for Traffic Assignment in TransCAD
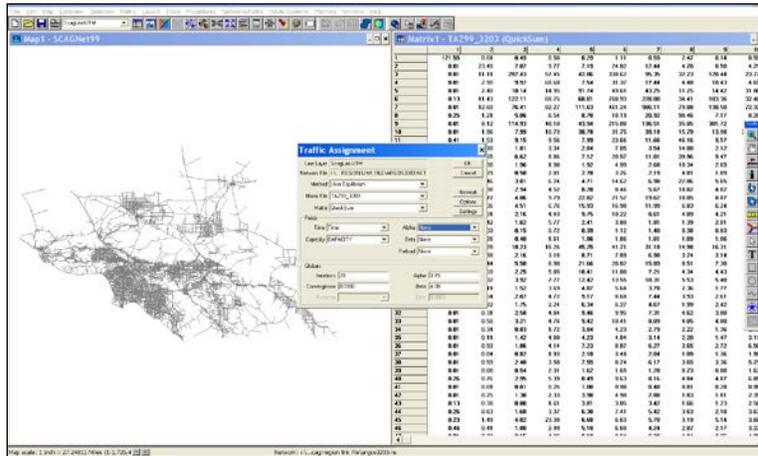
We selected user equilibrium for our base case traffic assignment demonstration. A user equilibrium assignment is deemed reached when the following conditions are satisfied:

$$(1-\beta)\ Fl_{i-1} \le\ Fl_i \le (1-\beta)Fl_{i+1}, \tag{4}$$

where Fl_i is the traffic volume at any given segment in the road network at the ith iteration, and β is a pre-assigned parameter that may range from 0 to 1. Values of β typically equal 0.05 or 0.01. In our case, β=0.05.

Once an equilibrium assignment is reached, results are automatically stored in a .bin file that contains the following information:

- IDs for all segments (links) in the road network,
- Total trips measured in PCE on each segment by direction of the roadway;
- Travel time in minute for each segment by direction of the roadway;
- Total vehicle miles traveled on each segment by direction of the roadway;
- Total vehicle hours traveled on each segment by direction of the roadway.

One advantage of TransCAD over the traffic assignment software used in our previous research is the graphical user interface that provides illustrations of the assignment results. Figure 2-12 provides an example. It shows the actual traffic assignment results for the base case. The red color shows presence of traffic on the link, and the width of each segment shows relative traffic volumes.

Figure 2-12: Traffic Volumes by Road Segment at Equilibrium for the Base Case
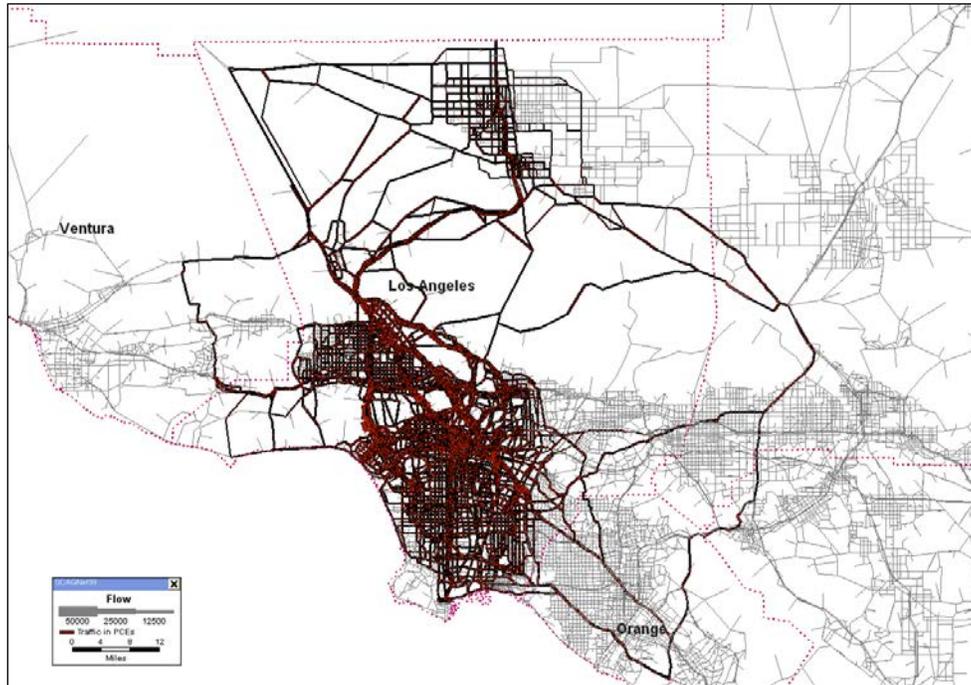
2.7 Evaluation of Results

In order to evaluate the results of our linked model, we compare the base case traffic assignment with ground counts, and with the previous results from the earlier version of our model. We use exactly the same data inputs as in our previous application (Giuliano et al, 2008).[3] However, we do not expect exactly the same traffic assignment results for the following reasons: 1) in reviewing the Argos workflow, we discovered one computational error, and therefore results would be somewhat different even if we had used our original method; 2) the highway network used in TransCAD is similar but not the same as the highway network used previously; 3) the assignment algorithms are different from those used previously.

Figure 2-13 illustrates differences in the coded network for a small portion of the region.   The SCAG network is based more closely on the street network. The SCAG network is quite large and complex; it has 92,559 links (including centroid connectors) and 35,360 nodes, compared with 89,356 links and 30,385 nodes in the network used in the earlier work. We have no information on possible differences in the assignment algorithm, because TransCAD assignment methods are proprietary and the algorithms are hidden.

---

[3] We were unable to replicate our previous O-D matrix results by running Argos planner on the original data, despite completely checking all data inputs and all computations within Argos. Thus our verification of TransCAD results is based on using the same O-D matrix as in the previous work.

Figure 2-13: Comparison of Coded Networks
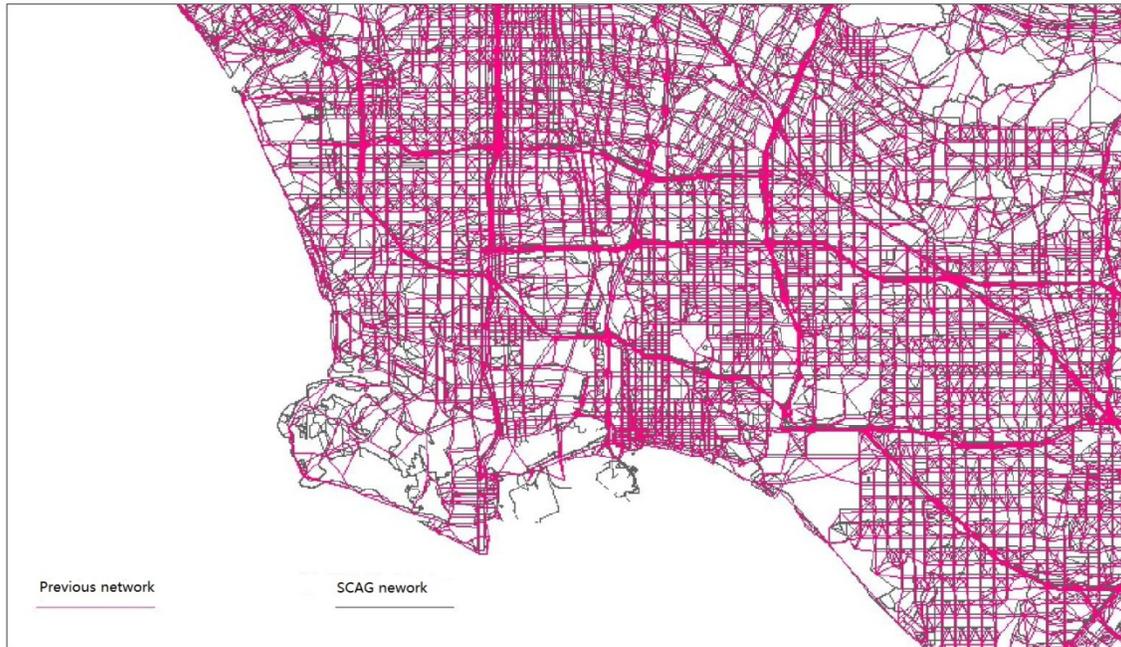
We follow the same process as described in Giuliano et al, 2008. In the earlier application, we assigned truck PCEs to the network already loaded with the equilibrium passenger assignment. We conducted a 3 hour AM peak assignment, and then factored up to a 24 hour assignment in order to compare results with 24 hour ground counts. The two stage assignment allowed us to identify truck PCEs as the screenline count differences before and after adding the truck PCEs. TransCAD has a multiclass assignment function that allows distinguishing PCEs associated with different vehicle classes. However, it requires separate generalized cost functions for each class. We do not generate different generalized costs functions. We therefore used the same process as before, first assigning all passenger PCEs, then adding the truck PCEs to the loaded network.

We used the same screenlines and ground counts as in the previous application. The 18 screenlines are shown in Figure 2-14. The ground count data were provided by SCAG and were obtained from field surveys and highway sensor data for 2001[4]. We conducted two runs, one with PCE as a weighted average based on region level vehicle classification data (Comparison 1); the other with PCEs unique to each screenline and generated by SCAG (Comparison 2).

---

[4] The SCAG screenlines are dated 2003 even though the data are drawn from 2001 counts.

Figure 2-14: SCAG Screenlines in 2003

Source: Adapted from Meyer & Mohaddes Associates, VRPA Technologies, and WILTEC 2004.

Results are given in Table 2-4 and Figures 2-15 and 2-16. Table 2-4 shows that using TransCAD somewhat reduces the fit of our results with the screenline counts, whether using actual PCEs or the SCAG generated screenline specific PCEs. However, given that we do not calibrate the model in any way, these results are still reasonable. As noted above, we would not expect the same results as in our previous work, but do not necessarily expect less robust results. The most likely reason for less robust results is the assignment process itself. In our earlier work, the assignment model allowed for adjustments in response to congestion on the system; we do not know the extent which such adjustments take place in TransCAD.

Having demonstrated that Argos results can be applied to TransCAD, the next step is to update Argos and apply it using more recent data.

Table 2-4: Comparison of Results, Prior Application vs TransCAD

| | Comparison 1 (actual PCE) | | Comparison 2 (SCAG PCE) | |
	Prior results	TransCAD	Prior results	TransCAD
Ave % difference	36.5	70.5	-5.3	3.61
Min % difference	0.8	1.7	7.5	-7.4
Max % difference	206.8	288.8	134.0	112.1
Ave weighted % diff	20.0	31.6	17.0	-22.4
Weighted % mean sq error	17.8	21.3	10.0	38.2
Regression R^2	0.80	0.73	0.67	0.58

Figure 2-15: TransCAD results, Comparison 1, actual PCEs

Estimated and Actual Screenline HDT, 24 Hr, in PCEs

Est = 0.84(Actual) + 60188
R^2 = 0.73

Figure 2-16: TransCAD results, SCAG PCEs

Estimated and Actual Screenline HDT, 24 Hr, in PCEs

Est = 0.56(Actual) + 63635
R2 = 0.65

Y-axis: Estimates
X-axis: 2003 Actual (Screenline-specific PCE factors)
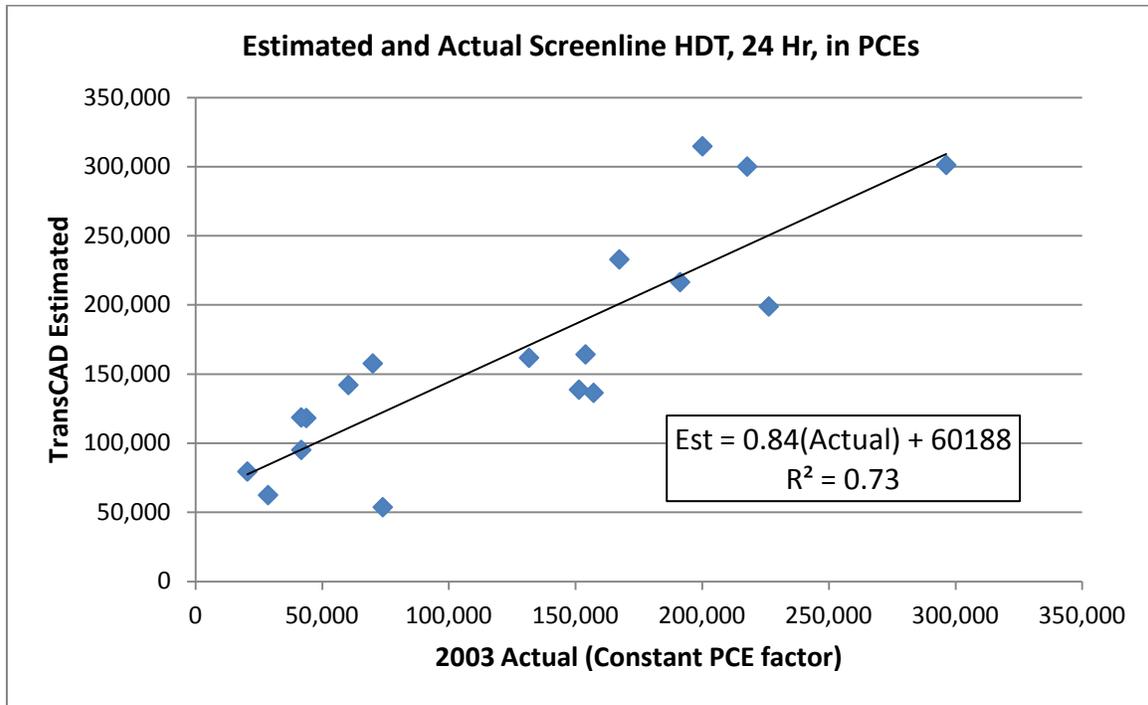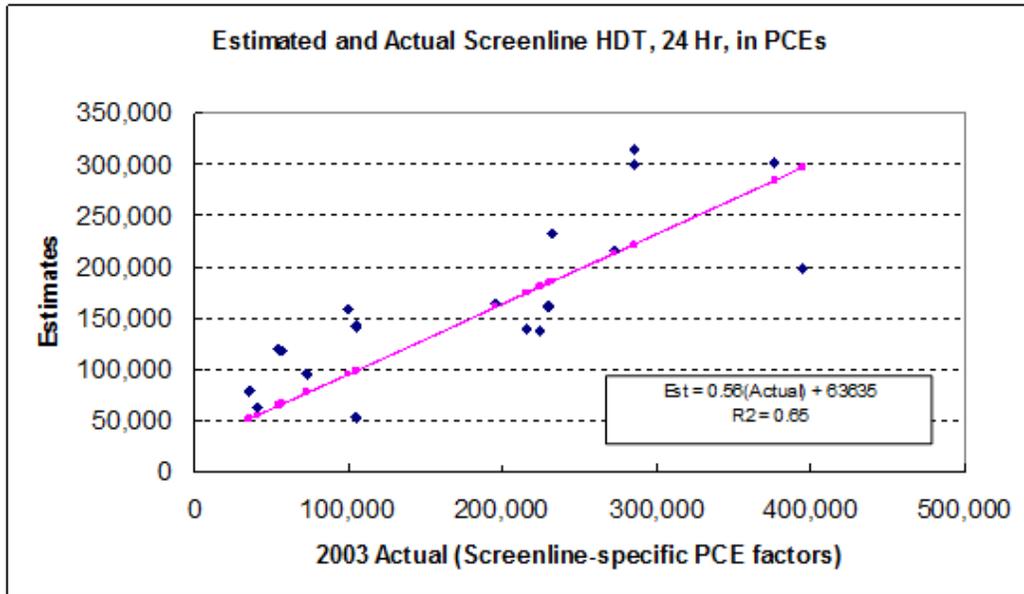
3. Task 2.1 -- Model Updating

This Chapter described the model updating process. Model updating is a major task in regional transportation planning. Regional plans are typically generated every four years, and each update requires a new baseline year. The more data that must be collected via surveys or other special methods, the more costly and time consuming the process becomes. As government at all levels becomes more fiscally constrained, less data are collected on a regular basis, and major data collection efforts such as travel surveys are conducted less often. The cumulative effect is less reliable transportation forecasting and planning. Any methods for using existing data sources are therefore worth pursuing.

The model updating process includes collecting data from all the data sources for a new target year, and then combining the data to generate the various flows. After surveying the availability of the various data sources, we set our target year as 2007, the most recent available for some of the key data sources.

3.1 Intraregional Flows

The two data sources for generating intraregional flows are the IMPLAN input/output data and the SCAG employment data. IMPLAN is commercially available and is updated annually. We purchased the 2007 IMPLAN data for the 5 county Los Angeles Region. IMPLAN provides county level inter-industry flows by 509 IMPLAN sectors. It also provides state and national foreign imports and exports. In our previous research, we evaluated the quality and reliability of alternative data sources, and concluded that the IMPLAN totals come closest to other corroborating data sources (e.g. total imports and exports as reported by the Department of Commerce). We therefore assume the IMPLAN county totals to be the "true totals", and adjust all other data sources to be consistent with IMPLAN. IMPLAN data cannot be used directly, because it includes some import and export transactions. These are factored out.

SCAG   generates small area employment data from state employment and tax records. The finest version of the data is employment by establishment (located by latitude and longitude), with employment categorized by 3 digit NAICS code. These data are not available to the public; we were able to obtain the 2007 version by special request. We aggregate the employment data into TAZs, the spatial unit of analysis. ESRI's ArcGIS software package and an ArcGIS freeware called Hawth's Tool were used to aggregate point-level data by TAZ.   In 2007 the SCAG region has 4190 TAZs (including virtual TAZs such as regional exit/entry TAZs).

Table 3-1 lists the main data sources for intraregional flows. No changes were made in the structure of the IMPLAN data. The SCAG employment data changed coding system from SIC to NAICS. The shape files for TAZs were also provided by SCAG.

Table 3-1: Main data sources for intraregional flows

Source	Code system	Year	Changes
IMPLAN	IMPLAN	2007	None
SCAG	3 digit NAICS	2007	Previous 2000 data in SIC codes

The SCAG employment data provides the basis for disaggregating the IMPLAN county level supply and demand to TAZ level supply and demand. We use employment by sector as the measure of each zone's production and consumption share of sector activity, taking into account the I/O inter-industry demand and supply coefficients. These calculations take place within the Argos planner.

It was noted in Chapter 1 that data sources utilize a variety of industry code systems, and there is no universal conversion system. A team of researchers at USC developed the "USC" coding system to be able to convert from one code system to another. The USC system has 47 codes, 29 commodity codes and 18 non-commodity codes. Bridge tables have been developed to convert SCTG, SIC, NAICS, SITC and HS codes to USC codes. As part of the NSF funded research, these bridge tables were used to create a web service that automatically converts data from one code system to another.[5]

How detailed should the industry sector data be? Although many of our data sources have highly detailed sector data, the question is how much detail is needed to make reasonable estimates of truck flows? For example, commodities differ in their value to weight ratio, so value per weight unit must be taken into account. The more we aggregate commodity categories, the more the variation across commodity categories is lost. We are not aware of any research that considers the effects of different commodity categories, and it is beyond the tasks of this project to explore the question. In the first version of Argos, we were constrained by the CFS data, which provided the most disaggregate flow data in one digit SCTG codes. We retained this structure in the update, but at later steps converted all data to the USC code system to take advantage of the more detailed data available from IMPLAN and the SCAG employment data. These conversions are done within the Argos planner.

3.2 Interregional Flows

Referring back to Figure 1-1, it can be seen that the generation of interregional flows is far more complicated than the generation of intraregional flows. The primary data sources for interregional flows are IMPLAN and CFS. However, neither is structured to provide the flow data we need. The logic of constructing the interregional flows is as follows.

We divide the world into three regions, the metropolitan area (in this case the Los Angeles CMSA, referred to as LA), the rest of the US (US) and the rest of the world

---

[5] The web service is available at http://www.isi.edu/~argos.

(W). Four commodity flows with an origin or destination in LA are possible, as illustrated in Figure 3-1. Transshipments are captured by combinations of the four flows; for example import cargo arriving at the LA ports for consumption in Iowa would be included in "W2LA" + "LA2US." We must identify these four flows in order to obtain a complete accounting of all import/export flows for the region. Because of the way commodity flows are reported in IMPLAN and CFS, we must also consider the internal (intraregional) flow, "LA2LA", in order to maintain sum totals consistent with the IMPLAN data. Note that "LA2LA" corresponds to the intraregional flows discussed above.

None of the flows in Figure 3-1 can be obtained directly from IMPLAN or CFS. The CFS data has "Total Outbound" (LA2LA + LA2US) and "Total Inbound (LA2LA + US2LA) flows by mode and sector. IMPLAN has various import/export totals by sector that can be used to derive the five flows, but has no mode data. We therefore use IMPLAN to derive the five flows, CFS to assign flows to mode for US based flows, and WCUS and WISERTrade to assign modes to world based flows. The formulae for computing the five flows are given in Giuliano et al, 2008.

Figure 3-1. Conceptual Freight Flows
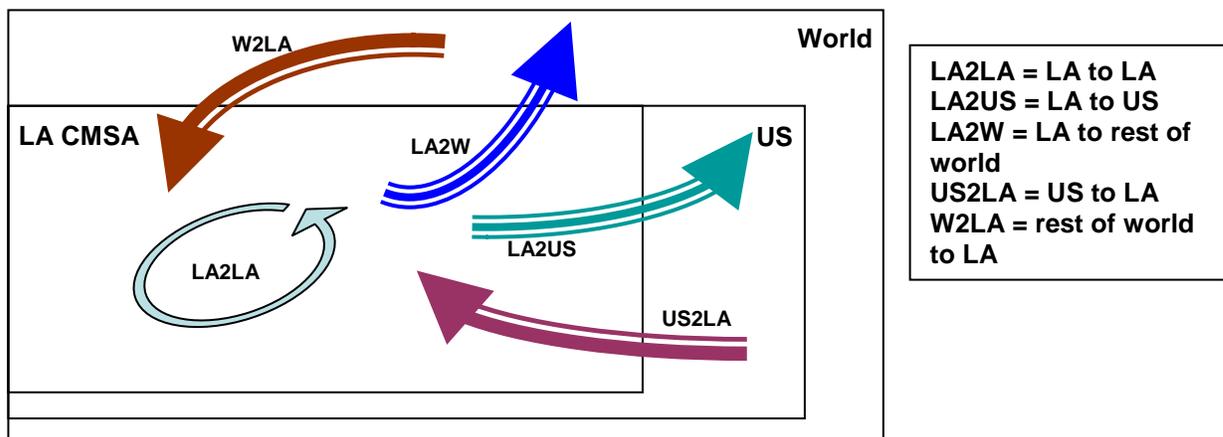
In order to calculate the five flows, we aggregate the IMPLAN 2007 information to the 9 SCTG commodity sectors. Note that only the modal shares are taken from CFS, as we use IMPLAN to generate LA2LA, LA2US, and US2LA. The rest of world flows are calculated from IMPLAN and WISERTrade. We estimate a total of 45 different flows: each of the 5 flows for each of 9 sectors. These flows are in annual dollars.

Once the flows have been estimated, we use CFS to proportionately allocate flows to air, water, rail and truck. Because CFS data is categorized as either "inbound" or "outbound," and because the LA2LA flow is embedded in both inbound and outbound data, we back out the LA2LA portion and assume it is all truck, use the CFS mode proportions for LA2US and US2LA (and WISERTrade where CFS data are not available), and use WISERTrade for the rest of world flow modes. The result of these

computations is five 9x4 matrices of proportions corresponding to the five trade flows in Figure 3-1.

Table 3-2 lists the data sources used for generating interregional flows. Some data sources were improved, making the process of compiling data for the Argos planner somewhat easier. As noted above, IMPLAN is used as the source of "true values," and the five flows are derived from IMPLAN. CFS is used for assigning most of the mode shares. Although drawn from a smaller sample in 2007, there is a little more data at the LACMSA level, allowing us to replace some of the state level data with CMSA level data. WISERTrade is used for export and import values in dollars for air and water. Because the WISERTrade data has been expanded, we no longer need WCUS or special sources for airport data. The Intermodal Transportation Management System (ITMS) data have not been updated (the 2002 edition offers GIS files of the previous data). This source is used only to allocate interregional truck flow shares to the freeway entry/exit points.

Table 3-2: Data sources for interregional flows

Source	Code System	Year	How Used	Changes
IMPLAN	IMPLAN	2007	Flow totals by sector	None
CFS	SCTG	2007	Mode shares	Smaller sample Adds air, water outbound freight $$ for LACMSA
WISERTrade	HS, SITG	2007	Export or import values in tons or dollar for air and water modes	Adds flows in tons by HS code for ports
ITMS	None	2002	Flow shares in dollar and ton among different entry/points and rail yards	Never updated

3.3 Transportation System Data

Our transportation network data was provided by SCAG. We used the network (link) and node files in the TransCAD format from the 2007 SCAG Regional Travel model. These files were built for 4191 TAZs in six counties in the SCAG region. Our 2001 Argos flows were for 3191 TAZs in five counties in the SCAG region. In order to preserve

consistency with the prior 2001 model applications, we retained the 3191 TAZ geography. We therefore adjusted the TransCAD network to 3191 TAZs by adjusting the zone connectors.

3.4 Argos Planner Updates

We conducted a full review of the Argos Planner to verify all computational elements and data sources of the workflow. In doing so we found one error in the operator that computed the intraregional demand due to an ambiguous interpretation of supply and demand coefficients of formulas (1) and (2) in (Giuliano et al., 2008). We corrected the error in the updated Argos planner.

One of the challenges of using secondary data sources to generate freight flows is the difference in units and codes across the data sources. In section 3.1 we discussed our conversions across the various industry sector codes. Here we provide a simplified overview of Argos Planner and explain how the intraregional and interregional flows are generated in a form compatible with the TransCAD file structures, The complete workflows are given in Appendix A. Figure 3-2 summarizes the generation of intraregional flows. The two main data sources are IMPLAN (dollars in IMPLAN sectors) and TAZ level employment (jobs in NAICS). We convert both to USC codes. Employment is used to allocate supply and demand by industry sector across the TAZs. In our previous work, dollar flows were allocated, and the end result was a set of productions and attractions in dollars. In this research, we have added the conversion from dollars to PCEs, as shown in Figure 3-2. The conversion accounts for sector specific dollars to tons to trucks relationships. Now Argos generates productions and attractions in PCEs by USC code. Note that only the commodity codes are allocated, as these represent the physical flows to be modeled. The result of this process is Ps and As by sector (n=29) by TAZ (n=3191).

Figure 3-2: Argos Planner: Intraregional Portion
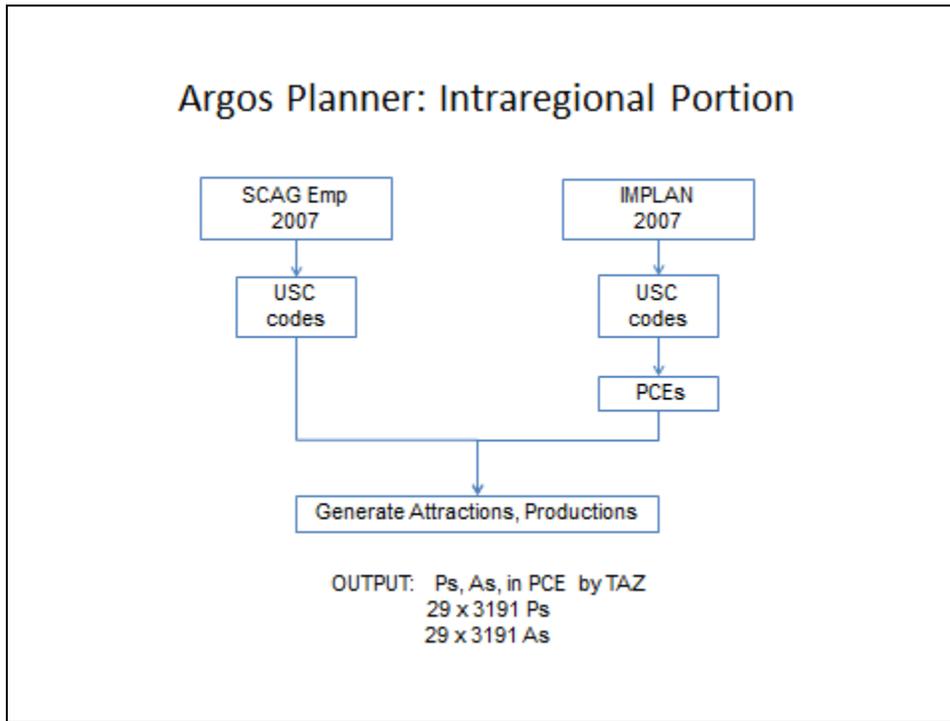
Figure 3-3 shows the interregional portion of Argos Planner. The four data sources are shown in the top row of boxes. As discussed above, each has data in different units. Here we convert to single digit SCTG codes, and, as described earlier, allocate import and export flows to modes. Air and water flows are allocated to the airports and ports, and rail flows are allocated to the major rail centers (based on volume shares). We have a total of 22 entry/exit nodes: 12 highway, 2 port, 5 airport, and 3 rail. Every export and import has an origin or destination inside the region. Thus for air, water, and rail there is an intraregional portion of the flow that we assume is by truck. Once all flows are allocated to modes, the resulting truck trips are converted to PCEs.

The distribution of imports/exports to/from points within the region has been added to Argos Planner. The distribution is based on the relative attraction/production of each TAZ (see Chapter 2 for details). Argos generates a 22 by 3191 OD matrix for each of the 29 USC codes. These matrices are the final output of the interregional portion of Argos.

Figure 3-3: Argos Planner: Interregional Portion
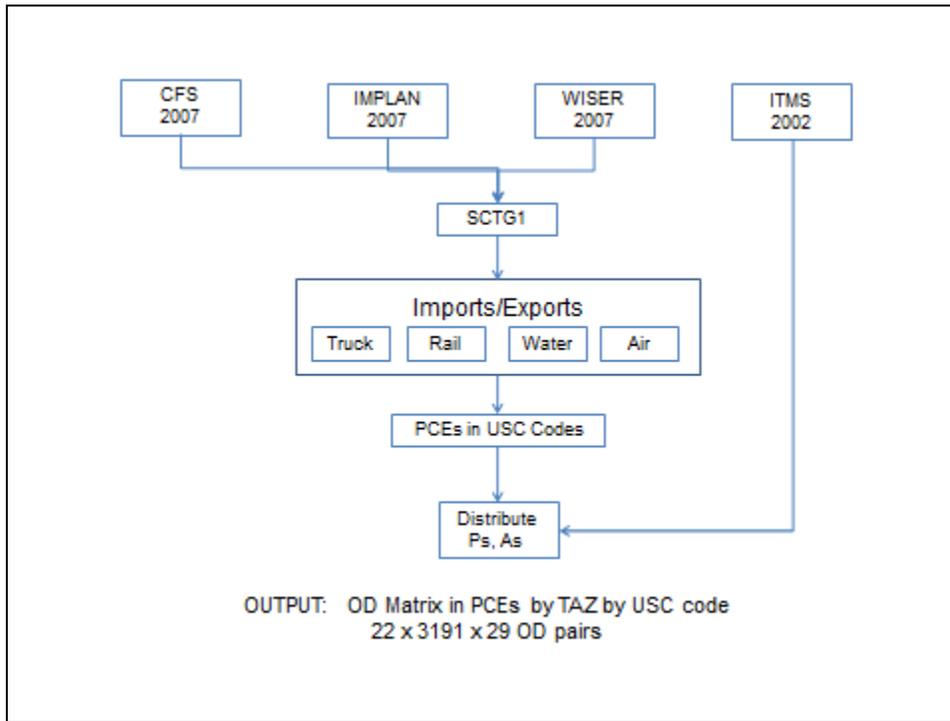
3.5 2007 Baseline Results

The outputs from Argos (intraregional Ps and As, interregional OD matrices) are the input for TransCAD. We processed the Argos output as described in Chapter 2. In order to evaluate our model results, we once again need actual ground count data. We worked closely with SCAG modeling staff in this part of our work. SCAG regional transportation modeling is conducted using TransCAD. SCAG provided their 2007 full OD matrix (passenger and freight), their 2007 network, and the 2007 screenline ground count data. As before, the screenline count is Average Annual Weekday Traffic (AAWT). In 2007 SCAG has 23 screenlines. Two are beyond the network we used, so we restrict our comparisons to the 21 that are within our network. Figure 3-4 shows the screenlines

We had anticipated using the SCAG model results as another comparison for our results, as we had done in the first Argos study. This gave us a benchmark for what is considered acceptable model performance in professional practice. However, SCAG has not yet produced a 2007 baseline model that generates results they consider to be satisfactory. Our comparisons are therefore limited to the AAWT data.

Figure 3-4: 2007 Screenlines
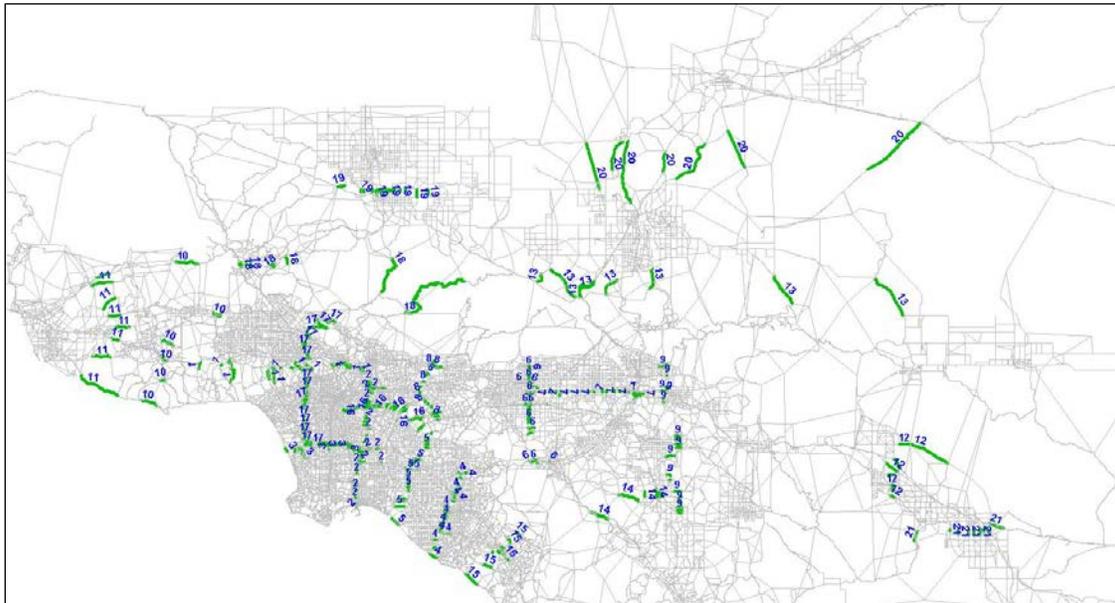
The TransCAD simulation is for a defined time period, in this case "AM peak." Therefore our Ps and As and interregional matrices must be adjusted from annual flows to day flows to AM peak flows. We simply divide annual flows by 365 days. This is likely an underestimate of daily flows, since we do not expect weekend flows to be the same as weekend. On average there are about 255 "weekdays." If we were to use 255, we would clearly overestimate average daily flow, because some flows take place on weekends. We have no data on variation in truck flows by day of week, and hence have no basis for adjusting the data to generate a typical weekday flow. We therefore generate the average based on 365 days. As discussed in Chapter 2, we used a factor from prior literature to estimate the AM peak portion of flows.

TransCAD allows for different categories of flows. The identity of the flow is retained throughout the simulation, so that the final equilibrium assignment identifies total VMT, VHT, and link flows for each category. SCAG uses 8 categories of flows, 5 for passenger trips and 3 for truck trips. Traffic flows should be segmented if there are differences in impedance factors, traffic performance, or routes available. Different impedance factors for each USC code were developed by Pan (2003), and we used them to generate the intraregional truck OD matrix. It would be possible in future work to create these categories within TransCAD and use TransCAD to generate the OD matrix. We have no reason to believe that PCEs behave differently across industry sectors in traffic assignment, unless truck characteristics differ across industry sectors. We had no data to test this possibility. We therefore combined the intra- and interregional OD matrices and used only one truck category.

In order for us to use the SCAG OD matrix as the basis of our assignment, we must factor out the truck PCEs in the SCAG matrix. This is straightforward, given the flow categorizations. We simply eliminate all the "truck" categories from the OD matrix.

A final preparatory step is to adjust our PCE totals to regional totals. In this case, the only available total is the SCAG model estimated total truck PCEs. We used this total to adjust the Argo generated data so that total PCEs were equivalent to the SCAG model estimate. Note that because the SCAG baseline model has not yet been fully validated, there is some uncertainty associated with this estimate.

Table 3-3 gives results by screenline. The 2007 AAWT is the actual daily count recorded at the screenline. The third column in Table 3-3 factors the AAWT to PCE, based on the fixed factor of 2.25. The difference between the Argos estimate and actual is given in the last two columns. It can be seen that results differ substantially by screenline; this is consistent with our 2001 results. The average difference is -4.3%, the weighted average difference is -16.8%, and the simple correlation between Argos and actual is 0.72.

Table 3-3: 2007 Baseline Results by Screenline

Screenline	AAWT	PCE	Argos	Difference	%Difference
1	52,656	118,476	133,197	14,721	12.43%
2	102,649	230,959	206,481	-24,478	-10.60%
3	79,387	178,620	91,815	-86,805	-48.60%
4	83,796	188,541	103,394	-85,147	-45.16%
5	59,169	133,130	158,367	25,236	18.96%
6	82,019	184,542	151,687	-32,855	-17.80%
7	49,733	111,900	35,653	-76,247	-68.14%
8	53,893	121,259	120,683	-576	-0.48%
9	36,911	83,049	47,157	-35,892	-43.22%
10	19,956	44,901	36,544	-8,357	-18.61%
11	14,691	33,055	25,123	-7,932	-24.00%
12	20,114	45,257	42,924	-2,333	-5.15%
13	23,368	52,578	100,799	48,221	91.71%
14	12,891	29,004	38,317	9,313	32.11%
15	18,516	41,661	27,195	-14,466	-34.72%
16	143,077	321,923	149,670	-172,253	-53.51%
17	71,873	161,714	175,323	13,609	8.42%
18	26,163	58,867	134,742	75,875	128.89%
19	9,922	22,325	23,144	819	3.67%
20	16,255	36,574	95,069	58,496	159.94%
21	17,779	40,003	9,274	-30,729	-76.82%

We estimated a simple regression of the actual data on the Argos estimate. Results are shown in Figure 3-5. Finally, in Table 3-4 we compare these results with the

2001 data TransCAD application. Results are rather mixed. The 2007 results have smaller average differences, but a larger weighted mean square error and lower goodness of fit. Differences in the results could be due to many factors, including the accuracy and reliability of the 2007 data, changes made within Argos planner, changes in the network, etc. Although the research team conducted many checks of the data and the workflow, we could not identify a specific reason for the difference in the robustness of the results.

For the purpose of demonstrating the feasibility of updating Argos and using the model system for sketch level scenario planning, results are adequate. However, results are not adequate for the type of detailed analysis required in long range planning. More work on the modeling system would be required to use the system in a conventional regional planning context. The model would have to be calibrated and adjusted to more closely fit the data. This type of effort is beyond the scope of this research. The Los Angeles Region is a particularly difficult context for testing new models due to its size and complexity. We note that SCAG planners and consultants have been working for several years to achieve acceptable baseline results for the 2007 model year.

Figure 3-5: Baseline Estimation Regression Results

Estimated and Actual Screenline HDT, 24 Hr, in PCEs

Est = 0.53(Actual) + 34294
$R^2 = 0.52$
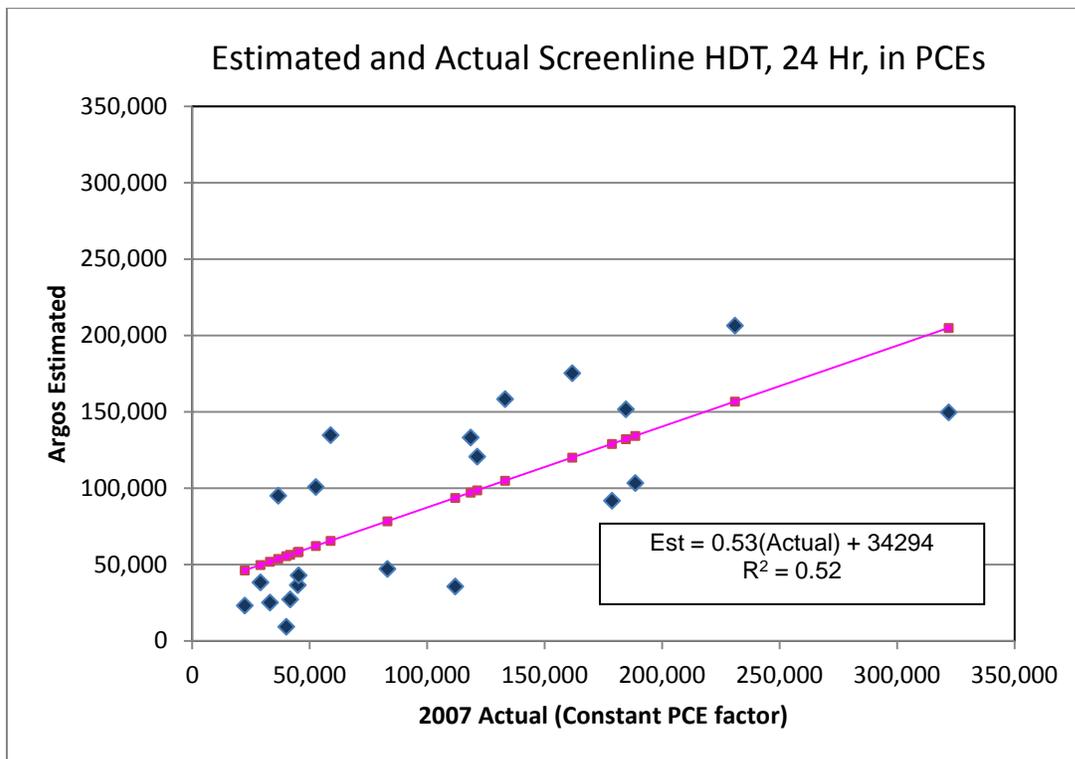
Table 3-4: Comparison of 2001 and 2007 Baseline Results

	2001 data	2007 data
Ave % difference	70.5	-4.3
Min % difference	1.7	-0.48
Max % difference	288.8	159.9
Ave weighted % diff	31.6	-16.8
Weighted % mean sq error	21.3	38.4
Regression R^2	0.73	0.52

4. Task 2.2 -- Policy Applications

The final task of this research is to use the new modeling system to conduct scenario analyses. Our efforts in updating the model showed that it is not robust enough for the detailed analysis and forecasting required for long range regional planning. However, the model can be used at the sketch planning level to compare different scenarios. The scenarios can be of two types: exogenous economic changes and system management changes. We selected three scenarios to demonstrate the ways that a modeling system such as this could be used in sketch planning.

4.1 Scenario Results

The three scenarios tested are 1) reduce international trade by 25%; 2) shift 25% of truck trips to rail; 3) implement peak pricing for all port truck trips. Scenario 1 approximates what happened in the region following the financial crash of 2007 and the resulting recession. Scenario 2 addresses the question of what would happen if we were able to shift longer distance truck trips to rail. Shifting truck traffic to rail is widely advocated as a means to reduce congestion, air pollution, and energy consumption. Scenario 3 approximates the PierPass program, which charges a fee for entry to the ports during peak hours. In each case we compare results to the baseline to examine freight flow changes.

4.1.1 Scenario 1: Reduced International Trade
We modeled Scenario 1 by reducing international imports and exports by 25%. Referring back to Figure 3.1 in Chapter 3, these are the "LA to ROW" and "ROW to LA" flows. All other flows remain the same. We run the Argos workflow to generate a new inter-regional truck O-D matrix, and then use TransCAD to run the new equilibrium assignment. In order to test the quality of our updated model results, we expanded the equilibrium assignment results to 24 hours in order to compare with the actual truck count data (see Chapter 3). We do not need to do this for the scenarios, as the basis of comparison is the model baseline. Thus our results are for the AM Peak.
Table 4.1 gives results for total number of truck trips, truck VMT, and truck VHT for the AM peak equilibrium assignment. Reducing international flows by 25% yields a reduction of truck trips of around 4%. This reflects the relatively small share of truck flows associated with international trade. It should be noted that we do not take into account the indirect and induced economic effects of this trade loss, hence it is a conservative estimate of impacts. It would be necessary to re-run the regional input/output model in order to capture the full economic effects, which is beyond the scope of this research.

Table 4-1: Scenario 1 Summary Results for AM Peak

	Truck trips	Truck VMT	Truck VHT
Baseline	46,038	6,754,713	124,878
Reduce Exports/Imports	44,151	6,476,288	118,214
Difference	4.10%	4.12%	5.34%

Table 4.2 and Figure 4.1 show how the reduced truck flows are distributed across the screenlines. In this case the reduction is evenly distributed. Why should this be the case? By definition, these are flows that either originate or end somewhere in the region (these are not the international flows that originate or end somewhere else in the US). Recall that we use economic activity to locate these origins and destinations. Since economic activity is spread throughout the region, the trade-related reduction is also spread throughout the region.

Table 4-2: Scenario 1 Screenline Results, AM Peak

Screenline	Base case	Reduced Int'l trade	Difference	% Difference
1	20379	19154	-1225	-6.0%
2	31592	29809	-1782	-5.6%
3	14048	13213	-834	-5.9%
4	15819	14850	-969	-6.1%
5	24230	22847	-1383	-5.7%
6	23208	22017	-1191	-5.1%
7	5455	5117	-338	-6.2%
8	18464	17330	-1135	-6.1%
9	7215	6787	-429	-5.9%
10	5591	5262	-329	-5.9%
11	3844	3613	-231	-6.0%
12	6567	6175	-392	-6.0%
13	15422	14508	-914	-5.9%
14	5863	5510	-353	-6.0%
15	4161	3912	-249	-6.0%
16	22900	21574	-1326	-5.8%
17	26824	25196	-1628	-6.1%
18	20616	19373	-1242	-6.0%
19	3541	3362	-179	-5.0%
20	14546	13699	-847	-5.8%
21	1419	1334	-85	-6.0%
			Average	-5.9%
			Wgt Ave	-5.9%

Figure 4-1: Scenario 1 Screenline Results Chart, AM Peak
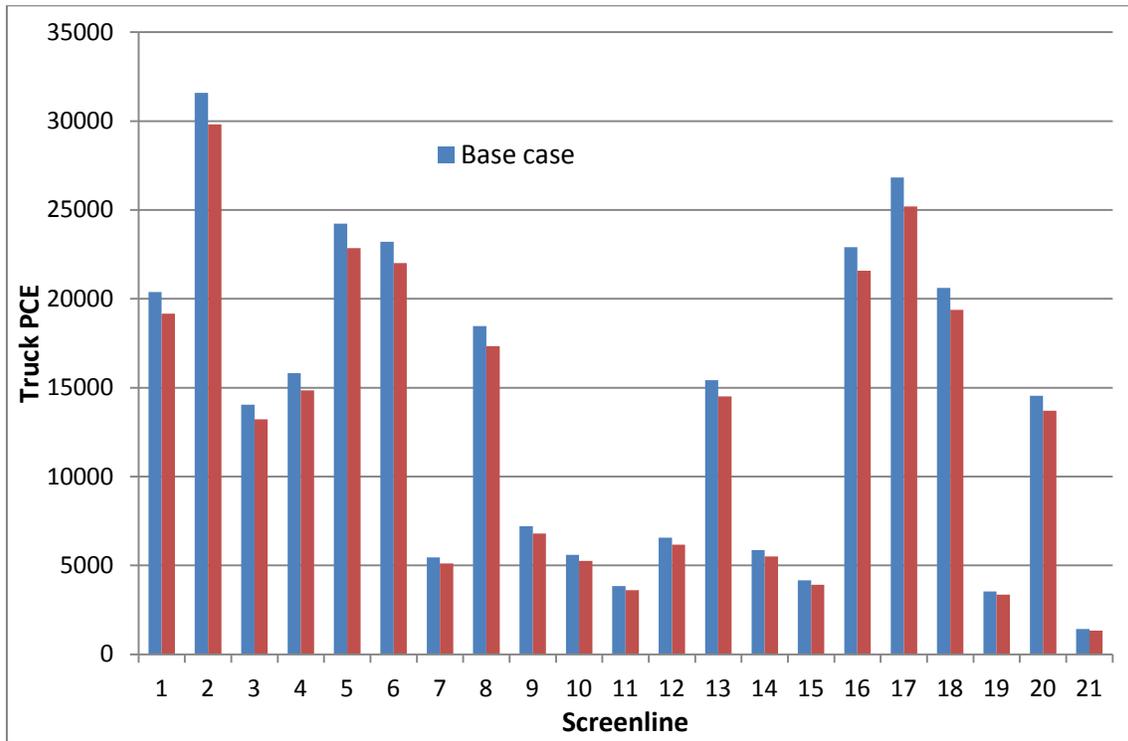
4.1.2 Scenario 2: Shift Trucks to Rail

Scenario 2 is modeled by taking the truck portions of domestic imports and exports and shifting 25% of the truck flow to rail across all industry sectors. These are the "LA2US" and "US2LA" flows in Figure 3.1, Chapter 3. We do not consider international imports and exports, because none of these are truck flows in the baseline. That is, imports and exports arrive/depart only from ports or airports. This scenario is equivalent to saying, what if rail were more competitive with truck and could capture more long-haul traffic?

Because every export that originates in the region and every import that has a final destination in the region, whether domestic or international, has a "last mile" truck trip, the total number of truck trips does not change in this scenario. Rather, 25% of the trips that were entering or exiting the region are now entering or exiting by rail, hence reducing truck VMT within the region. Table 4.3 gives summary results. Truck travel drops substantially as a result of the mode shift, because long distance truck trips are removed from the network.

Table 4-3: Scenario 2 Summary Results, AM Peak

	Truck trips	Truck VMT	Truck VHT
Baseline	46,038	6,754,713	124,878
Truck2Rail	46,038	5,809,547	102,985
Difference	0.00%	13.99%	17.53%

Table 4.4 and Figure 4.2 show results by screenline. It can be seen that the reduction in trips is not consistent across screenlines. There are increases at some and decreases at others. As would be expected, truck trips around the rail nodes increase (for example screenlines 2 and 3; see Figure 3.3 in Chapter 3), because some trips are diverted towards the rail nodes rather than traveling through the region. Truck trips at screenlines located on the major routes into and out of the region decrease (for example screenlines 18 through 21), reflecting the same dynamic. Figure 4.3 shows the results on the highway network. Changes on links of 500 PCE or more are shown; green represents decreases from the baseline, and red represents increases. The size of the change is represented by the width of the line. Figure 4.3 illustrates the rather large changes on the main highway routes into and out of the region.

Table 4-4: Scenario 2 Screenline Results

Screenline	Base case	Truck2Rail	Difference	% Diff
1	20379	18610	-1770	-8.7%
2	31592	34074	2482	7.9%
3	14048	14806	758	5.4%
4	15819	16204	384	2.4%
5	24230	25064	834	3.4%
6	23208	21141	-2067	-8.9%
7	5455	4245	-1210	-22.2%
8	18464	16939	-1525	-8.3%
9	7215	5717	-1498	-20.8%
10	5591	5369	-222	-4.0%
11	3844	3594	-250	-6.5%
12	6567	4990	-1577	-24.0%
13	15422	11667	-3755	-24.4%
14	5863	4685	-1178	-20.1%
15	4161	3807	-354	-8.5%
16	22900	23697	797	3.5%
17	26824	24591	-2234	-8.3%
18	20616	15494	-5121	-24.8%
19	3541	2790	-751	-21.2%
20	14546	10878	-3667	-25.2%
21	1419	1094	-325	-22.9%
			Average	-11.2%
			Wgt Ave	-6.43%

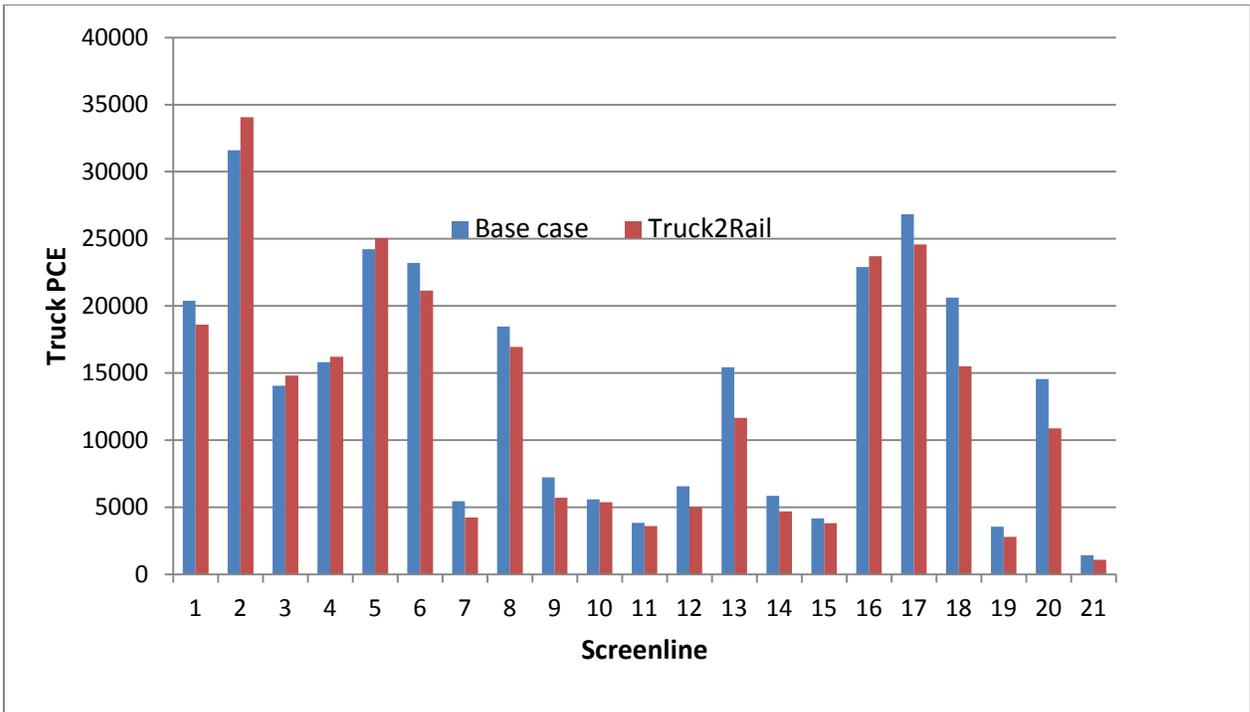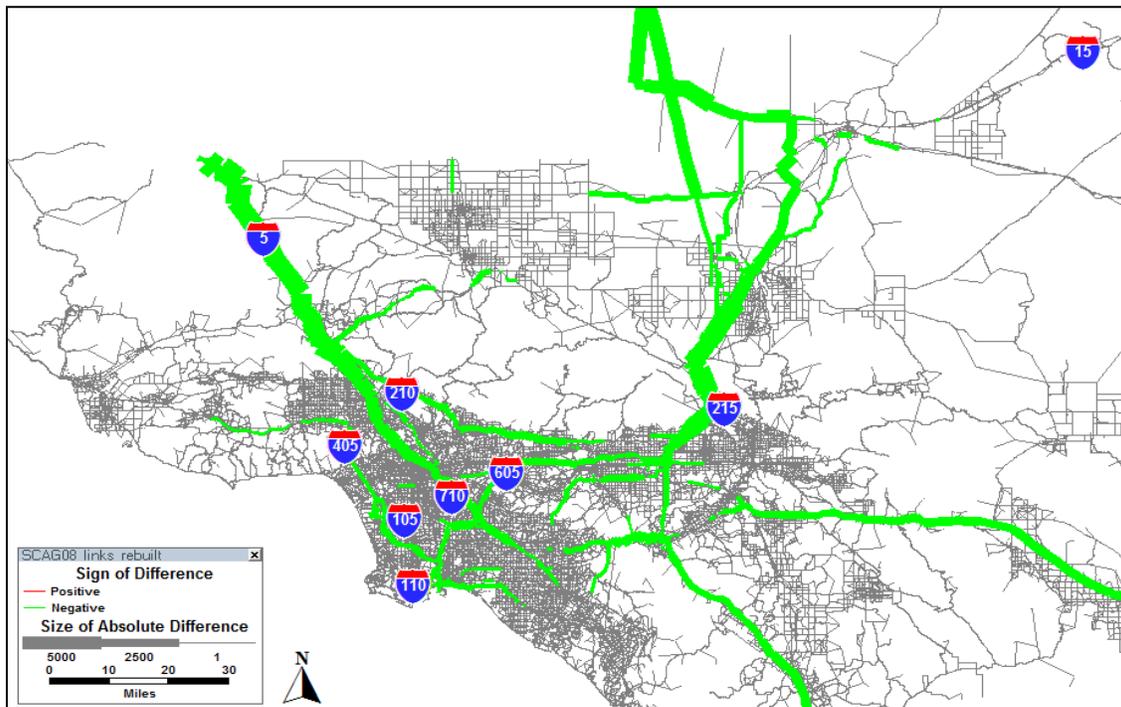Figure 4-2: Scenario 2 Screenline Results Chart

Figure 4-3: Scenario 2 Change in Truck PCEs, AM Peak

4.1.3 Scenario 3: Peak Pricing at the Ports

The region's ports have been very innovative in seeking ways to reduce port-related truck traffic. From around 2004, the ports faced strong political pressure to address the growing congestion and pollution problems associated with growing trade. In 2005 the ports implemented PierPass, which charged a fee of $40 per TEU (twenty foot equivalent unit) for containers entering the ports during daytime hours. The following year, the fee was raised to $50. The typical container is 2 TEUs, so the fee is about $100. This fee is charged to the beneficial cargo owner, not the trucker. Truck tolls have been discussed in other contexts, for example on truck only facilities, or on facilities where truck traffic constitutes a larger than average share of total traffic.

Scenario 3 estimates the impact of a toll of $45 per truck for all trucks entering the ports during the AM peak. We have no information on who owns the cargo, so we cannot simulate the PierPass program. We assume that the toll is imposed on the truck, and hence the truck (driver) chooses whether to make the trip during the peak or shift to another time period. We use parameters from existing studies for the truck travel demand function: value of time is $47/hour, price elasticity of demand is -0.84, and generalized running costs are $1.10 per truck mile (Zhou, 2010). We asssume a "before tolls" average speed of 31.1 mph, which is based on the SCAG regional model data (SCAG, 2007). Our starting point is the unpriced demand estimated in the baseline, and we assume no change in the level of trade activities.

This scenario is modeled outside the Argo workflow; we take the initial truck demand as given from the baseline O-D matrix. We identity the truck flows to and from the ports, and then estimate a truck demand model based on the parameters described above. We then adjust the baseline O-D matrix to reflect the change in truck trips to/from the ports and proceed to a new network multi-user equilibrium assignment, combining the new truck PCE O-D matrix with the baseline passenger O-D matrix. . Based on Salas et al (2008), We use the following formula to calculate the truck demand reduction where there is a toll:

$$\Delta PCE = T_{it} * \tau / GC_i * \varepsilon , \qquad\qquad (1)$$
where
T_{it} is the truck flows between TAZ i and the port,
τ is the toll charged on the truck, which is also the assumed change in generalized cost before and after the tolling,
GC_i is the overall generalized cost per truck from TAZ i to the port before the tolling,
ε is the toll-price elasticity for trucks, in our case it is -0.84.
GC_i is calculated as:

$$GC_i = TT_i * VOT + RC * D_i, \qquad\qquad (2)$$
where
TT_i is the average travel time between TAZ i and the port before the tolling,
VOT is average value of time for trucks,

RC is the average running cost per truck per mile,
D_i is the distance in miles from TAZ i to the port.

Summary results are given in Table 4.5. it can be seen that pricing has less impact on the region than one might expect. This is due to the small share of port entry trips in the total trip matrix – about 3%. The screenline results show that the change is concentrated around the ports (screenlines 2 and 3), as would be expected. If we look at the port entries, we find that AM peak truck entries decline by about 50%. Thus the effects in the immediate vicinity of the ports is quite large. Figure 4.4 shows changes in flows on the network around the ports.

Table 4-5: Scenario 3 Summary Results, AM Peak

	Truck trips	Truck VMT	Truck VHT
Baseline	46,038	6,754,713	124,878
Truck toll	44,212	6,652,567	123,119
Difference	3.97%	1.51%	1.41%

Table 4-6: Scenario 3 Screenline Results

Screenline	Base Case	Port Pricing	Difference	% Difference
1	20,379	19,856	-523	-2.57%
2	31,592	29,670	-1,922	-6.08%
3	14,048	13,536	-512	-3.64%
4	15,819	15,453	-366	-2.31%
5	24,230	23,382	-848	-3.50%
6	23,208	23,354	146	0.63%
7	5,455	5,338	-117	-2.14%
8	18,464	17,981	-483	-2.62%
9	7,215	7,077	-138	-1.92%
10	5,591	5,453	-138	-2.47%
11	3,844	3,746	-98	-2.55%
12	6,567	6,436	-131	-1.99%
13	15,422	15,059	-363	-2.35%
14	5,863	5,747	-116	-1.97%
15	4,161	4,076	-85	-2.03%
16	22,900	22,320	-580	-2.53%
17	26,824	26,592	-232	-0.87%
18	20,616	20,268	-347	-1.68%
19	3,541	3,502	-39	-1.10%
20	14,546	14,391	-154	-1.06%
21	1,419	1,390	-28	-2.00%
			Average	-3.76%
			Wgt Ave	-7.14%

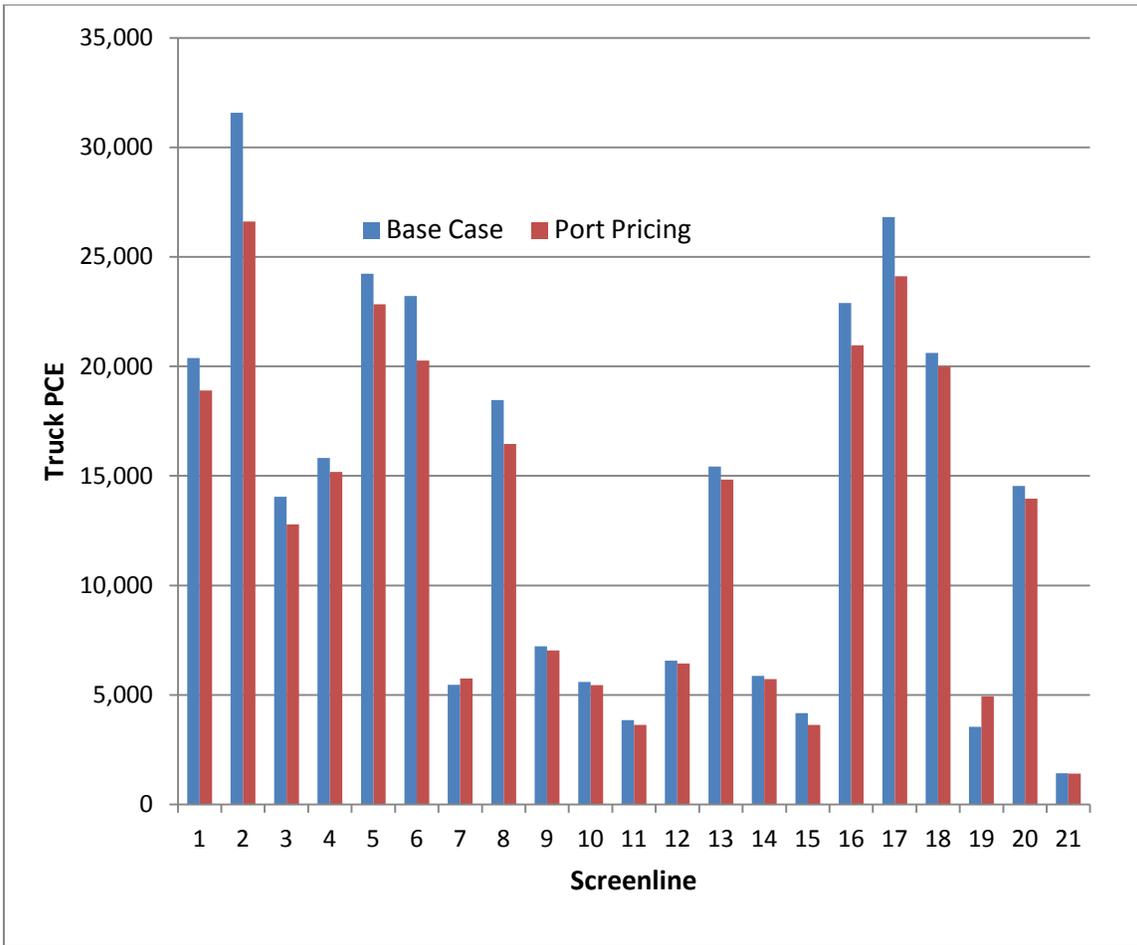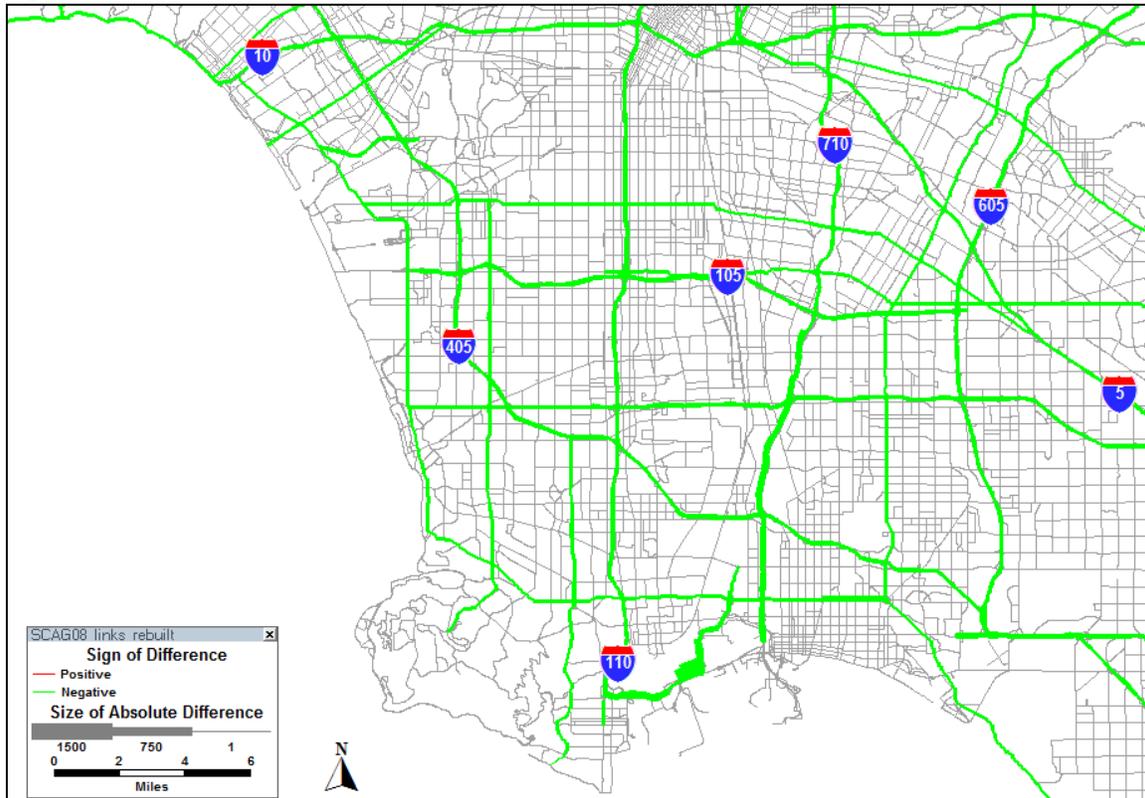Figure 4-4: Scenario 2 Screenline Results Chart

Figure 4-5: Scenario 3 Impacts on Network Around Ports

4.2 Conclusions on Scenarios

We have demonstrated that the Argos system can be used to conduct scenario analysis. Exogeneous economic changes as well as policy changes can be modeled. Results from the three scenarios are informative. A reduction in Los Angeles based international trade results in a modest reduction in truck traffic throughout the region. Had we taken into account the indirect impacts of trade losses, the reduction would have been larger. Shifting longer distance traffic from rail to truck has the largest impact on total truck VMT, because the longest trips are being removed from the network. Port entry pricing has a significant impact around the ports, but a modest impact on the region overall. These scenarios demonstrate the utility of having a relatively easy and quick method to test alternative policies or assumptions about regional economic activity.

4.3 User Interface

Use of Argos by practitioners requires a user friendly interface for manipulating the input data and generating new results. Therefore, we developed a web-based graphical user interface that allows a practioner to explore different scenarios. The interface allows the user to modify several parameters and run the Argos planner under those conditions automatically. The interface then presents the resulting attractions and

productions computed by the Argos workflow under the specified condtions. Specifically, we considered the following scenarios:

- o *Variation of import and export commodities*: The user can change the imports or exports of specific commodities or apply a global reduction or increase to the base import and exports. Figures 4.6 and 4.7 show screenshots of the Argos interface illustrating this scenario. Figure 4.6 shows the total dollar value of imports and exports by water (ports) and air (airports) by commodity sector in the LACMSA. The user chooses to apply a 25% reduction in imports and exports across the board, perhaps to model an economic recession. Ths is indicated in the interface by 0.75 factor over each of the data columns. Figure 4.7 shows the modified import (cropped in the image) and export input data, and the resulting attractions (not shown) and productions (labelled exports) in Passanger Car Equivalent (PCE) units calculated by the Argos workflow under these conditions, as well as the original unmodified values. For example, in TAZ 498 for SCTG commodity 1 the nominal (unmodified) total production was 6.2506 PCEs. However, under the scenario 25% reduction of imports and exports into the region, the resulting production in TAZ 498 for SCTG commodity 1 would be 5.7988 PCEs. Note that the user could have chosen to the import or export values of different commodities by simply editing the desired cells in the interface.
- o *Transportation mode shifts*: The user can also specify changes in the mode used to transport specific commodoties. Figures 4.8 and 4.9 show screenshots of the Argos interface illustrating this scenario. Figure 4.8 shows a shift from of 25% of truck traffic to rail. The user indicates this by inputting the 0.75 factor in the truck column in the domestic inbound and outbound tables, and the formulas '(+ TRUCK_INBOUND * 25)' and '(+ TRUCK_OUTBOUND * 25)' in the corresponding rail columns. Figure 4.9 shows the modified domestic inbound (cropped in the image) and outbound input data, and the resulting productions and attractions (not shown) in Passanger Car Equivalent (PCE) units calculated by the Argos workflow under these conditions, as well as the original unmodified values. The resutls are shown in this case ordered by the largest difference between nominal and scenario values. For example, in TAZ 3196 for SCTG commodity 8 the nominal (unmodified) total production was 114325.2 PCEs. However, under the scenario of 25% transfer from truck to rail, the resulting production would be 85775.3 PCEs. Note that the user could have chosen different mode shifts for different commodities on inbound or outbound flows.

Figure 4-6: Argos scenario interface screenshot for the import/export variation scenario, initial modification.

Figure 4-7: Argos scenario interface screenshot for import/export variation scenario, results.

PRODUCT_SCTG_1_2002	AIR_EXPORTS	WATER_EXPORTS	RAIL_EXPORTS	TRUCK_EXPORTS	Total	Modification
9	2390.25	16862.2!	0	0	19252.5	
Total	18574.5	95232.7!	0	0	113807.2	

apply modifications · reset · save

select PRODUCT_SCTG_1_2002, AIR_EXPORTS * 0.75 as AIR_EXPORTS,WATER_EXPORTS * 0.75 as WATER_EXPORTS,RAIL_EXPORTS,TRUCK_EXPORTS from argos2_sources.DATA_REL_EXPORTS_LACMSA_2007 [show modification points]

PRODUCT_SCTG_1_2002	AIR_EXPORTS	WATER_EXPORTS	RAIL_EXPORTS	TRUCK_EXPORTS	Total	Modification
Modification						
1	52.5	739.5	0	0	792	
2	151.5	1955.25	0	0	2106.75	
3	0	84.75	0	0	84.75	
4	99	1341	0	0	1440	
5	438.75	1443	0	0	1881.75	
6	1166.25	8149.5	0	0	9315.75	
7	9204.75	15201	0	0	24405.7!	
8	10555.5	4203	0	0	14758.5	
9	16650.7!	17766	0	0	34416.7!	
Total	38319	50883	0	0	89202	

apply modifications · reset · save

Ran Argos, comparing with nominal results below

Results:

taz	sctg	nominal_Exports	altered_Exports
498	1	6.2596	5.7988
2556	1	2.3726	2.198
900	1	252.431:	235.770<
1138	1	8.582	7.952
1973	1	92.3546	92.2808
498	2	5.5537	4.2481
2556	2	2.1044	1.6097
900	2	203.036:	155.830(
1138	2	7.595	5.81
1973	2	8.7107	8.5016
498	3	1.9125	1.9125
2556	3	0.725	0.725
900	3	80.325	80.325
1138	3	2.625	2.625
1973	3	39.4125	39.4125

Figure 4-8: Argos scenario interface screenshot for transportation mode shift scenario, initial modification.

Argos Scenario Interface

domestic outbound ⬍ apply help

Click 'apply modifications' to make the modification

PRODUCT_SCTG_1_2002	AIR_INBOUND	WATER_INBOUND	RAIL_INBOUND	TRUCK_INBOUND	Total	Modification
Modification			+ (TRUCK_INBOUND * 0.25)	* 0.75		
1	381	232	2568	7064	10245	
2	40	11	114	16737	16902	
3	21	24	370	3666	4081	
4	157	23	892	44388	45460	
5	682	871	2934	36678	41165	
6	383	285	1245	49621	51534	
7	3640	418	4774	72199	81031	
8	10715	596	7226	106414	124951	
9	2302	348	2385	69403	74438	
Total	18321	2808	22508	406170	449807	

show modification points apply modifications reset save

Click 'apply modifications' to make the modification

PRODUCT_SCTG_1_2002	AIR_OUTBOUND	WATER_OUTBOUND	RAIL_OUTBOUND	TRUCK_OUTBOUND	Total	Modification
Modification			+ (TRUCK_OUTBOUND * 0.25)	* 0.75		
1	292	509	197	24453	25451	
2	25	21	447	36066	36559	
3	125	23	67	2395	2610	
4	601	3347	1217	74242	79407	
5	1193	294	736	39572	41795	
6	1004	165	470	74793	76432	
7	1180	376	589	124108	126253	
8	2707	395	758	348093	351953	
9	970	393	350	167858	169571	
Total	8097	5523	4831	891580	910031	

show modification points apply modifications reset save

Examples

Figure 4-9: Argos scenario interface screenshot for transportation mode shift scenario, results.

5. Conclusions

In this Chapter we discuss the performance of the Argos system and its potential utility for planning practice. The utility of the Argos system for planning practice depends on the following factors: 1) model performance, 2) ease of updating, 3) utility for planning applications, and 4) transferability.

5.1 Model performance

We tested model performance by first replicating our earlier results using 2001 data and then updating to 2007 and comparing with actual ground count data. Replicating the earlier results proved to be quite challenging. Likely causes include turnover within the research team between the two projects, and inadequate documentation of data processing and data preparation. The entire workflow was checked and rebuilt, and the entire process of generating the input data was performed multiple times. Our extensive checking revealed only one error in the original workflow, but this was not sufficient to explain differences in results.

Model performance with the 2007 data was not as good as our results from the previous project, as measured against screenline data. In our earlier research we were able to compare results both with screenline data and with SCAG regional model results. SCAG has not yet released validated results for their 2007 screenline, so we could only compare with the screenline data. The 2007 results could be the result of many factors, including the accuracy and reliability of the 2007 data, changes made within Argos planner, changes in the network, etc. Although the research team conducted many checks of the data and the workflow, we could not identify a specific reason for the difference in the robustness of the results.

In rebuilding the Argos workflow we sought to make improvements to make the flow both more efficient and more extensive. One change was to incorporate the entire conversion from dollar flows to PCEs within the workflow (recall this conversion starts with annual dollars, accounts for dollars/ton ratios by industry sector, calculates truck trips by tonnage, and converts truck trips to PCEs). This extends the workflow, but also reduces options for external consistency checks (the only external checks are from the IMPLAN totals in dollars), and does not allow the user to make adjustments to this conversion process. A future improvement would be to allow options for the conversion.

5.2 Ease of updating

We tested ease of updating by collecting new data for 2007 and performing all the processing steps to generate the Argos input data. There were mostly minor changes in the structure of each data source, hence few changes were required in the workflow. The availability of our industry sector conversion web service facilitated all the required industry sector conversions. Changes in the data allowed us to eliminate one data

source – for air cargo – because WISERTrade added air and port data. Data changes may affect model results. For example, the 2007 CFS is a smaller sample than 2001, and thus may be less reliable at the sub-county level.

Preparing the intraregional data is straightforward. Preparing the interregional data is complicated and proved to be quite time consuming, because none of the data sources directly provide the various flows required by Argos. Interregional data preparation also requires expertise with input/output modeling and with regional trade data. This could prove challenging for transportation planning practitioners.

Manual computation is also required to prepare the workflow output for TransCAD input. In this case, programs for the various steps have been developed (see Chapter 2), and the process is relatively easy.

5.3 Utility for Planning Applications

Conventional regional transportation planning models require extensive data and calibration. The Argos system is intended to allow testing of alternative scenarios with relatively little effort. To demonstrate the sketch planning capabilities of the Argos system, we developed and tested three scenarios. The first scenario is an example of an exogenous economic shock, in this case the reduction in international trade that took place from 2007 to 2009. The second and third scenarios provide examples of policy alternatives: shifting a large portion of long distance trucking to rail, and imposing a toll on trucks arriving at the ports during peak hours. The first two scenarios could be implemented with some simple changes to the Argos workflow data. The third required some additional analysis outside Argos: estimation of a travel time/route choice model for the affected truck trips. Together these scenarios demonstrated the broad applicability of Argos to sketch planning and alternatives analysis. Many other scenarios could be imagined: growth or decline of an industry sector, shift in the location of major freight trip generators, peak truck pricing on all interstate highways, capacity expansions within major freight corridors, etc.

Because the Argos workflow is automated, processing any given scenario takes only seconds of computation time. If the scenario does not require a major change in input data, scenario preparation time is also minimal. Running the scenario through TransCAD requires far more time. One run takes several hours on a desktop PC, due to the size of the regional network and the use of multi-user assignment to differentiate truck and passenger trips.

Overall the Argos system proved to be a very good tool for sketch planning. A broad array of scenarios can be generated simply from manipulation of the workflow input data. Other scenarios can be handled by a combination of computations from outside the system and running the workflow and TransCAD.

5.4 Transferability

The Argos system was intended to be transferable across both time and space. We demonstrated transferability across time by updating the entire model to 2007. Transferability across space (eg to other metro areas) is beyond the scope of this project, but a logical next step in model development.

5.5 Argos as Tool for Practitioners

The goal of this research was to create a tool for practitioners that would be easier to update and apply than the current state of practice. The goal has been partially met. The Argos system offers a more efficient and lower cost way to estimate freight flows at the metropolitan level. We have demonstrated that Argos can be linked with TransCAD, allowing the Argos workflow to be used with conventional transportation planning software. We have also demonstrated that the Argos system is easily updated and can be applied to many different scenarios.

On the other hand, the method for generating freight supply and demand is highly complex, and from the perspective of professional planners and modelers is a black box. We noted earlier that the Argos method requires significant expertise beyond transportation planning. Users must have expert knowledge of input/output models and of regional trade dynamics and data. Typically professional planners do not have this expertise. Thus widespread use of Argos would require additional training for professional staff and consulting resources to support staff.

The research team worked closely with SCAG modeling staff throughout Task 2. SCAG staff provided much of the 2007 data, as well as assistance with setting up our TrasnCAD data files. We developed our 2007 baseline with advice from SCAG. Like many other regional planning agencies, SCAG relies on consultants for most of their modeling needs. The SCAG planning staff are experts on the regional and data sources, but only a few staff are experienced in urban modeling. SCAG staff were interested in the Argos system, but found it difficult to understand. The Argos approach is quite different from current practice (an approximation of the 4-step model applied to freight), and SCAG staff did not have training in regional economics or input/output modeling. Our experience with SCAG suggests that significant training and consultant resoruces would be required to use Argos without assistance from the university research team.

References

Ambite, Jose Luis, and Dipsy Kapoor. 2007a. Automatically Composing Data Processing Workflows with Relational Descriptions and Shim Services. Paper read at Proceedings of the 6th International Semantic Web Conference (ISWC-2007), at Busan, Korea.

Ambite, José Luis, and Dipsy Kapoor. 2007b. Automatic Generation of Data Processing Workflows for Transportation Modeling. Paper read at Proceedings of the 8th Annual National Conference on Digital Government Research (dg.o2007), at Philadelphia, PA.

Caliper, 2005. *Travel demand modeling with TransCAD 4.8*. Newton, MA: Calipe Corperation.

Caliper, 2006. *User's Guide: TransCAD Transportation GIS Software*. Newton, MA: Caliper Corporation.

Giuliano, G., P. Gordon, Q. Pan, J. Park, and L.Wang. 2008. Estimating Freight Flows for Metropolitan Area Highway Networks Using Secondary Data Sources. *Networks and Spatial Economics*. Online first no. 10.1007/s11067-007-9024-9

Gordon , P. and Q. Pan 2001 *Assembling and Processing Freight Shipment Data: Developing a GIS Based Origin-Destination Matrix for Southern California Freight Flows.* Final Report 99-25. Los Angeles, CA: METRANS Transportation Center. Available at www.metrans.org.

Holguin-Veras, J., G. List, A. Mayburg, K. Ozbay, R. Paaswell, H. Teng, S. Yahalom. *An Assessment of Methodological Alternatives for a Regional Freight Model in the NYMTC Region.* Available at http://www.utrc2.org/research/assets/6/regionalfreight2.html.

Holguin-Veras, J. and J. Zorilla 2006 A first approximation to longitudinal modeling of commercial vehicle empty trips, Transportation Research Board Annual Meeting paper 07-1659.

Meyer & Mohaddes Associates, VRPA Technologies, and WILTEC. 2004. Regional Screenline Traffic Count Program, Prepared for Southern California Association of Governments and Los Angeles County Metropolitan Transportation Authority. Los Angeles: Southern California Association of Governments and Los Angeles County Metropolitan Transportation Authority.

Pan, Qisheng. 2003. Non-Survey Regional Freight Modeling System, PhD Dissertation., The University of Southern California, Los Angeles.

Salas, R. M., Roubuste, A.F. and Sauri, M.S. 2008. Impacts of two-part pricing schemes on social welfare for congested metropolitan express networks. The 88th Transportation Research Board Meeting, Washington, D.C.: Transportation Research Board

SCAG. 2007. 2003 Model Validation and Summary: Regional Transportation Model (Draft). Los Angeles: SCAG

Southern California Association of Governments. 2003. Year 2000 Model Validation and Summary: Regional Transportation Model. Los Angeles, CA: Southern California Association of Governments.

Southworth, F. 2011 Modeling freight flows, Chapter 14 in L. Hoel, G. Giuliano, M. Meyer, eds., *Intermodal Transportation: Moving Freight in a Global Economy.* Washington DC: Eno Foundation for Transportation

Taylor, I. J., Deelman, E. Gannon, D. B., Shields, M. 2006. *Worflows for e-Science: Scientific Workflows for Grids.* Springer-Verlag, New York,

Wesetjindawat, W., K. Sano, S. Matsumoto 2005, Commodity distribution model incorporating spatial interactions for urban freight movement, Transportation rEsearch Board Annual Meeting paper 06-1856.

Zhou, J. 2010. Congestion pricing with heterogeneous users and an unpriced temporal alternative. Ph.D. Dissertation. University of Southern California

Appendix A

ARGOS WORKFLOW