

# 1. INTRODUCTION

Origin-destination (O-D) trip tables play an important role in transportation planning and operations. This research effort is motivated by the need to obtain O-D trip information for an urban area. The role of O-D trip tables in reducing congestion problems and in other transportation management activities are addressed in this chapter. The research goal and overall organization of this research effort are also presented in this chapter.

## 1.1. Traffic Congestion Problem

Advanced transportation systems are a key characteristic of modern-day society. It affects the lifestyle of individuals, the structure of the society, and gives people convenience and freedom. However, it also poses a problem of frustrating congestion and delays, especially in most metropolitan areas, where traffic demand is steadily increasing and the transportation infrastructure, on the other hand, has been unable to expand at the same pace. These facts lead to the so-called *traffic congestion problem*.

Traffic congestion itself has directly cost millions of dollars of wasted fuel and millions of hours of delayed man-power, and has also resulted in increased accidents, which in turn increase congestion, and aggravate the problem of environmental pollution. This problem costs heavily and deserves serious attention. The magnitude and seriousness of traffic congestion problems have been noticed by authorities, society, as well as different research agencies. Some assessment studies on this problem have been conducted by many transportation professionals. In the “2020 Transportation Program” issued by the Advisory Committee on Highway Policies, congestion is identified as the major concern of urban

transportation users. The “Statement of the National Transportation Policy” issued by USDOT (U.S. Department of Transportation) underscores the need to “maintain and expand the nation’s transportation system”, with particular commitment “to reducing congestion in the aviation and highway systems” (USDOT, 1990).

## **1.2. Need for O-D Trip Tables**

In order to reduce traffic congestion, several potential solutions are being investigated, and a great deal of effort is being put into practice, from transportation planning to transportation management. Some proposed solutions include: demand restriction policies (such as increasing taxes and other expenses of transportation, ramp metering); increasing transportation supply; improving transportation system management strategies (signal control, real-time diversion planning, etc.), and more recently, the development of IVHS (Intelligent Vehicle/Highway Systems). Notice that most transportation problems are very complicated and cost heavily in practice. Also, some chain reactions may be associated with these problems. For example, increasing supply could attract more users and in turn increase the demand, resulting in enhanced congestion problems! In addition, there are many social problems combined with transportation planning, operation and management. A careful investigation on the effect of relevant demand and supply is necessary before any decision is implemented.

Demand and supply information in transportation planning is usually described by a trip distribution table (in short, trip table or trip matrix). This table estimates the trips between zones of an urban area, between major activity centers and zones or between entrances and exits of a highway facility (e.g., a freeway). It is a basic element of short-range and long-range transportation planning. There are two types of trip tables: P-A (Production-Attraction) trip tables and O-D (Origin-Destination) trip tables. Mathematically, these two kinds of trip tables differ mainly in that a P-A trip table has no directional meaning and its cell elements represent trip interchanges,

whereas an O-D trip table has directional meaning and its cell elements represent trip flows. In practice, a P-A trip table automatically satisfies the flow conservation law and can be converted into an O-D trip table (Easa, 1993a).

Traditional O-D distribution matrices are mainly used in traffic assignment procedures, where a set of present or future trip interchanges (O-D demands) are allocated to a specified transportation network. In the last few years, many transportation engineers and other scientists have turned to Intelligent Transportation Systems (ITS), which include Advanced Traffic Management Systems (ATMS), Advanced Driver Information Systems (ADIS), Freight and Fleet Control Operations, and Automated Vehicle Control Systems (AVCS) (USDOT, 1989). From the point of view of control theory, an ITS consists of a traffic network on which planning and regulation layer controls are applied (Varaiya, 1993). It is believed that some accurate and quick-response O-D distribution trip table generation techniques are needed, and would be very useful in the planning, maintenance and operation of ITS.

### **1.3. Research Goal and Outline of the Thesis**

An O-D trip table is a two dimensional matrix in which the rows and columns represent the origin and destination zones, respectively, and its cell values indicate the number of trips made from origin zones to destination zones in a given period of time. Conventionally, O-D trip tables were obtained through various kinds of surveys. Some cheaper and quick-response theory and models for synthesizing trip tables from conveniently available information have been developed since the 1970s. The goal of this research is to develop a linear programming-based approach for solving the problem of estimating a trip table using traffic counts on links. As discussed in the literature review, some similar topics have been previously studied. The difference between the approach provided here with others is mainly based on the fact that the model given in this research places more

emphasis on the nature of uncertainty in the data and in the problem. Furthermore, for the purpose of real-time application, the algorithmic procedure is more tuned toward quick execution time and user-friendly interactions.

The thesis is organized as follows. A literature review is provided in the next chapter, beginning with a discussion of general historical developments on this subject, and focusing on equilibrium-based models and linear programming models, on which this research is based.

Basic concepts and notation used in this thesis are introduced in Chapter 3, and a modified version of the “user equilibrium principle” is introduced therein. Based on the fact that observed link information may contain some uncertainties, a confidence interval is allowed for the flow to accommodate possible deviations, and penalized artificial variables are used for flows that might violate this confidence interval constraint within a linear programming model. The model is also extended to the case wherein prior trip information might be available to guide the solution. Two different versions of this model, one that is modified from the LP(TT) model in (Sherali *et al.* 1994a) and another that is motivated from the idea used in LINKOD (Gur 1980), are provided for handling this case. Two other problems occur in practice: the problem of missing observed volumes on some links, and the problem of the model system not having reached a representative optimum. The first problem is treated by a preprocessing routine in this model, to obviate extensive computational effort as incurred by other kinds of treatments. The second problem is handled by a post-processing routine, emphasizing the fact that the system may not have been “optimized”, and that a modification in the solution might be necessary. This is particularly relevant to avoid the sparse characteristics of an extreme point optimum as produced by the linear programming model. Related research is discussed and reviewed.

Chapter 4 focuses on how to implement the model developed in practice, and on some advanced algorithmic issues. Note that the artificial variables used in the

model give a convenient starting feasible solution for this kind of a linear programming model. Unfortunately, this kind of a starting point is not efficient and effective for solving large sized problems, since it is computationally expensive. Advanced-start routines via a modification of Dial's method for generating explicit prior paths are used in this particular case. It is also noticed that a standard simplex method application is not suitable for this kind of a problem because of limitations in computer memory. Hence, a modified column generation method will be developed.

Chapter 5 considers suitable computer coding techniques for the proposed algorithm. Instead of using traditional *structured programming languages* such as FORTRAN, C, and Basic, an *Object-Oriented Programming* (OOP) language is employed for its efficiency with regard to both the computing speed and the usage of computing memory.

Chapter 6 presents some test results on the related LP models. Although these results were not obtained by directly applying the models developed in this research, it is expected that the test results for the proposed model would fall in the same category as LP model used in the computations. The final chapter summarizes the results and suggests topics for further research.