Analysis of Light Rail Access to Airports for the Effective Ground Transportation

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ABSTRACT

This paper discusses the attractiveness the cost-effectiveness of the light rail service connecting the airport and the main destinations in a city compared with other modes of ground transportation. A mathematical model is developed and the optimal frequency of light rail service is decided based on the minimization of the total cost including waiting time cost of travelers at the airport and operating cost of the light rail. Sensitivity analysis is made to show the effect of such parameters as passenger flow, unit time cost, operating time cost and etc. on the optimal frequency of the light rail service to provide the convenient, cost-effectiveness, and advanced accessible ground transportation service at the airport.

Keywords: Cost-Effectiveness, Frequency, Light Rail Service, Operating Cost, Waiting Time Cost

INTRODUCTION

When passengers travel to a city by air, their main destinations are characterized by the main business of the city, which makes the passenger flow possibly heavy enough for rail service between airports and main destinations. For example, Casino is the main destination for most travelers to Las Vegas; Disney world, universal studio, sea world and so on are the main destinations for most travelers to Orlando. Furthermore, most business and professional conferences are held in the hotels near these main destinations in a city which provides resort convenience for business travelers. It is necessary to enhance the visitor experience by moving tourists, business travelers and even transferring air travelers more conveniently.

Travel time, ticket cost, convenience, and waiting time cost are the key factors to be considered by the travelers on the ground transportation. In the light rail service, ticket fares are the same as bus fares, which is much cheaper than that of the rental cars and taxi. Waiting time cost for travelers is determined by the operating frequency of the transportation mode, which is closely related to the headway. For example, if there are four buses per hour in operation (frequency), then the operating headway of buses is fifteen minutes. We assume passengers’ waiting time is half of the headway (Chien & Qin, 2004). Obviously low headway will create high convenience and low waiting time cost. However, the low headway and high

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frequency will lead to high operating cost. To achieve the cost-effectiveness of light rail service, we need to decide the optimal frequency of rail service.

We find that the optimal headway is increasing in the distance between the airport and the destinations and unit operating cost; and decreasing in the operating speed, the passenger flow and the unit passenger time cost. The results from the sensitivity analysis are in accordance with those from the mathematical models.

There are four major sections in this paper. A literature survey is made in the section “literature”. A mathematical model is formulated in the section “model formulation”, which considers the optimal frequency based on the minimization of the total cost. Sensitivity analysis, outlining the effects of the parameters in the model on the decision is also presented in this section. Conclusions are made in the last section.

LITERATURE

In the previous research, one stream focuses on the bus transit. Brouwer (1983) and Wirasinghe and Ghoneim (1981) optimized the locations of bus stops considering the costs incurred not only by bus passengers and transit suppliers, but also by other road users, local residents, and businesses. In our study, due to the exclusive right of way for the light rail service and then no competition with other transportation modes, it is not necessary to consider the cost of other users. Fitzpatrick, Perkinson, and Hall (1997) developed guidelines for allocating bus stops considering bus patron’s convenience, safety, and access time, as well as the efficiency of transit operations. Based on given traveler preferences and budget constraints from the transit provider, Van Nes and Bovy (2000) developed an analytical model for optimizing stop spacing and line spacing, while performance characteristics (i.e., travel time, operator costs, and patronage) were analyzed. They studied the effects of space including stops and line on the operating cost, waiting time and access time costs while our paper will consider the effects of headway on those costs. Some researchers also considered the distribution of passenger flow when developed the mathematical models of the total costs (Holroyd, 1967; Gerrard et al., 1975; Bramel & Simchi-Levi, 1996; Chien & Schonfeld, 1997). Byrne and Vuchic (1971) optimize the bus route spacing, stop spacing and headways to minimize the total cost. All of these papers show the analysis in the bus system and little study focuses on light rail. From this viewpoint, our paper contributes to the literature in this field. Another stream in the literature is related to intermodal transportation in rail (Tsamboulas & Kapros, 2000; Harrington & Parolin, 1991). Qin and Du (1998) investigated the headway of the high speed trains along with the highway for short distance and air for long distance. Li and Tayur (2005) analyzed the effect of pricing on the intermodal transportation. Our study contributes to the rail-air intermodal transportation.

Most of the aforementioned studies considered additive time cost while optimizing their objective functions while Chien et al. (2002) and Chien and Qin (2004) did non-additive time costs. In our study, we use the additive time cost to formulate the model.

MODEL FORMULATION

Travel time, ticket cost, convenience, and waiting time cost are the key factors to be considered by the travelers on the ground transportation. In the current environment, when the city traffic becomes more and more congested, travel speed directly affecting travel time cannot be improved given the ground transportation network only consisting of buses, taxi and rental cars at the airport. Although taxi and rental cars can provide satisfactory convenience and short waiting time at the airport, ticket cost is kind of expensive for most travelers. Therefore, light rail service connecting airport with main destinations in a city has attracted considerable attention over the last few decades (López-Pita & Robusté, 2005; Lythgoe & Wardman,
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