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Evaluation of the Benefit-to-Cost of Freeway Service Patrol in Advanced Video Surveillance System Environment: A Case Study in China

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Abstract

With the growing traffic incidents led by the rapid increase of traffic volume on freeways, Chinese government is facing how to ensure the efficiency and safety of the freeway system. One of the hot debates is the efficiency of Freeway service patrols (FSPs) technology in the advanced video surveillance system environment, namely dense video-based surveillance system (DVBSS). To help making a correct decision, this paper develops an effective approach to assess the effectiveness of FSPs in the DVBSS environment. This paper proposes a simulation method to measure the B/C ratios of FSPs in advanced VSS environment. B/C ratios are evaluated under four scenarios namely basic scenario, FSP1, FSP2, and FSP3. All scenarios were simulated in the 9.4-kilometer segment and data were collected from the working log of traffic monitoring center. Among all scenarios, B/C ratio of FSP1 is lowest, sometimes less than 1, indicating that not all the FSPs scenarios are effective in the advanced VSS environment. However, the B/C ratios of FSP2 and FSP3 in mean cost scenarios exceed 1, represent as 4.33:1 and 3.47:1 respectively. It indicated that FSPs technology is still an effective way for traffic incident management in VSS environment. To explore the robustness of the results, authors extended the length of patrolling segment to 13.4 kilometers.

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1. Introduction

Over the last 20 years, the total length of freeways increased by more than 100 times, from 147 kilometers in 1988 to 96,200 kilometers in 2012. The freeway network system of China integrated national and provincial-level freeways currently formed the world's largest freeway system. Managing such huge freeway system is no doubt a big challenge for China. A major current focus in freeway operation is how to address the growing traffic incident led by the rapid increase of traffic volume. A typical intelligent transportation systems (ITS) adoption in China, especially in the well-developed eastern regions, is dense video-based surveillance system (DVBSS) which equipped with a multitude of video cameras.

The biggest difference between DVBSS and normal video surveillance systems (VSS) is the numbers of traffic cameras. DVBSS integrates different Closed-Circuit Television (CCTV) systems, which consists of a larger number of cameras connected to a set of monitors that help operators monitor freeway systems. Policymakers believed that with many traffic cameras, DVBSS could significantly improve the efficiency when identifying incidents. Many freeways operation divisions in different provinces of China have already adopted or possess such plans to build the DVBSS. Thus, DVBSS becomes one of the most striking characteristics of freeway traffic incident management in China.

In such circumstance, one of the most controversial technologies in Chinese freeways incident management is the Freeway service patrols (FSPs). Some researchers and policymakers recommend launching the FSPs programs which has been broadly proved to be efficient in U.S. programs. While, others hold the opposite point of view on the application of FSPs programs. They argued that the difference of freeway incident management system between the United States and China must be concerned. It is that China extensively uses the DVBSS in the freeway incident management. With the DVBSS, a larger number of cameras are set up over the road in an appropriate altitude to quickly detect and respond to the traffic incidents. They believed that the DVBSS have already significantly improved the incident clearance efficiency, thus it is not necessary to invest the additional funds for FSPs startup. In fact, the latter point of view is an international popular perception, and by default, researchers usually think that detecting incidents by patrolling is not necessary (Pal and Bose, 2009).

In order to make the appropriate decision, it is significant for governments and policymakers to clearly know the efficiency of FSPs program in traffic management systems which have already applied the DVBSS. Thus this paper used a quantitative method to evaluate the efficiency of FSPs considering the existing DVBSS functions. Authors try to answer the following questions, which mainly focus on the arguments above: whether the FSPs programs still benefit both the public and freeway operating company? What are the benefit-to-cost ratios (B/C ratio) of FSPs programs in the DVBSS environment?

Freeway service patrols (FSPs) are programs that use specially equipped vehicles to patrol congested or high-incident freeways for searching traffic incidents. By more accurate incident detecting and faster incident responding, FSPs can aid motorists and assist incident clearance quickly to reduce the incident duration. Based on the advantages of FSPs, service patrols have been widely operated in the U.S. in different forms. However, the discussions on the FSPs application never stopped, and the relevant critical issues of FSPs are broadly studied by engineers and researchers in past decades.

From the literature reviews, researches mainly focused on evaluating B/C ratio of FSPs programs, optimizing FSPs operation elements, and discussing the FSPs planning and institutional problems (Dickey and Santos, 2011; Baird and Jacobs, 2003). There exists an extensive literature on evaluating benefits of FSPs programs by using simulation evaluation method (Ma et al., 2009; Pal and Sinha, 2002; Ozbay and Bartin, 2003) or statistical analysis method by comparing the pre and post FSPs data (Skabardonis et al., 1998; Garib et al., 1997; Morales, 1997; Sullivan, 1997). The B/C ratios of different FSPs programs have significant differences and most B/C ratios of FSPs are more than 1.0 (Singh, 2006). The varying ratios can be attributed to the different analysis scope (i.e., individual freeway corridor, freeways network in jurisdiction area) or different regions and different operational variables (i.e., operation hours, FSPs function and fleet allocation). In FSPs operation practice, researchers mainly used simulation methods and operation research theory to optimize the chosen operation variables (Yin, 2006; Yin, 2008; Lou and Siriphong, 2011).

The issues discussed in this paper are different from the previous studies. Actually, the core argument is whether we use the specially equipped vehicles to patrol on the freeway, or just let them stay at fixed location waiting for the instruction from DVBSS center. In other words, considering the powerful function of dense video cameras, the efficiency of patrolling strategies should be carefully explored. Unlike previous studies which usually simulate

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