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Scanning secondary derived crashes from disabled and abandoned vehicle incidents on uninterrupted flow highways

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ABSTRACT

Introduction: Extent of secondary crashes derived from primary incidents involving abandoned and disabled vehicles are presented in this paper. *Method:* Using years 2004 to 2010 incident and crash data on selected Tennessee freeways, the study identified secondary crashes that resulted from disabled and abandoned vehicle primary incidents. The relationship between time and distance gaps before the secondary crash with respect to individual incident characteristics were evaluated through descriptive statistics and linear regression. *Results:* The time and distance gap analysis indicated that a large portion of secondary crashes occurred within 20 min after the primary incidents and within a distance of 0.5 miles upstream. While 76% of incidents involved shoulder, most secondary crashes were related to the closing of right lanes. Overall, 58% of the secondary crashes occurred within 30 min after the occurrence of the primary incidents. Most of the vehicles in the incidents that involved towing and caused secondary crashes were towed or removed out of the travel way within 60 min from the time of occurrence. The study found that most (95%) secondary crashes were property damage only (PDO), while 49% were rear-end crashes. The negative binomial model was used to evaluate the impact of roadway geometry and traffic factors associated with frequency of these secondary crashes. It was found that the posted speed limit, congested segments, segments with high percentages of trucks, and peak hour volumes increased the likelihood of secondary crash occurrence. Roadway segments with wider medians, shoulders, and multilanes decrease the likelihood of secondary crashes caused by abandoned and disabled vehicles as the primary incidents. *Practical applications*: The paper recommends that wider shoulders be provided on any section of freeway to accommodate abandoned or disabled vehicles to avoid blocking of travel lane(s).

1. Introduction

Secondary crashes are generally considered to be those occurring following incidents considered as primary. They usually occur as part of the incident chain or as part of the queue formed from the primary incident. Primary incident is defined here as any disruption of traffic flow caused by the presence of abandoned or disabled vehicles. This study investigates the occurrence of secondary crashes with respect to abandoned and disabled vehicle incidences; catalyzed by statistics experienced in Tennessee whereby for the past five years, incidents on Tennessee freeways have been dominated by disabled or abandoned vehicles. For instance, from 2005 to 2009, there were 108,911 incidents reported, in which 78,105 (72%) of them were due to disabled or abandoned vehicles. Additional analysis showed that disabled and abandoned vehicle incidents increased substantially from 2005 to 2010 at an average of 7% per year. Disabled vehicles are the combination or part of a motor vehicle, trailer, or semitrailer that is immobilized and incapable of moving under its own power due to several contributing factors such as being involved in an accident, mechanical breakdown, bad weather, or other emergency situations. Further, the definition of abandoned vehicle is more or less legal than operational as it depends on the time the vehicle remained illegally on the highway's right of way. This study utilized incidents caused by disabled and abandoned vehicles with the latter defined as shown in Table 1. This incident information is collected by Tennessee Department of Transportation (TDOT) Traffic Management Centers (TMC) from its four regional offices. The information reaches TMC from different sources such as observation by the TMC operator, TDOT official, Highway Emergency Local Patrol (HELP), law enforcement, and volunteer citizens. The specific duration for classifying abandoned and disabled vehicles may also vary by states, counties, or cities. The abandoned and disabled vehicle incidents can have significant impacts on traffic flow, safety, and economic loss among others. This study therefore evaluates secondary crashes occurring as a result of disabled or abandoned vehicle primary incidents. A detailed analysis of abandoned and disabled vehicle incidents and crashes derived from these incidents (which are termed as secondary crashes in this paper) was undertaken. Apart from detailed descriptive

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Table 1
Definition of abandoned vehicles in Tennessee and its major cities.

Jurisdiction	Abandoned vehicle definition
State of Tennessee (Tennessee Codes)	…is left unattended on public property for more than three (3) days
City of Memphis (City of Memphis Codes)	…any vehicle which is wrecked or partially dismantled or inoperable for a period often (10) days… if it has remained inoperable or partially dismantled or if the owner has relinquished dominion or control of such vehicle for ten days
Metropolitan Nashville (Nashville MPO Codes)	…that is left unattended on public property for more than ten days, or a motor vehicle that is in an obvious state of disrepair and is left unattended on public property for more than 3 days
City of Chattanooga (City of Chattanooga Codes)	…any vehicle or part thereof which is left unattended on public or private property for more than ten (10) days, or a vehicle that has remained illegally on public property for a period of more than forty-eight (48) hours, or a vehicle that has remained on private property without the consent of the owner or person in control of the property for more than forty-eight (48) hours
City of Knoxville (City of Knoxville Codes)	…any motor vehicle that has remained illegally on public property for a period of more than forty-eight (48) hours

statistics, the study performed inferential statistics and developed secondary crash model utilizing roadway geometry and traffic characteristics associated with these types of crashes. The developed crash models are expected to be used in unbiased estimate of the expected incident impacts on freeways and major arteries.

2. Literature

According to NTIMC (2004), abandoned vehicles may cause drivers not only to slow down but also to crane their necks to get a view of the spectacle, taking their eyes off the roadway ahead, thus creating a lot of issues with traffic flow and accidents. Abandoned vehicles, although not directly blocking the lanes, may cause confusion to drivers without knowing whether the vehicles on the shoulder are trying to enter the lane or not. A study by Maxfield (2008) on abandoned vehicles highlighted generalized factors to be considered in classifying a vehicle as abandoned. The study stated that the length of time, the appearance condition, missing or outdated license plates, and the location (parked on public streets or other public property) are significant factors to consider in classifying vehicle as abandoned. Smith, Jacobson, and Webb (2003) supported the above study in the research conducted in England on the impact of the end of life directive and new initiatives on likely future trends. It listed the cost of operating and disposing of vehicles, which include cost of repair and insurance, safety and emission compliance, and the declined value of scrap metal, and natural disasters. Other mentioned factors include auto theft, insurance fraud, long-term or unlimited parking in public facilities and auctions of low-value vehicles. In another study, Parham et al. (1999) found that nearly 80% of all the incidents in the state of Texas were attributed to disabled vehicles. The study further indicated that 80% of those disabled vehicles were on the shoulder for an average of 15 to 30 min, which caused approximately 100 to 200 vehicle-hours of delay during the peak periods. The remaining 20% of disabled vehicles on travel lanes caused an average of 15 to 30 min and 500 to 1000 vehicle-hours of delay during peak hours.

2.1. The association of abandoned vehicles with crash occurrences

About 20% of all crashes nationwide are secondary having been linked to the primary crash or other traffic related incidents (Tennessee DOT, 2003). Studies related to secondary crashes are very diverse (Agent & Pigman, 1990; FHWA, 2012; Metro Atlanta Traffic Incident Management Strategic Vision, 2006). The abandoned/disabled vehicle incidents have been associated with secondary and fatal crashes (Hu, Li, & Ming Liu, 2007). Abandoned or disabled vehicles parked on the shoulder can increase the probability of collision with moving vehicles especially if the parked vehicles are trucks of large sizes. According to NCHRP (2003), hazard or obstruction includes but is not limited to any vehicle that is parked such that any of its parts extend within the paved portion of the travel lane or highway shoulder or bicycle lane. Another study by Smith, Qin, and Venkatanarayayana (2003) estimated that an accident or disabled vehicle blocking one lane out of three lanes will reduce traffic flow by an average of 50%, while an accident blocking two lanes out of three lanes will reduce traffic flow by an average of 79%. They also found that an accident or disabled vehicle blocking shoulder lane(s) for a three lane highway will reduce traffic flow by an average of 33%. In the state of Ohio, the disabled vehicles on the side of the road and debris were reported as one of the major safety concerns and contributing causes to traffic accidents (Ohio DOT, 2007). It was also reported that, from 2000 to 2005 a total of 3,652 crashes occurred on the Ohio interstate highway systems, which involved collisions with a stopped or parked vehicle in a travel lane or on the shoulder, while 726 crashes involved debris. Smith, Qin, and Venkatanarayayana (2003) reported that in the state of Virginia crash database, disabled vehicle accidents are by far the most frequent type of incident, accounting for 72.9% of all incidents in the database, which are also the primary cause for 8.2% of all accidents reported. The severity of secondary crashes is often greater than that of the original incident and the longer an incident is in place, the greater the probability for secondary crashes (FHWA, 2000). Analysis of data from several arteries and expressways in California in 1995 showed that secondary crashes represented 600% increase in collision risk and the likelihood of a secondary crash increased by 2.8% for every minute that the primary incident remained as a hazard (Lopez, 2008).

3. Study data and secondary crashes identification

A total of 172,645 incidents obtained from the Tennessee Department of Transportation (TDOT) covering two metropolitan counties were utilized in this study. TDOT Region III (covering Nashville Metropolitan Area and nearby counties) incident data were from 2004 to 2010 while incident data from TDOT Region I (covering the city of Knoxville and nearby counties) were from 2005 to 2009, Fig. 1. The study routes included I-40, I-440, I-65, I-24, Ellington Parkway, Briley Parkway, and Vietnam Veterans Parkway in Region III and I-640, I-40, I-140, I-275, I-75, SR 115 and SR 162 in Region I. In addition to the incident data, crash data used to extract secondary crashes were also gathered from TDOT and the Tennessee Department of Safety (TDOS). Apart from incident and crash data, roadway geometry and traffic conditions for each of the roadway segments were downloaded from the TDOT database.

3.1. Identification of secondary crashes

Identification or classification of an incident or crash as secondary is somehow complex. Meyer and Sun (2003) stated that "…accident records frequently have no place to indicate that an accident was a secondary accident except in a field for general comments. As a result, some records may show no indication that an accident was caused by backup from a previous accident rather than other cause." When identifying secondary crashes, it is desirable to measure queue lengths built from the primary incident. If queue lengths are not recorded, it becomes difficult to estimate traffic delays, and related queue dissipation times for potential primary incidents. Thus, researchers generally link secondary crashes to primary incidents according to some pre-defined spatial and temporal criteria. The rationale being that, a secondary crash mostly