Chapter 65
The Integrative Time–Dependent Modeling of the Reliability and Failure of the Causes of Drivers' Error Leading to Road Accidents

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ABSTRACT

Nowadays, the human error is usually identified as the conclusive cause of investigations in road accidents. The human although is the person in control of vehicle until the moment of crash but it has to be understood that the human is under continued impact by various factors including road environment, vehicle and human's state, abilities and conduct. The current advances in design of vehicle and roads have been intended to provide drivers with extra comfort with less physical and mental efforts, whereas the fatigue imposed on driver is just being transformed from over-load fatigue to under-load fatigue and boredom. A representational model to illustrate the relationships between design and condition of vehicle and road as well as driver's condition and state on fatigue and the human error leading to accidents has been developed. Thereafter, the stochastic mathematical models based on time-dependent failure rates were developed to make prediction on the road transportation reliability and failure probabilities due to each cause (vehicle, road environment, human due to fatigue, and human due to non fatigue factors). Furthermore, the supportive assessment methodology and models to assess and predict the failure rates of driver due to each category of causes were developed and proposed.

INTRODUCTION

The failures in transportation systems impact on the economy, environment and people's life (Dhillon, 2011). Around 0.8 million fatalities and 20–30 million injuries occur each year in the globe as the result of road accidents (Pearce & Maunder, 2000; Jacobs, Aeron-Thomas, & Astrop, 2000). A large number of people lose their lives worldwide annually due to road transportation and accidents (e.g., 42000 loss of life annually in highway accidents alone in USA; 22000 loss of life annually due to road accidents in Iran as a developing country with almost one fifth of US population; 40000 road fatalities and 1.7 million injuries within the European Union (EU-15) each year) (United States Department of Transportation (USDOT), 1999; Islamic Republic of Iran Police (IRI), 2011; European Commission (EC), 2003). The road accidents are the second most serious cause of fatalities and injuries for EU citizens and for Europeans under 45 years of age, the road accidents are the largest cause of death (Clarke, Ward, & Truman, 2002; European Commission (EC), 2006).

Based on various studies on road accidents in both developed and developing countries, the human error has been identified as the main cause of accidents in 65% to 90% of cases (Wierwille, Hanowski, Hankey, Kielisaewski, Lee, Medina, … Dingus, 2002; UK Drive and Survive, 2006; South African Press Association (SAPA), 2003; Zogby, Knipling, & Werner, 2000; Wegman, 2007). The human error research has rooted in such safety critical domains as aviation, nuclear, and patient safety (Jou, Yenn, Lin, Tsai, & Hsieh, 2011; Kontogiannis & Malakis, 2009; Shappell, Detwiler, Holcomb, Hackworth, Boquet, & Wiegmann, 2007; Taib, McIntosh, Caponecchia, & Baysari, 2011), rather little research has systematically investigated the factors contributing to driver error (Stanton & Salmon, 2009).

With the ongoing advancement in automation level of vehicles, the task under-load fatigue is taking larger and different stake of drivers' general fatigue level compared to older days where the fatigue mostly was in the form task overload fatigue. Besides human fatigue, three are three other main categories of accident causing factors in roads (i.e., road environment, vehicle, human due to non fatigue factors). There is no doubt that the driver's fatigue state has significant impact on the human error and consequently on the safety and reliability of transportation systems. In literature, the task load-related fatigue is broken down into task over-load fatigue and task under-load fatigue, the former deals with the problems when the task requirements exceeding the ability of the concerned individual, and the latter is concerned with repetitive performance, lack of intellectual input, lack of proper opportunities to use individual's acquired skills or prolonged static tasks (Seth, Weston, & Freivalds, 1999; Chaffin, Andersson, & Martin, 1999; International Standard Organization (ISO), 2000). The likelihood of life threatening accidents as the result of direct failure in physical components of vehicle and roads are becoming dimmer day by day due to tougher competitions and stricter regulations. Nevertheless, there are still some challenging issues in prevention of deadly accidents as the result of failure in the designed conditions of safe roads and vehicle components under severe environmental conditions.

Furthermore, the human as driver may endanger the safety of transportation system due to non-fatigue factors such as behavior, poor skill, ill health, inexperience, etc.

This paper incorporates the time-dependent failure rates for all vehicle, environment, human fatigue and human non-fatigue factors into the developed stochastic models to make predictions on the reliability and failure rates of road transportation systems at any given time. Thereafter, some additional models and methodology were developed and proposed to be used for analysis, assessment and prediction of the expected failure rates of road accidents due to each category of causes. The authors believe that this research is unique in

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