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On  
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## The relationship of crashes to driver hours of service

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### Summary

Understanding the relationship between truck driver hours of service and crashes is a complex and challenging task. Researchers working in this area come from backgrounds as diverse as human factors, psychology, medicine and road safety. Some of the research in this field has been described by the term “fatigue”, even though questions have been raised in the literature about the definition of the term fatigue itself (Haworth, et al., 1988). Others (e.g. Jovanis et al., 2012) have focused on studying the association of crashes to the duration of driving, use of rest breaks, schedule of driving over several days and time of day. All approaches contribute in different ways to our accumulation of knowledge about hours of service and crashes. This testimony is not an exhaustive review of this literature as there would likely be hundreds of citations. Rather this is an attempt to summarize the most recent work in the field, with a few additional references to well-cited research.

Concerning the effect of hours of service on crashes, I offer the following summary:

*Hours of continuous driving* – Using data supplied by carriers over a period of more than 20 years, there are a number of studies that support the basic principle that the longer one drives the greater the odds of a crash (e.g. Jovanis and Chang, 1989; Jovanis et al., 1991; Kaneko and Jovanis, 1992; Lin, et al., 1993; Lin et al., 1994; Jovanis et al., 2011; Jovanis, et al., 2012). These eight studies estimated the effect of driving time, *when controlling for other factors such as experience, off duty time, driving pattern over multiple days and, in one case, time of day directly*. These studies are among the few that control for multiple factors while seeking to estimate the effect of driving time. A study using fatal truck-involved crashes from 1980-2002 (Campbell and Hwang, 2005) also indicated an increase in crash risk with hours driven.

Using trucks instrumented with cameras and other vehicle-based sensors a series of studies have sought to connect risky driving maneuvers to hours of service. Using these measures, one study (Hanowski, et al., 2008) found little connection between the observed events and hours of service. A second study with more extensive data (Blanco, et al., 2011) did find an association of driving time with the occurrence of safety critical events (including a few crashes). This second study, like the first, also showed a close correlation with time on duty. Other studies using instrumented vehicles, physiological or other tests of fatigue for a limited number of drivers during regular work conditions have found little association of these metrics with hours driving (e.g. Wylie, et al., 1996).

In summary, based on a series of studies using carrier-supplied data and one with fatal truck crashes measured over 20 years, I believe there is evidence that crash risk increases as driving time increases.

*Hours off duty* – the increase in required off-duty time was implemented in 2003. Crash-based research using data from the 1980's (Lin et al., 1993) indicates that drivers with more than 9 hours off duty have a lower crash risk when returning to work than drivers with 8-9 hours off-duty. This is a case where the change in regulations (increasing off-duty time from 8 to 10 hours) is consistent with the research.

*Time of day* – the effects of time of day are particularly difficult to identify because trucks share the road with other traffic, which has marked peaks in urban areas during the morning and evening rush. In a study using crash data (Lin, et al., 1993), with a baseline of 10am to noon, crash risks were elevated in the early morning (4am to 6am) through to 10am; and then again elevated from 4 to 10pm. Another study (Campbell and Hwang, 2005) found an increase in the odds of a crash from 11pm through 6am. Using fatigue tests and instrumented vehicle data (Wylie, et al., 1996), others found strong association of declines in performance and fatigue tests linked to time of day. Fatigue (self rated) increased more during night than day shifts in a study in Australia (Williamson et al., 2004). Time of day is associated with crash risk; the question is how to address this in regulations.

*Rest breaks* - Breaks are included in the hours of service rules for the European Union, which require 45 minutes for each 4.5 hours of driving (Wikipedia, 20013). In 2013, the new US rule requires a 30-minute rest break after 8 hours driving. Lack of mandatory inclusion in the policy allowed researchers (Jovanis et al., 2012) to compare drivers with break and those without. The presence of two breaks reduced crash odds by 30% in a 2012 study (Jovanis, et al., 2011). The benefits of rest breaks seem overwhelming.

*Cumulative driving over several days* –the introduction of the 34-hour restart in 2003 has triggered a series of studies of the effect of cumulative driving both with and without a restart.

Two laboratory studies have been recently completed that focused on the 34-hour restart. In the first study (Van Dongen and Belenky, 2010) subjects were split into two groups: one group worked a daytime schedule for 5 days, was off duty for 34 hours, then worked 5 more days for 14 hours per day. The second group had a similar schedule except the participants worked at night for 5 days, had a 34-hour day-oriented break and then another 5 days of night work. The principal finding is that the day-oriented work group showed no decline in performance, while those with the night work showed a decline when they returned to work after the 34-hour “restart”. These studies were enhanced in a follow-up experiment in which participants were subjected to night work periods separated by a 58-hour “restart” aimed to emulate the effect of an additional day required from the 34-hour regulation. In this case drivers were compared against each other before the restart compared to after. This longer restart resulted in no performance degradation after return from the 58-hour off-duty period.

This concludes my oral testimony; I'll be happy to answer any questions you may have.

### **Brief summary of older research:**

Federal hours of service were largely unchanged from the 1940's until 2003. Since then, there have been a series of changes to those regulations including those implemented this year. Federally sponsored research underlying changes in the regulations were conducted in the U.S. in the early 1970's (Harris and Mackie, 1972; Mackie and Miller, 1978) and during a major field study conducted in the 1990's, the Driver Fatigue and Alertness Study, (Wylie, et al., 1996). At the same time, there was research underway outside of federal funding (Jovanis and Chang, 1989, Chang and Jovanis, 1990; Jovanis, et al., 1991; Kaneko and Jovanis, 1992; Lin et al., 1993, and 1994) seeking to associate crash occurrence with driving hours use carrier-supplied data.

### **Detailed Comments on recent studies:**

#### *Recent crash-based analyses:*

A study was recently completed using crash data from carriers during 2004-05 and 2010 (Jovanis et al., 2011). The study team used a methodology similar to one used in many previous papers (e.g. Kaneko and Jovanis, 1992), which compared crashes and non-crashes using a method called case-control analysis. Over 500 crashes and 1000 non-crashes were used in the study; all crashes were sufficiently severe to be reportable to FMCSA through state safety organizations (i.e. a person was killed or required medical attention or a vehicle had to be towed from the scene). Factors included in the modeling included driving time along with multiday driving (derived from driving schedules over a seven day period) to estimate crash risk. Central to the modeling is the notion of survival: a driver who has a crash in the 5<sup>th</sup> hour, for example, *survives*, that is successfully completes the first 4. The statistical modeling used by the team represents this survival process. Findings in the report and a recent paper based on the research (Jovanis et al., 2012) include an increase in crash risk after the 5<sup>th</sup> hour of driving and an increased risk when returning to work after extended (34 hours of more) off duty. This was not a test of the restart policy, but a test of crash risk immediately after return to work after extended time off. The risk was higher for drivers returning to a night shift compared to a day shift. Because the study was conducted before the currently required rest breaks the research was able to identify a reduction associated with short driving breaks from driving (typically 15 to 60 minutes) reduced crash risk by 20-50% depending on the number of breaks and type of operation.

A limitation of the study was that there were only 66 observations of the 1564 total (4%) that remained in the 11<sup>th</sup> hour. As a result of this data loss, the estimate of crash risk in the 11<sup>th</sup> hour is quite large. It is interesting to note how relatively few trucks in the study drove into the 11<sup>th</sup> hour. Considering non-crash data alone, 50 of 1022 (4.9%) of trucks utilized the 11<sup>th</sup> hour. Further, data were limited in most cases to 7 days prior to a crash, restricting the ability to assess the effect of the 34-hour restart.

#### *Recent naturalistic driving analyses:*

In the naturalistic method, a set of participants are observed while driving “naturally”; in this case during the conduct of their jobs. In addition to any crashes observed, near misses and crash-relevant conflicts (events where evasive maneuvers are needed to avoid a crash) are tracked to assess driving performance. The vehicles are instrumented with cameras, GPS and other sensors to measure vehicle motion. A recent study (Hanowski, et al., 2008) used naturalistic driving methods to measure truck critical event occurrence during vehicle movement. Naturalistic driving means the vehicle is instrumented with a set of cameras, radar, accelerometers, gyroscopes and GPS (among others), to watch and record how people drive. The critical events observed included crashes, near crashes (when extreme braking or driver reaction avoided a

collision) and crash-relevant conflicts (where an avoidance maneuver resulted in no collision). In this study, 710 of 819 events observed were crash-relevant conflicts so these events dominated all analyses. Recording of events began when vehicle motion started (speed greater than zero).

This study found little association of event risk and driving time, particularly between the 10<sup>th</sup> and 11<sup>th</sup> hour; rather a stronger association was found with hours worked. A follow-on study using a larger data set and more quantitative statistical methods (Blanco et al., 2011) found associations with driving time and hours worked. This second study also found positive safety aspects to rest breaks.

One potential difficulty of this use of naturalistic studies is that events occurring in the first hour may be occurring in the terminal or marshaling areas. This is not necessarily equivalent to occurring on the road and may effect the assessment of driving time effects. The analyses largely assessed one factor at a time; there was no combined assessment of driving time, cumulative driving and rest breaks as in the crash analyses. Further, the process represented by the models is different. When a crash occurs, the truck driver does not typically continue to drive. With the naturalistic approach, drivers involved in near crashes and crash-relevant conflicts continue to operate. It is not known if the occurrence of one of these non-crash events influences subsequent driver behavior, and thus subsequent risks associated with driving time and hours worked.

Lastly, there is a concern about the implied equivalence of crashes and the non-crash events. Research has shown (Wu and Jovanis, 2012; Wu and Jovanis 2013 a, b) that the definition of near crashes and crash-relevant conflicts depends details of the search algorithm used to identify the events. Depending on the method used, some non-crash events may differ from the crash events they are being compared to. This is a potential source of error in the hours of service data used in the naturalistic studies.

*Laboratory studies of the 34-hour restart:*

The summary of findings concerning the 34-hour restart referenced two recently conducted studies at Washington State University (Van Dongen and Belenky, 2010; Van Dongen et al.,

2010). In addition to the description of findings provided on Page 4 of this testimony, there are a few additional issues in need of discussion. One could raise a question about establishing a policy based primarily on laboratory studies of 39 individuals. However, the studies appear to have been carefully conducted and would, in my view pass scientific scrutiny. The positive results with the 58-hour recovery period lead to wonder if another off-duty period between 34 and 58 would be successful. Further, it would be interesting to test longer work and duty periods with more extended use of the restart, both to increase the sample size of participants and to see better understand the changes in performance that result.

**Concluding remarks:**

I hope the testimony provided additional understanding of this complex topic. I place greater weight on use of crashes as a performance measure for assessing hours of service effects, primarily because I have worked with these data for over 25 years. In addition, the engineering profession has focused on the use of crashes and their outcomes (fatalities, injuries and property damage) to assess safety; this applies in research (e.g. Hauer, undated) and in education programs (NCHRP 667, 2010). In my view other techniques offer important insights, but crash-based studies should be given priority consideration.

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