



Ergonomic Assessment:



Braking System for Road Safety

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BACKGROUND INFORMATION

Following a meeting with Mr Erland Olofsson on 9 January 2014, I was introduced to the ET Braking System for Road Safety and a follow up meeting was conducted with Mr Olofsson on 29 January 2014 and from these meetings, the following is an ergonomics evaluation of the system in question.

In addition to the meetings with Mr Olofsson, the in-depth discussions relating to the mechanism, its application, operational mechanics, design and technology and prior to conducting this ergonomic assessment I was able to complete the following tasks:

- (1) Supplied with a copy of the risk assessment completed on the ET Braking System by Ms Kerrie Sheaves from Tzara Enterprises dated 3 September 2013.
- (2) Completed a review of the risk assessment document with particular reference to page 23 titled Manual Tasks/Ergonomics Risks.
- (3) Conducted a teleconference with Ms Kerrie Sheaves on 28 January 2014 to review the risk assessment findings of the ET Braking System with a focus on page 23.
- (4) Identified and reviewed the ET Braking System website www.etbrakingsystem.com for all relevant information useful to this ergonomics report.
- (5) Identified, using appropriate search engines, relevant research information and in turn reviewed this information in line with some ergonomic parameters that had been set.
- (6) Witnessed the ET Braking system in action, this being a refit to a motor vehicle – Holden Commodore Station Wagon. Also witnessed its operation as a prototype on the road and the functional application of the ETBS.

ET BRAKING SYSTEM (ETBS)

Information from the ET Braking System website outlines that this system has been devised with the primary purpose of **“reducing the braking distance of a vehicle”**. This is achieved through the ET Braking System (ETBS) linking the braking operation to the top end of the accelerator pedal motion, with the remainder of the motion of the accelerator pedal operating in its usual manner. In layman terms this means using the accelerator as both (when the system is engaged) an accelerator and as a brake making the use of the brake potentially redundant.

The application of this concept is very broad and potentially could involve cars, trucks, emergency vehicles and buses by either completing a retrofit or as part of the original design and manufacture provided the vehicle has an automatic transmission. This application was supported by the research which is outlined as part of this report. A potential limitation to the device is the fact that it's application is not suitable to manually driven vehicles.

Potentially the benefits of this device include reducing the consequences of driver fatigue e.g. number of accidents, and decrease the stopping distance required as a result of an emergency braking situation. It is the clear expectation of the designer that this device will reduce both the number of accidents and the degree of injury severity sustained by crash victims.

In order for the system to work it needs to be engaged prior to starting the car and this engagement would be confirmed by a dashboard light illumination or similar. Driver can place his/her foot on the brake at any time to disengage the system and this returns the operation of the separate brake and accelerator pedals back to normal. That is one pedal to brake and the other to accelerate and decelerate. When the system is active the accelerator pedal has to be rapidly released to activate the emergency braking.

In an emergency braking situation such as heart attack or perhaps falling asleep from fatigue, the ETBS has been designed, using sensor to sense how fast the accelerator pedal is released and then applying up to 80% brake force in acceleration, neutral or braking zones. This allowing time for the driver to transfer his foot to the brake pedal to apply 100% braking.

Refer to Technical section of the website www.etbrakingsystem.com.au for further information and specifications.

RESULTS

The ETBS system has been tested with respect to its capability in “coast down testing” conducted by Human Impact Engineering Pty Ltd (HIE) with impressive results. For example when decelerating from 80km/hr, the ETBS equipped vehicle would reach 20km/hr 5.1 meters before the vehicle without ETBS.

The vehicle without the installed ETBS system was recorded travelling at 35.2 km/hr.

Refer to Testing section of the website www.etbrakingsystem.com.au for further information and specifications.

RISK ASSESSMENT FINDINGS – ERGONOMIC ISSUES

Following the review of the risk assessment conducted by Tzara Enterprises it was apparent from their investigation and the review completed by myself that there were a number of items that were identified as needing further ergonomic evaluation. These were defined as;

Repetition – defined as “using force repeatedly over a period of time to move or support an object” (Ref – National Code of Practice for the Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work. Australian Safety and Compensation Council Canberra 2007), or as a general guideline “a movement that is performed more than twice a minute” (Ref - National Code of Practice for the Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work. Australian Safety and Compensation Council Canberra 2007). Repetition is also defined as a hazardous manual task.

Sustained Postures – defined as “using the same body part/s to maintain a particular movement or body position” (Ref - National Code of Practice for the Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work. Australian Safety and Compensation Council Canberra 2007) or as a general guide a movement continued for more than 30 seconds at a time (Ref - National Code of Practice for the Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work. Australian Safety and Compensation Council Canberra 2007). Sustained posture is also defined as a hazardous manual task. Specifically we would look at the impact on the lower limb being by definition the knee joint down and encompassing the foot.

Fatigue – the effects of operating such a system if an individual became fatigued. Potentially we are looking at two different types of fatigue, physical fatigue which is well understood and well defined in the literature and mental fatigue which is less understood and not yet accurately measureable. One of the primary influencing variables being that of alcohol and the impact it has on an individual in terms of motor control and cognitive processes.

REPETITION

Under normal driving circumstances a person operating a standard set up in an automatic vehicle of an accelerator and brake pedal, where the standard is for the accelerator to be lower than the brake pedal would be required to lift their foot from the accelerator, move it laterally and then apply pressure to depress the brake (Human Factors in engineering and design E.J. McCormick and M.S. Sanders 1983 McGraw Hill International Book Co page 269). This sequence of movements would take place across a horizontal distance between both pedals of, on average, between 10-13cms - refer Appendix one.

The actions described above would be defined as a repetitive movement and would incorporate compound lower limb movement across three primary joints being the ankle, knee and hip joints. This would be possible via the activation of the relative muscular systems in the upper and lower leg regions of the right leg. The average pressure required to operate a foot pedal and in turn overcome the resistance would be between 3-5 kp (29.41 – 49.03 Newtons).

In the literature these types of actions for lengthy durations have been associated with injuries to the knee and thigh areas as outlined in a handful of studies below.

- E.J. McCormick and M.S. Sanders 1983 Hill International Book Co, Page 269.
- Bus drivers (Work-related Musculoskeletal disorders in urban bus drivers in Hong Kong. J Occupational Rehabilitation. 2007 June;17(2): 181-189 E pub 2007 Feb 2.).
- Truck drivers (Burden of Work-Related Knee Disorders in Washington State, 1999 to 2007. Journal of Occupational Environmental Medicine. 2011 May; 53(5): 537-547. Doi:10. 1097. JOM. ObO13e31821576ff).
- Taxi Drivers (Knee pain and Driving Duration: A Secondary Analysis of the Taxi Drivers Health Study. American Journal of Public Health. April 2004, vol 94, No 4.) and
- Occupational activities (Knee disorders in the general population and their relation to Occupation. Occupational Environmental Medicine 2003;2003;60:794-797).

In the case of the ETBS where the sequence of movements as outlined above are not required and instead the action is with one pedal only, notwithstanding the fact that there would still be repetition evident involving the ankle and foot, it would not be unreasonable to postulate that the risk of knee injuries would be significantly reduced if not eliminated. The primary joint in operating the ETBS would be the ankle and associated musculature of the lower limb responsible for the movement of the foot - refer Appendix two.

With the focus moving to the operation of one pedal by one foot and associated structures this does however potentially increase the risk of repetitive based conditions due to the increased number of flexion and extension movements (Kodak's Ergonomic Design for people at Work. John Wiley & Sons Inc 2004) that would result from operating a single pedal only. This suggestion however would have to be investigated further to make a clear determination.

On a physiological level this reduction in whole leg movement involving the big muscle systems brings with it the potential risk of an increase in physiological conditions such as DVT. This is based on the fact that one of the risk factors with DVT is sitting for long periods of time such as driving. Although sitting for long periods is a risk factor, your chance of developing deep vein thrombosis while driving is relatively low. The risk of increase would be under these circumstances for the non-active lower limb (National Library of Medicine).

SUSTAINED BODY POSTURES

When evaluating the two scenarios, one where an individual uses a two pedal system (as described previously) and the other where an individual uses a one pedal system ETBS, it is evident that in both situations an individual could adopt a sustained awkward posture and/or a sustained body posture encompassing the whole leg, ankle and foot as a result of different biomechanics. It is however more likely that a person will result with this type of posture when using a two pedal system.

By definition a sustained posture is where a movement or position is held for more than 30 seconds (National Code of Practice for the Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work. Australian Safety and Compensation Council Canberra 2007).

Based on a literature review conducted observations of driving postures show humans develop Piriformis muscle syndrome typified by a laterally (away from the mid line position) rotated right (majority of cases) foot position. This is where the heel of the right foot remains in line with the base of the brake pedal and two thirds of the right foot is turned laterally to operate the accelerator pedal as illustrated clearly in Appendix three.

This foot position would be eliminated with the use of the ET Braking system due to the primary use of the accelerator only. Foot positioning could be vertically aligned with the accelerator pedal, minimising the potential for the heel to be positioned in line with the brake pedal and the subsequent overuse of the piriformis muscle as illustrated in appendix 2.

Research by Barnes, R. M., Hardaway, H. And Podalsky, O.: Which pedal is Best? Factory Management and Maintenance 100, 98-99 (1942) concluded that pedals such as the accelerator of a car is best operated "with the heel on the floor and the foot resting on the lower edge of the pedal".

If this is accepted as the optimal position for a human to operate a pedal, and given ETBS technology involves primarily the accelerator pedal and consequently this optimal position as can be seen in appendix two, clearly it could be concluded that there is less likelihood of any issues occurring with the leg, lower limb, ankle and/or foot of individuals using the ET Braking System.

However with the use of the ETBS (using only one pedal) it would not be unreasonable to hypothesise that there is still a likelihood of an operator holding a sustained posture which would incorporate the foot in a flexed position about the ankle joint involving the anterior musculature of the lower limb. However this would need further biomechanical and functional investigation given that there are several important design parameters that affect performance with foot controls, including the need for thrust with or without ankle action, location of the fulcrum (if the pedal is hinged), the angle of the foot to the tibia bone of the leg, the force required to operate the foot control and the placement of the control relative to the user (Human Factors in Engineering and Design. E.J. McCormick and Mark S. Sanders 1983 McGraw-Hill International Book Co page 267).

FATIGUE

Physical Fatigue is well understood and well defined in the literature, however, “Mental Fatigue” is a lot less clear. Mental Fatigue tends to be thought of as a state of being in which an individual cannot concentrate or think clearly which causes a loss in attention and results in them falling asleep. The implications of this when an individual is involved in hazardous activity can result in a serious safety risk. Mental Fatigue is not yet measurable and consequently we cannot relate it accurately to performance impairment.

Fatigue contributes to 20-30% of all deaths on the road and in particular crash types such as fatal single vehicle semi-trailer crashes between 40-50% (Centre of Accident & Road Safety – Queensland University of Technology Kelvin Grove) and one of the benefits of the ET Braking System is to reduce the consequences of driver fatigue by reducing the braking distance of a vehicle.

Extensive research has shown that 90% of the driving population can react in 2.5 seconds or less and it is this brake reaction time of 2.5 seconds that is used in design. This is where the ETBS demonstrates significant value with its ability to reduce the braking distance compared with normal braking systems in an emergency situation. Due to the ETBS reacting quicker compared with the manual braking system.

Research states that a driver who has been awake for 17 hours has a driving ability similar to that of a driver with a blood alcohol concentration (BAC) of 0.05, and after 21 hours, similar to a BAC of 0.15. At 0.05% BAC alcohol increases self-confidence, decreases inhibitions, diminishes attention, judgment and control (Council on Scientific Affairs. Alcohol and the driver. JAMA 1986:255 522-527) and leads to hazardous driving (Ogden E.J., Moskowitz H. Effects of alcohol and other drugs on driver performance. Traffic Inj Prev 2004;5: 185-198).

Another consequence of these levels of fatigue or BAC at 0.05% and 0.15% are reduction in reaction times of between 8-15% and approximately 30% respectively. In terms of time this means an increase in reaction time of 0.2875 seconds and 0.75 seconds respectively. (Oem.bmj.com/consent/57/10/649. Short Med. Sleep deprivation produces impairment in cognitive and motor performance equivalent to legally prescribed levels of alcohol intoxication). This increase in reaction time with the ETBS engaged versus not being engaged could be the difference between, in the worst case scenario, life and death.

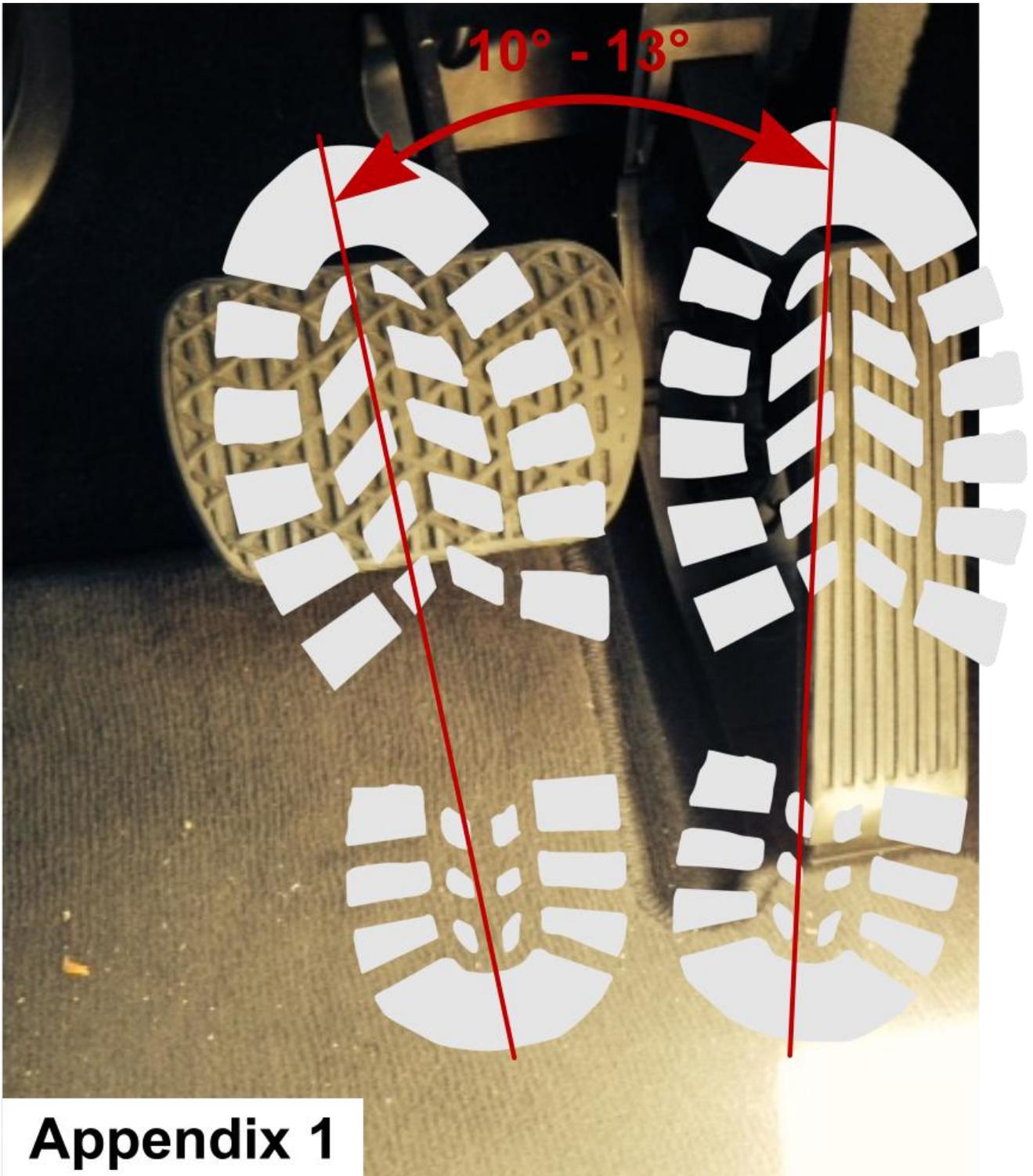
One study showed that increased variability in speed control during simulated driving, in a moderately fatigued and alcohol affected state, variability increased 34%. In subjects with a high fatigued state, variability increase by 75% (Neurobehavioural Performance of Residents after Heavy Night Call vs After Alcohol Ingestion. JAMA, September 7, 2005 – Vol 294, no 9).

Two groups considered to be at high risk of fatigue are shift workers and people with long work hours plus commercial drivers. It is also a known fact that people with sleep apnea have up to 7 times the number of motor vehicle crashes compared to people without the condition.

It was evident from the research conducted that the greater majority of fatigue related studies revolve around the eye and facial measurement, describing reduced vigilance when fatigued or effected by alcohol.

There was no specific research that was identified which studied directly the effect of physical fatigue on lower limb use.

APPENDIX 1



Appendix 1

APPENDIX 2



Appendix 2

APPENDIX 3



Appendix 3