Applying the 'many models' approach to the successful introduction of advanced automated vehicles

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THE WORK IN CONTEXT

There have been previous calls for a 'many model' approach to solving complex challenges in ergonomics (Salmon and Read, 2018). In this work, we demonstrate how the combination of three systems ergonomics methods can provide different, yet compatible insights into the emerging challenge of the successful (safe and effective) introduction of advanced automated vehicles. Specifically, we applied ActorMap, Hierarchical Task Analysis, and the abstraction hierarchy from the Cognitive Work Analysis framework. Each model provides detailed descriptions of the road transport system that can be used as a basis to explore the issues surrounding the introduction of automated vehicles. Importantly, they provide a series of compatible insights from different perspectives regarding the future road transport system that can inform policy response and other initiatives to support the successful introduction of advanced automated vehicles. It is concluded that the application of multiple methods is beneficial to gain more insight than would be available from a single method used in isolation.

KEYWORDS

Actormap, Hierarchical Task Analysis, Cognitive Work Analysis, road safety, automated vehicles

Introduction

A 'many model' approach to solving complex challenges in ergonomics has been encouraged (Salmon and Read, 2018). Different models provide different perspectives and insights on a system, thus combining models can provide a deeper understanding than applying a single method. This work applied a many model approach to the emerging challenge of the successful (safe and effective) introduction of advanced automated vehicles (AVs) into the road system.

While predictions vary, it has been suggested that advanced AVs will enter the Australian road system from 2020 (NTC, 2018). While automation is postulated to create safety and efficiency benefits, it poses potential risks (Hancock, 2019; Stanton and Marsden, 1996). Given that road transport is a complex sociotechnical system (Salmon et al., 2016), systems ergonomics methods are required to address the challenges posed by these disruptive technologies.

Three systems ergonomics methods were used to develop models of the Australian road transport system in five to ten years' time, including the range of new technologies likely to be implemented in that timeframe. The methods used were:

1) ActorMap (Rasmussen, 1997): identifies the actors that reside within a system at various hierarchical levels from the equipment and environment (for example, road environment) at the lowest level of the hierarchy up to government actors at the highest level. The ActorMap defines *who* resides within the system. In the present study, the ActorMap was developed from document review and was reviewed by road transport subject matter experts (SMEs).
2) Hierarchical Task Analysis (HTA) (Annett and Stanton, 1998): decomposes the goals, sub-goals and requisite operations that need to be undertaken to meet an overall system goal. It defines *what* needs to be done for the system to perform successfully. In the present study, the scope of the HTA was the overall road transport system in Australia, as opposed to a specific road transport task in isolation (for example, negotiate an intersection). The HTA was developed based on document review and was reviewed by SMEs.
3) Cognitive Work Analysis (CWA) (Vicente, 1999): identifies constraints on behaviour within a system. The abstraction hierarchy (AH) was applied to describe the future Australian road transport system. This provides an actor- and event-independent description of a system, using five levels of abstraction. It defines *why* various elements are present within the system, and how elements interact to support the system's overall purposes. The AH was based on a model of the current road system (Salmon et al., in press), with future road technologies and their affordances added.

Findings

The ActorMap identifies new actors that will enter the road system including different AVs (for example, cars, public transport vehicles, maintenance vehicles) as well as other new technologies such as drones used for traffic monitoring. Other new actors include road safety regulators as well as existing entities who do not currently play a role in road transport, but due to technological advances will contribute to the road transport system (for example, government departments responsible for regulating communications systems, satellites and information privacy).

The HTA includes no wholly new tasks that relate specifically to AVs. However, several existing tasks will change. For example, with the increasing availability of data, government agencies will have a significantly improved capacity to conduct the task of 'monitor road performance and safety'. However, the HTA also highlights existing tasks within the road transport system that may require modification. For example, the task 'used vehicle sales/change of ownership' should be reviewed to understand how this can be managed to ensure that vehicles remain compliant with safety standards.

The AH shows that the overall purposes of the system (to provide access and to support economic growth) remain the same into the future. However, changes were identified due to the addition of new physical objects relating to AVs. These include new processes provided by the technologies such as vehicle communications and storage of data. A new function of 'optimise traffic flow' was identified. Also, as found with the HTA, many existing functions will remain, however their operation will change. For example, technology advances offer new ways to undertake enforcement, and post-crash litigation will become more complex, involving parties such as vehicle manufacturers.

Together, the three models provide a stronger understanding than would have been gained from a single model. The analyses also provide a basis for additional systems ergonomics methods (for example, NET-HARMs (Dallat et al., 2018)).

Impact

The insights from the analyses can be used by policy makers and other stakeholders to plan for the successful introduction of AVs.

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