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A hierarchical task analysis of commercial distribution driving in the UK

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Abstract

At the heart of distribution operations is an essential influence in the success or failure of achieving the triple bottom line of safety, efficiency, and environmental friendliness: commercial vehicle drivers, and the increasingly complex technology with which they interact. To the authors' knowledge, no hierarchical task analysis exists for commercial distribution driving, and this gap suggests that the first step in clarifying these functional relationships is to fulfill the evident need for a HTA of the commercial driving task. Thus, relevant literature (e.g. the UK Driving Standards Agency; existing hierarchical task analysis of private vehicle driving) is consulted to review procedure and construct a hierarchical task analysis of commercial distribution driving, in accordance with UK standards for C, CE, C+1 and CE+1 licensed driving activities. Preliminary analysis indicates that successful completion of the commercial driving task is subject to a far more complex set of factors than that of private vehicle driving, many of which require input from actors across various contexts, and rely heavily on automated vehicle technology.At present there exists no comprehensive, standardized measure against which to evaluate the quality of content in commercial driver training, and much is left to the expertise and discretion of individual companies to determine content which will create and support an 'effective' driver. This hierarchical task analysis provides a normative characterization of commercial driving which informs driver training needs and course content, and supports industry expertise with a functional structure. Furthermore, this analysis may also serve as an input to a wide range of human factors analyses for effective system design.

*Keywords:*Road freight; Commercial vehicle driver (CVD); Heavy goods vehicle (HGV); Hierarchical task analysis (HTA)

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1. Introduction

1.1. Purpose

In recent years, freight operators have experienced significant pressure to deliver goods economically, while maximizing safety and minimizing environmental impact throughout operations. Without human factors intervention, this triple bottom line of cost, society, and environment will become increasingly difficult to achieve, especially under consideration of projected economic growth and consumption trends. At the heart of distribution operations is an essential influence in the success or failure of achieving this triple bottom line: commercial vehicle drivers, and the increasingly complex technology with which they interact. Many models of driver behaviour and driver-transport systems exist. However, few address commercial vehicle use, which is arguably more complex than private vehicle use due to variation in vehicle types and licensing requirements; categories of goods and services; additional regulatory constraints on workers' hours; the nature of ordering and routing systems, and; increasing complex vehicle automation. Commercial distribution driving is essentially linked to an overwhelming number of systems issues which necessitate examination from a functional perspective. Despite this human factors analyses for logistics driving tasks are few and far between, amidst widespread calls for new approaches to road safety, vehicle efficiency and greenhouse gas reductions.

At present there exists no comprehensive, standardized measure against which to evaluate the quality of content in commercial driver training, and much is left to the expertise and discretion of individual companies to determine content which will create and support an 'effective' driver. Application of human factors analyses for professional driving is nearly non-existent, and as an exciting new ground for human factors research, it follows that a foundational knowledge base should be developed before moving on to more complex, innovative methods. As a core method with over 40 years' continuous use [1], hierarchical task analysis (HTA) can provide this much-needed foundation. Furthermore, according to the methods matrix developed by Salmon et al. [2] over 40% of existing human factors methods can utilise HTA as a direct input. As such the effort expended in completing an HTA has potentially large returns – particularly for fertile new fields for human factors such as commercial vehicle driving. This HTA provides a normative characterization of commercial driving which informs driver training needs and course content, and supports industry expertise with a functional structure. Furthermore, this analysis may also serve as an input to a wide range of human factors analyses to inspect system design, which will be critical in meeting the triple bottom line.

2. Materials and methods

2.1. Design andliterature review

Previous task analyses for driving tasks are few and far between in human factors literature. Published instances often cover specific ancillary tasks such as tanker filling [3, p. 755], refueling errors in light vehicles [4], manual handling [5], or more generic task analyses [6] which do not cover a sufficient level of depth to fully represent task complexity in such a way that may enable future systems development. The most comprehensive published vehicle-related HTA covers private vehicle use in the United Kingdom with a manual transmission and standard fuel-injected engine [1]. This HTA of private vehicle driving served as a sound basis for the adapted HTA of commercial vehicle driving below.

The scope of this initial HTA of commercial driving (HTAoCD) encompasses right-hand-drive (RHD) articulated vehicles designed for driving on British roads with a C+E or C1+E license. Tractor units are assumed to be of Euro 6 emissions standard equipped with automatic transmission, dash-mounted handbrake, air braking system, breathalyzer, and digital tachograph unit. The use of technological systems such as lane departure warning systems (LDWS) and hands-free microphones are also included as such systems are commonly present in modern vehicle models.

2.2. Procedure and data collection

The procedure for HTA involves six main stages including: definition of the overall task, data collection, definition of the overall goal of the task, definition of task sub-goals, decomposition of sub-goals, and completion of plans analysis. Data was collected in two forms in two iterative stages: the consultation of official training guides and legal documents, and observation studies (with accompanying video data) of commercial drivers.

Materials consulted include:

- Driving rules established by the UK Highway Code [7]
- Operating rules and loading guidance established by the UK Driver & Vehicle Standards Agency (DVSA) [8]
- The Official DVSA Guide to Driving Goods Vehicles [9]
- Complete LGV & PCV Theory and Hazard Perception Tests with Official Highway Code: 2014/15 Edition [10]
- EU Directive 2003/88/EC (otherwise referred to as the Workers Time Directive 2003) [11]

Observation studies of commercial drivers in a variety of sectors were carried out to navigate the complexity of the industry and clarify initial stages of analysis. This cross-section of commercial driving activities included:

- Daytime long-haul operations (shifts approximately 9.00 AM – 20.00 PM)
- Nighttime long-haul operations (shifts approximately 21.00 PM – 8.00 AM)
- Heavy load operations
- Urban delivery operations
- Intercity passenger bus driving

Despite the availability of this real-world data, it should be reiterated that the presented HTAoCD focuses strictly on ‘normative’ driving rather than variations present in real-world adaptive behaviour. Data collected by observation studies supported the HTAoCD by providing researcher access to subject matter experts (totalling over 130 years international commercial driving experience) to a wide range of activities, sectors, traffic environments, road/weather conditions, organisations, and (crucially) vehicle systems and designs which are only described broadly in official documentation. Such an approach marks this initial HTA analysis as tending toward the prescriptive, rather than descriptive – and thus creates a base line of ‘normative’ professional driving.

3. Results and discussion

3.1. Results

The completed HTAoCD is comprised of over 70 pages of tabular analysis, and as such only a brief summarised version of the analysis is presented below. Several areas (operational and tactical driving task sub-goals) remained highly similar to the original HTAoD completed by [1] for private vehicle driving which was used as a basis for this work and thus serves as the nearest point of comparison. However, the addition of sub-goal 3 (loading and cargo securing) and sub-goal 8 (unloading and delivery tasks) proved equally lengthy and complex compared to the more directly driving-related tasks.

Table 1.Primary goal and nine high-level sub-goals of the commercial driving task.

#	TASK GOAL	
0	Complete a shift operating a modern Euro VI heavy goods vehicle with articulated trailer in compliance with EU Directives, UK Driver & Vehicle Standards Agency, UK Department for Transport, and UK Highway Code licensing and operation standards and guidelines under a C+1 or CE+1 license	
#	SUB-GOAL	EXAMPLE(S)
1	Pre-shift tasks	Receive work assignment; locate assigned vehicle
2	Pre-drive ancillary tasks	Check vehicle systems; load personal items
3	Loading and cargo securing	Identify required cargo at pickup point; operate hydraulic lift mechanism
4	Basic vehicle control tasks	Accelerate; decelerate; perform steering manoeuvres
5	Operational driving tasks	Follow other vehicles; approach junctions
6	Tactical driving tasks	Drive on rural roads; perform emergency manoeuvres
7	Strategic driving tasks	Perform auditory surveillance; exhibit appropriate driver attitude
8	Unloading and delivery tasks	Complete delivery paperwork; interact with customer
9	Post-drive tasks	Park vehicle; unhook trailer from cab

Some noticeable additions to the HTAoCD included the required, active use of specific technological systems, for example:

- The requirement of breathalyzer use to enable vehicle start-up
- Tractor/trailer hook-ups
- Ancillary warehouse equipment (e.g. forklifts) required for loading and unloading heavy cargo
- Hydraulic systems for vehicle lifting and ramp use
- Communications technologies for booking intermodal transport links ahead (e.g. ferry transport)

3.2. Discussion

This HTAoCD identifies that operators' information processing and memory capabilities are crucial to the task of commercial vehicle driving. A high number of cues are required in plans which often occur simultaneously – particularly in the case of surveillance sub-goals and 'attitudinal' activities which describe the operator as being required to maintain constant attention on a wide range of tasks. This highlights the importance of cognitive engineering in this domain, and suggests that future research attention is required on the subject of commercial drivers' cognitive workload during normal operation. Further insight into the decision-making processes of commercial drivers is required in order to ensure the effective design of autonomous or semi-autonomous systems. Barbera et al. [12] propose that task analysis may be used to develop technological support systems enabling autonomous vehicles. However, in order to account for the often unexpected, emergent behaviours which arise from user adaptations to systems, it may be of greater long-term impact to first expand the knowledge base of human-system cooperation in commercial driving activities, for example by investigating real-world behavioural variations to the normative HTAoCD presented above.

While operational driving sub-tasks (sub-goal 5) remained of a more or less similar nature and number when compared to the HTAoD completed by Walker et al. [1], higher-level strategic tasks required much greater specificity in the associated plans. Indeed, the higher the level of decomposition, the more sophisticated plans must become to cope with system-wide complexities, which may reflect the complexity of large-scale logistics transport systems. This has potential impact not only for driver-focussed studies (as previously noted) but also for the research of larger-scale systems. A wide range of situations and activities are present in this analysis, suggesting an opportunity to fully apply Cognitive Work Analysis (CWA) beyond work already initiated by Bodin [13] as a first step toward systems analyses.

Although the scope of this HTAoCD has been intentionally specific in order to create a manageable initial task, the authors intend to elaborate upon this foundation for a wide range of sectors, applications, and infrastructural layouts. Iterations of this work soon to follow will include left-hand-drive (LHD) vehicles; rigid vehicles; longer, heavier vehicles (LHVs) and double-trailer vehicles connected by an active dolly; and specialty trailers such as those used for the transport of refrigerated goods, hazardous materials or livestock. Future iterations also intend to incorporate the driver training process with an accredited HGV training provider as a further method of data collection to fortify these findings.

4. Conclusions

To the authors' knowledge this work presents the first instance of a hierarchical task analysis for commercial driving, and supports the application of over 50 additional human factors methods as well as serving as a reference for technology and system development. Results show that commercial driving found that higher levels of decomposition required more elaborate plans to cope with variations in situations and the high rate of information available to and required by the driver, especially in comparison to private vehicle use. The analysis provides a normative characterization of commercial driving which informs driver training needs and course content, and supports industry expertise with a functional structure. Further work in the immediate term includes several in-depth variations for normative driving, taking into account a wider variation of industries and vehicle designs.

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