UDRIVE

European Naturalistic Driving Study

The UDrive dataset and key analysis results

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Executive Summary

UDrive is a large European naturalistic driving study, sponsored by the European Commission (FP7). Nineteen partners across Europe have come together and, along with stakeholders, defined research questions, developed data acquisition, collected and managed data, and finally, performed a first analysis on the UDrive dataset with respect to driver/rider behaviour related to traffic safety and the environment (eco-driving).

This document presents key results of the UDrive analysis performed in *UDrive Sub-project 4: Data analysis*. It also describes the UDrive dataset and, in brief, how we got here.

As shown in Figure 0.1, the UDrive dataset consists of 38 157 hours of analysable passenger car data from 192 drivers (collected in five countries: Germany, France, the Netherlands, Poland, and the United Kingdom), 14 503 hours of analysable truck data from 46 drivers (collected in the Netherlands), and 497 hours of analysable powered two-wheeler (scooter) data from 39 drivers (collected in Spain). The descriptive statistics of the data in this deliverable is the status of the dataset (analysable data in the UDrive database) as of June 27th, 2017.

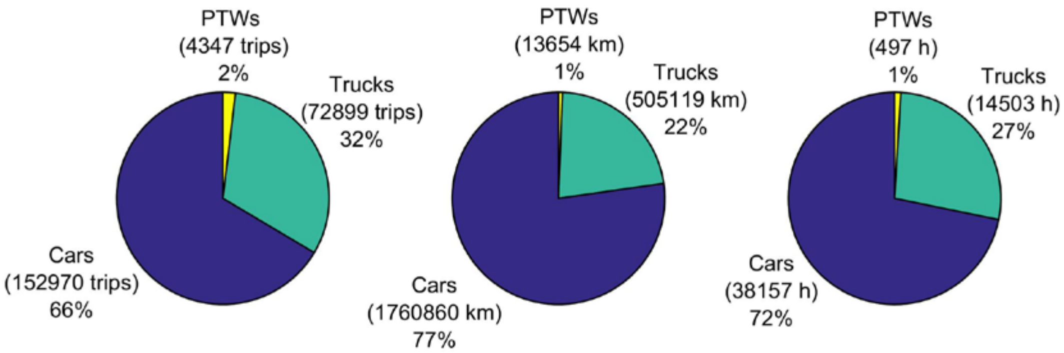

Figure 0.1: The data collected across the three modalities.

The analysis in UDrive was facilitated by tools such as the quality assurance procedures and data tracking (e.g, the on-line data monitoring tool), the SALSA dataprocessing tool, the UDrive annotation codebook, high-quality manual annotation of video, and a team of highly skilled researchers. The analysis itself is described in short in this report, while details are presented in separate UDrive deliverables.

This document summarizes the key results of UDrive, so only a few typical examples are given in this executive summary. For example, in the safety-related analysis of risky and everyday driving, results show how car drivers' speeding varies across the day (Figure 0.2, left), and how males and females speed differently (Figure 0.2, right). Note that "light speeding" is defined as exceeding the speed limit by 11%-15%, and "severe speeding" as exceeding the speed limit by 16-20%. ("Extreme speeding", exceeding the speed limit by >21%, did not occur in this sample.)

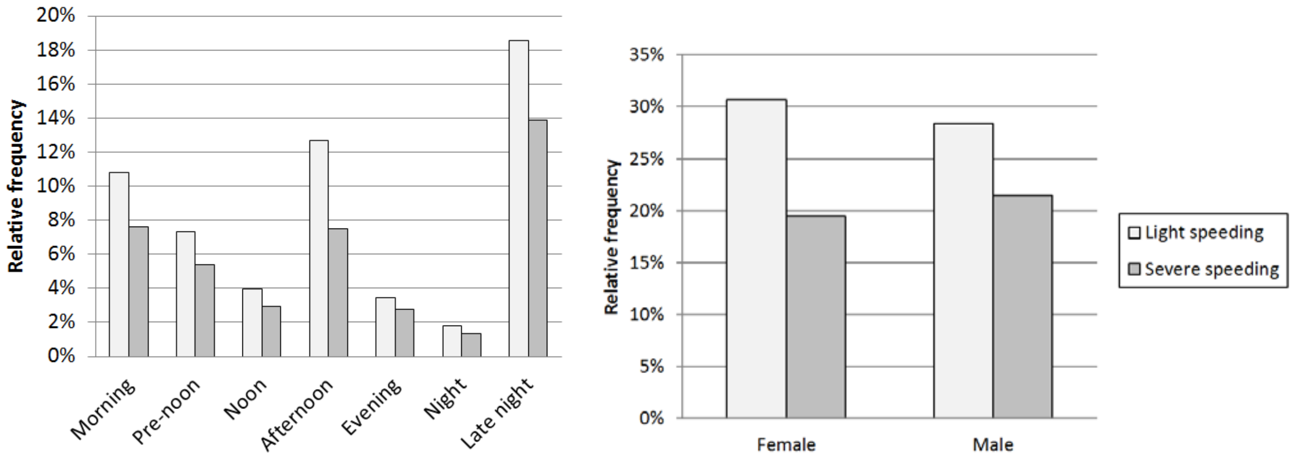

Figure 0.2: Relative frequency of speeding events by time of day (left) and gender (right). The frequencies are weighted by exposure of time driven during a specific time of day and gender, respectively.

In the analysis of distraction and inattention, the focus was on when, where, and how drivers engage in secondary tasks while driving. Figure 0.3 shows to what extent drivers in four different European countries perform secondary tasks (any of the tasks annotated in UDrive: mobile phone use (further broken down into individual actions in other analyses), electronic device use, eating/drinking, smoking, reading/writing, personal grooming, talking/singing, and other) across 653 trips (approximately 167 hours) driving by 87 passenger car drivers. An obvious observation is the large difference by country in secondary task performance while driving (see Figure 0.3). Unfortunately the data from The Netherlands were not annotated in time to take into account in this analysis.

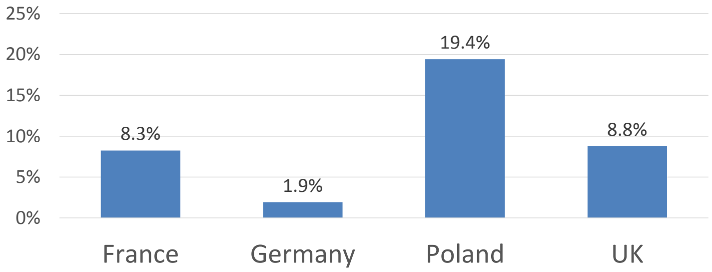

Figure 0.3: The percent of driving time spent performing secondary tasks while driving a passenger vehicle, across countries.

UDrive is unique in that one of its foci is on the safety of vulnerable road users (i.e., the interactions between cars and pedestrians/bicyclists as well as aspects of powered two-wheel driving). For example, Figure 0.4 shows how car drivers' glance behavior (blind spot checks) when turning right (UK left) in intersections, and roundabouts differs across four European countries. A startling insight in UDrive was not only the very low proportion of blind spot checks, but also the large variablility between countries.

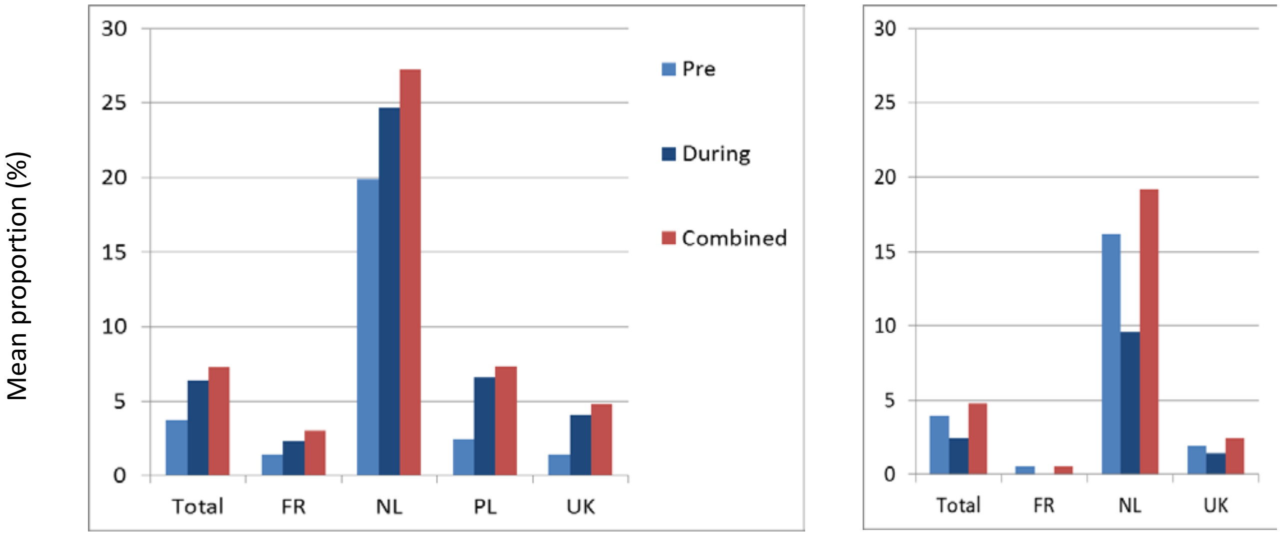

Figure 0.4: Mean proportion of manoeuvres with at least one blind spot check across car drivers, stratified per country (left: intersections, right: roundabouts). NOTE: FR = France, NL = Netherlands, PL = Poland, UK = United Kingdom. Pre = time window 6 seconds prior to the manoeuvre onset, During = during the manoeuvre, Combined = time window of 6 seconds prior to the manoeuvre onset until the end of the manoeuvre. Roundabout manoeuvres have not been examined in Poland.

Results were obtained from the analysis of just over 400 Pedestrian Collision Warnings (PCWs; from the MobilEye smart camera data) in car data from Great Britain and France. Speed choice and speed management are key factors in all road conflicts—particularly in conflicts involving vulnerable road users, such as pedestrians. Therefore, speed is the most natural choice for clustering PCWs. The PCWs were clustered into four conflict categories; see below and Figure 0.5.

A. Conflicts that involved the highest-speed group, mainly comprising situations in which the pedestrian was on the pavement.

B. Conflicts that involved a group of car drivers who increased their speed just before the conflict occurred; again, mainly situations in which the pedestrian was on the pavement.

C. Conflicts in which the high-speed drivers had probably noticed the potential conflict well in advance, and had reduced speed to avoid a collision with the pedestrian.

D. Conflicts in which the car drivers had not reduced speed until very late, seemingly because they had not noticed the pedestrian. This group of potential conflicts contained the highest percentage of real conflicts (safety-critical events; SCEs).

These four clusters provide clear and distinct speed choice behaviours relating to the occurrence of PCWs. The most interesting is the cluster in which the drivers did not reduce their speeds until the actual onset of the conflict, meaning that drivers were not aware of the conflict until it actually occurred. This cluster has the highest percent of safety-critical events (i.e., 22 of the 67 identified safety-critical events) and the lowest proportion of vulnerable road user (VRU) facilities (e.g., sidewalks etc.).

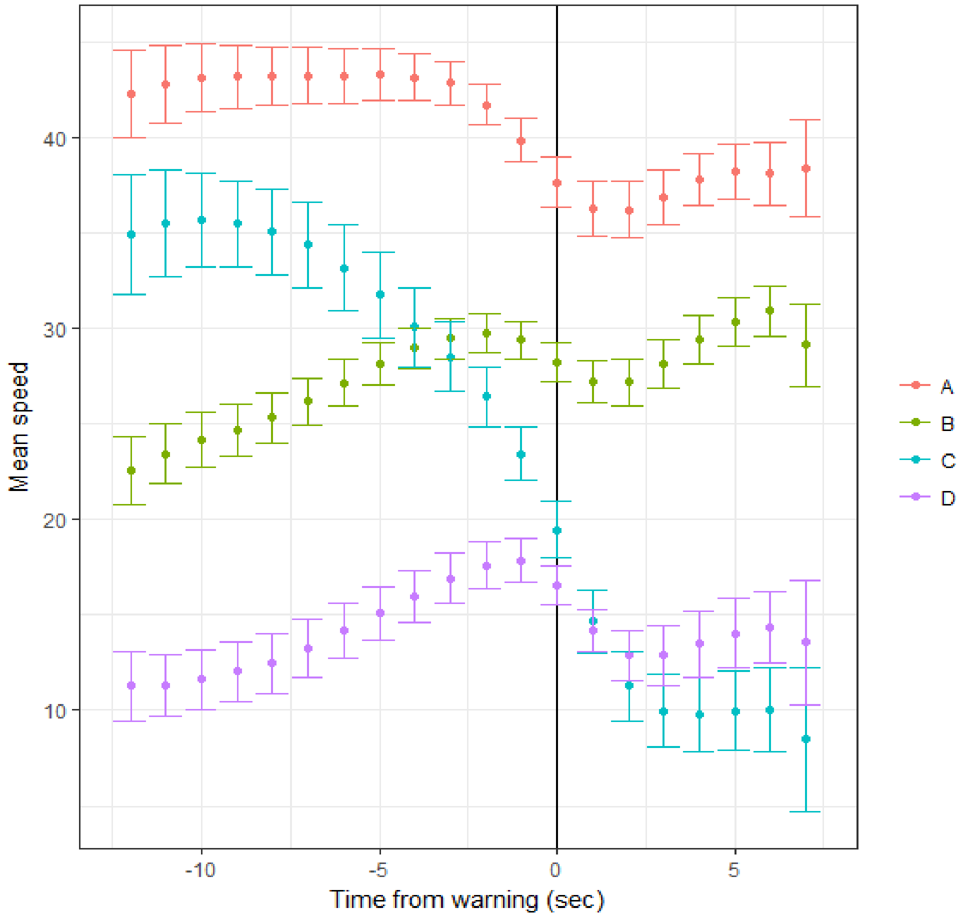

Figure 0.5: Clusters of PCW according to longitudinal speed distribution.

Finally, eco-driving was a key area of analysis in UDrive. An example of one such analysis is shown in Figure 0.6, which presents the results of eco-driving scores calculated in UDrive as the average of the residual values of:

- Braking energy at 50-60km/h
- Engine speed when shifting from second to third gear
- Most frequent (peak) velocity at speed limits between 95 and 120km/h
- Width of the peak around the most frequent velocity at speed limits between 95 and 120km/h
- Weighted mean of the absolute acceleration at speed limits between 95 and 120km/h

The rationale behind this eco-scoring is that braking energy is, for most drivers, the main energy consumer at low velocities (larger than rolling resistance or air drag). The difference in lost braking energy between the best and worst drivers is in the order of 120%, resulting in a difference in energy consumption of up to 10%. Further, engine losses are not negligible for passenger cars. Idling in urban areas occurs 15% of the time, with a range of 0-50% in the UDrive dataset. In addition, some drivers shift gear much earlier than others, even in the same type of vehicle. The estimated difference in fuel consumption due to different engine speeds can be as much as 20-25%.

The average of the residual percentage values of the variables described above gives an eco-score—negative for better-than-average and positive for worse-than-average eco-drivers (Figure 0.6). Since it is expected that a correction for driving circumstances has a large influence on driving behaviour, a selection is made on free-flow circumstances (based on headway), excluding trajectories with bends and intersections. The results show a wide spread in eco-score. Further analysis identified individual aspects of eco-driving and driving style.

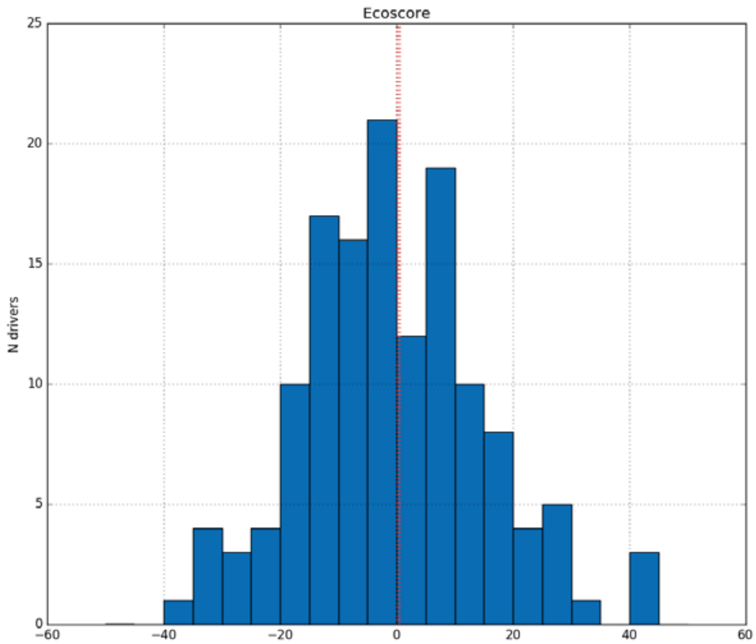

Figure 0.6: Distribution of eco-driving scores of all car drivers in UDrive, for straight sections and freeflow conditions

In summary, in UDrive a large variety of analyses was performed on the UDrive naturalistic driving data (NDD). Although the efforts and results have been significant and already impact safety measure design and development, the UDrive project has only scratched the surface of the analysis potential, for both safety and eco-driving. Similar to the US government agencies funding the large US naturalistic driving study SHRP2, which expect the SHRP2 data to be "…useful to transportation safety researchers and others for at least 20 years." (SHRP2, 2010, p. 1), the UDrive partners believe the UDrive data will be a valuable resource facilitating research, traffic safety, and eco-improvements for many years to come.

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1. Introduction

This document is a UDrive project report (deliverable) with the aim of describing the UDrive Naturalistic Driving Data (NDD) dataset and providing a summary of the key results from the UDrive analysis performed in UDrive sub-project four (SP4 - Data Analysis). UDrive has two general foci—traffic safety and eco-driving—covered in this report.

1.1 Background

Traffic fatalities are the ninth leading cause of death world-wide and the leading cause of death for men between 15 and 29 years old. Although there is a general trend towards fewer traffic fatalities in Europe, more than 26,000 people were killed in traffic in the European Union in 2015 (EC, 2016). Since 2010 the EC has had a safety target of a 50-percent fatality reduction between 2010 and 2020 (European_Commission, 2010; SafetyNet_Consortium, 2009); efficient measures to improve traffic safety are required to reach it. Similarly, emissions from traffic have large negative effects both on the health of humans directly (Kryzyzanowski, Kuna-Dibbert, & Schneider, 2005) and on the environment as a whole (Khan Ribeiro & Kobayashi, 2007). To facilitate the identification and development of the next generation of measures that will enable us to reach the EC targets for both traffic safety and emissions, far more in-depth understanding of road-users' behaviour is needed.

To help us understand road-user behaviour in everyday driving as well as in complex and unexpected critical situations, methods that study road-users unobtrusively over longer periods of time are necessary. Naturalistic driving studies (NDS) are such a method—defined by, for example, Bärgman (2016) as "A study where data is collected unobtrusively in drivers' vehicles as they go about their everyday lives. Typically an NDS aims to reveal correlations between traffic events, driver behaviour and crash causation." (p. vii). UDrive is an NDS.

The first large scale NDS was the 100-car naturalistic driving study in the US finishing its data collection effort in 2005 (Neale, Dingus, Klauer, Sudweeks, & Goodman, 2005); its much bigger brother, the SHRP2 NDS (SHRP2, 2010), completed its data collection in 2014. Data from both of these studies have had a large impact (particularly in the US) on society's view of, for example, distraction—legislators have used the results from NDS as key components for legislation and policy making (Bronrott, 2010), and key insights into crash-causation mechanisms have been found (e.g.,Dunn, Hickman, & Hanowski, 2014; Victor et al., 2015). In fact, the US government agencies funding the research expect the SHRP2 data to be "…useful to transportation safety researchers and others for at least 20 years." (SHRP2, 2010, p. 1). Prior to UDrive there was no large-scale NDS in Europe collecting data in several countries on the three modalities of transport: cars, trucks, and powered two wheelers (PTW), and focussed on both traffic safety and eco-driving.

1.2 The UDrive project

UDrive is a large naturalistic driving study in Europe, sponsored by the European Commission (FP7). Nineteen partners across Europe have come together and defined research questions, developed data acquisition, collected and managed data, and finally, performed a first analysis on the UDrive dataset with respect to driver/rider behaviour related to traffic safety and the environment (i.e., with respect to emissions).

The partners involved in UDrive were:

- SWOV (the Netherlands; analysis; *project coordinator and leader of two sub-projects: 'Data management' (SP2), and 'Management and dissemination' (SP6)*)
- BASt (Germany; legal issues)
- CDV (Czech Republic; analysis)
- CEESAR (France; car operation site; DAS development; local data centre*;* analysis tool development)
- CIDAUT (Spain; DAS development; PTW operation site)

- DLR (Germany; car operation site; local data centre; analysis; *leader of the UDrive sub-project 'Design (SP1))*
- ERTICO (Belgium; *leader of the UDrive 'Data collection' sub-project (SP3)*)
- FIA (Belgium; dissemination)
- IBDIM (Poland; car operation site)
- IFSTTAR (France; analysis)
- KFV (Austria; analysis)
- LAB (France; analysis)
- University of Loughborough (United Kingdom; car operation site; analysis)
- Or Yarok (Israel; analysis)
- SAFER ((Sweden; Chalmers University of Technology (Central Data Centre; analysis; *leader of the UDrive Data analysis sub-project (SP4)*), VTI, and Volvo Car Corporation (Sweden), and TÖI (Norway))
- Technische Universität Chemnitz (Germany; Responsible for annotation; analysis)
- TNO (the Netherlands; DAS development; car and truck operation site; analysis; quality assurance; *leader of the UDrive sub-project 'Impact' (SP5))*
- University of Leeds (Great Britain; car operation site; analysis)
- AB Volvo (Sweden; local data centre; analysis; leader sub-project two during the first part of the project)

UDrive (EC grant number 314050) was a 57 month duration project ending June 30th 2017. The total person month budget was €10.7m of which €8.0m was funded by the EC, and the remainder comprised in-kind contributions from the partners.

In UDrive a data acquisition system was developed including these specifications: able to collect up to eight video streams simultaneously and acquire data from the vehicle's controller area network (CAN), complementary accelerometer and angular rate sensors, GPS, and the MobilEye www.mobileye.com) smart camera. Car data was collected in the Netherlands, Poland, France, Germany, and Great Britain. A key element of UDrive is that the same data acquisition system was used across all operation sites (OSs) and vehicle types. All cars in the study were Renaults. Truck data was collected in the Netherlands. All trucks were Volvos. Finally, powered two-wheeler (PTW) data (all were Piaggio scooters) were collected in Spain. Participant recruitment, installation of data acquisition systems, and every-day operations were handled by one OS in each country (except for Great Britain, which had two).

Data collection, processing, and management were monitored through an UDrive-developed online monitoring tool. Data from the vehicles were sent to three local data centres (LDCs; in France, Germany and Sweden; see 2.4) where data was pre-processed, after which they were sent to the central data centre (CDC; in Sweden; see 2.4). At the CDC, data were uploaded to a MySQL database with InnoDB (MySQL, 2017) and TokuDB (Percona, 2017) storage engines. A tool (SALSA; see 2.4.4) was developed in UDrive that enabled a) researchers to develop, share, and apply algorithms (Matlab source code) for calculating, for example, derived measures, events, and performance indicators for each individual trip (or trip segment) in the database; b) manual annotation of video. Analysts then used a variety of tools for the actual analysis, including SAS, SPSS, R, Python, MS Excel, and Matlab.

Three main research topics in UDrive addressed traffic safety on European roads: a) risky and everyday driving, b) distraction and inattention, and c) vulnerable road users. These topics were chosen/prioritized based on interactions with stakeholders from government, industry, and academia. In addition, research has been conducted on eco-driving—studying driving styles and how driver behaviour affects fuel consumption and the corresponding emissions—a key concern world-wide. Within each research topic, research on a variety of important sub-topics has been conducted, and the key results are presented in this report.

As a reflection of the efforts across different parts of the analysis process a survey was, just prior to the UDrive final event, administrated to UDrive analysts. The aim with the survey was to provide future UDrive-data analysts with information to enable informed budgeting of analysis efforts. The analysts were asked to estimate the time spend in the SP4 analysis across a) data preparation, b) statistics and modelling, and 3) interpretation & documentation. They were to exclude time related to performing annotations, and data preparations was to include work such as data identification/retrieval, filtering/processing, and performance indicator calculations. Results are shows in Figure 1.1:

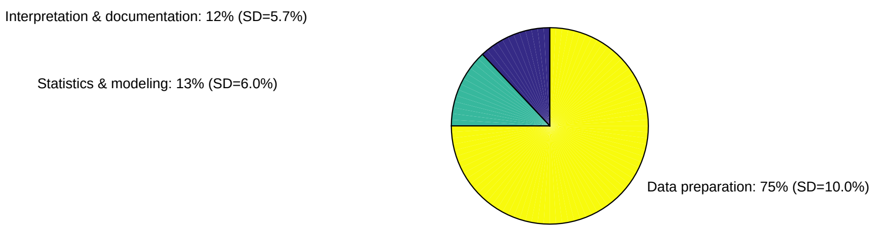

Figure 1.1: Results from a survey administered to UDrive analysts on their estimate of the distribution of time across three different analysis tasks during UDrive.

To help guide the project and its research, UDrive had an external advisory board that met with the management team and key researchers on a yearly basis.

1.3 Overall project aims

The UDrive aims, as stated in the description of work, are to contribute to developing a far better in-depth understanding of road user behaviour, to facilitate the identification and development of measures aimed at reaching the traffic safety and emission targets set by the EU, by:

- Conducting a large-scale European Naturalistic Driving Study (NDS);
- Building one central database with the collected NDD;
- Performing targeted analyses in the areas of:
    - crash-causation factors and associated risks,
    - distraction and inattention,
    - vulnerable road users,
    - eco-driving;
- Applying the findings in four specific areas:
    - the identification of new and promising countermeasures,
    - the potential of simple data acquisition systems (DAS) for monitoring performance indicators over time,
    - the improvement of driver behaviour models for road transport simulation,
    - the possibilities for commercial applications of NDD;
- Leaving behind the collected data to be used for additional analyses, subject to legal and ethical constraints, once UDrive is finished.

This report is focussed on providing the key results from the analysis (3rd bullet), but will also provide an overview of data collection, data management, and the UDrive dataset (2nd bullet). The latter is included to enable subsequent researchers to have the background needed to design future UDrive-data analysis.

1.4 Content and structure of report

Chapter 2 addresses the UDrive Dataset, describing the dataset, data acquisition, and data generalization. Chapters 3-5 cover traffic safety: Chapter 3 is on everyday and risky driving; Chapter 4 is on secondary tasks while driving; and Chapter 5 is on cars' and trucks' interactions with pedestrians and bicyclists, and the analysis of powered two wheeler NDD. Chapter 6 is on eco-driving, specifically with respect to fuel efficiency and emissions. Chapter 7 provides a short conclusion.

This document only includes brief descriptions of methods and only some of the results for each respective research topic. For detailed descriptions and all results for each respective research topic, see the relevant deliverable:

Chapter 3: UDrive Deliverable D42.1

Dotzauer, M., Stemmler, E., Utesch, F., Bärgman, J., Guyonvarch, L., Kovaceva, J., Tattegrain, H., Zhang, M., Hibberd, D., Fox, C., Carsten, O., (2012) *UDRIVE deliverable 42.1 Risk factors, crash causation and everyday driving,* of the EU FP7 Project UDRIVE (www.udrive.eu)

Chapter 4: UDrive Deliverable D43.1

Carsten, O., Hibberd, D., Bärgman, J., Kovaceva, J., Pereira Cocron, M.S., Dotzauer, M., Utesch, F., Zhang, M., Stemmler, E., Guyonvarch, L., Sagberg, F., Forcolin, F. (2017) *UDRIVE deliverable 43.1, Driver Distraction and Inattention*, of the EU FP7 Project UDRIVE (www.udrive.eu)

Chapter 6: UDrive Deliverable D44.1

Jansen, R.J. et al, (2017) *UDRIVE deliverable 44.1 Interactions with vulnerable road users*, of the EU FP7 Project UDRIVE (www.UDRIVE.eu)

Chapter 7: UDrive Deliverable D45.1

Heijne, V.A.M., Ligterink, N.E., Stelwagen, U. (2017) *UDRIVE deliverable 45.1 Potential of eco-driving,* of the EU FP7 Project UDRIVE (www.udrive.eu)

2. The UDrive dataset

2.1 Introduction

Large naturalistic driving studies which have collected data unobtrusively from participant drivers/riders going about their daily lives, over long periods of time, have only been performed in the last 10–20 years or so (e.g., Benmimoun, Ljung Aust, Faber, & Saint Pierre, 2011; Fancher et al., 1998; LeBlanc et al., 2006; Neale et al., 2005; Victor et al., 2010). Actually, a large portion of those studies were intended to evaluate the effects of an in-vehicles safety system, rather than to study driver behaviour in general—such studies are typically called naturalistic field operational tests (NFOT; Bärgman, 2016; See also www.fot-net.eu). However, both 'pure' NDSs and NFOTs have been used extensively post-hoc (after the original study was completed) to address a wide variety of traffic safety (e.g., Lind, Selpi, & Dozza, 2012; Sayer, Devonshire, & Flannagan, 2007; Sayer, Bao, & Funkhouser, 2013; Tivesten & Dozza, 2014; Woodrooffe et al., 2012; Young, Seaman, & Hsieh, 2014), and eco-driving questions (De Goede & Hogema, 2010; Hausberger & Stadlhofer, 2010; Vermeulen, 2006).

The largest NDS to date, the US SHRP2 NDS, finished its data collection on an unprecedented scale in 2014, making data available (given data protection is adhered to) to researchers world-wide from 2015—both in aggregated form (http://insight.shrp2nds.us/) and as data extracts by request. The US Government has set aside $4 million per year for the four years following the project to hosting the SHRP2-data and making it available (including basic support). At the UDrive final event, Ann Brach (key-note speaker; Director of Technical Activities at Transportation Research Board—National Academies of Sciences, Engineering, and Medicine) stated that to date over 200 projects have used (or are about to use) the SHRP2 NDD.

With the UDrive data, European naturalistic driving data across several European countries are also now available for research/analysis. The UDrive dataset consists of naturalistic driving data from cars (collected in France, Germany, Great Britain, Poland, and the Netherlands), trucks (in the Netherlands) and powered two-wheelers (PTW; scooters; in Spain). In UDrive this data has been used to address key traffic safety and eco-driving questions (key results reported in this deliverable).

2.2 UDrive data access after UDrive

The intent in UDrive has always been to make data available for both UDrive partners and external (third) parties after the project. As described in the UDrive description of work (DoW), as long as external funding is secured to host and manage the data, the UDrive consortium commits to providing access to the collected data after the project (obviously within legal and ethical constraints). However, care will be needed to control the use of this collected data, as it requires substantial know-how and experience which reside in the consortium itself. However, there is, at the time of writing this deliverable, no external (non-UDrive partner) funding for hosting and making data available after the project. A few UDrive partners have committed (with their own funding) to keeping the data available for some time after the project. Because external funding to enable access to the data is currently not available, parties (other than the UDrive partners having commited own funding) wanting analysis performed on the UDrive dataset need to set up collaborations with the partners having access. However, UDrive consortium partners will continue to seek venues for enabling broader access to data.

2.3 Data acquisition

2.3.1 The output: what has been collected?

Approximately 270 measures (signals) were collected and stored in the data acquisition system for cars and trucks in UDrive. For PTWs the number of measures was approximately 30 (CAN and MobilEye were available). In addition, approximately 50 map (geographic information system; GIS) attributes were added after the data arrived at the LDC. Appendix A provides a list of the measures collected and the map data available. Throughout the UDrive analysis, more than 400 additional (derived) measures were created by the analysts. These are not documented in this deliverable, but range from filtered raw signals (calculation of time headway and time to collision) and identified instances of hard braking to segments defined by elaborate algorithms (created to, for example, find bicycle overtaking manoeuvres).

2.3.2 Limitations and issues from a researcher's perspective

Data in UDrive are unique and very rich, and can be used for a wide variety of research and development purposes within traffic safety and eco-driving. However, as with all datasets, there are some limitations and inherent issues. This section shortly describe some key aspects that analysists need to consider (both before committing to using UDrive data, and while using them):

- The UDrive dataset has limited generalizability (e.g., only one brand for cars, trucks and PTW, and limited representation of young and old drivers; for details see 2.7).
- Synchronization: For some (unknown) reason there is an issue with synchronization between some data sources. For example, video data and CAN data are sometimes not synchronized. For cars, although there is basically no drift in time synchronization over a trip, video may be up to 2 seconds offset compared to CAN at any point in time. For trucks there is both an issue with drift (up to 2 seconds' difference in synchronization between the beginning and the end of a trip), and absolute synchronization between CAN and video (up to 6 seconds' misalignment has been found). Users of data must be aware of this limitation and are strongly encouraged to perform corrections as needed for each individual research question/analysis. An example of how to check speed synchronization is given in the appendix/supplementary material of Bärgman, Boda, and Dozza (2017).
- Some trips are missing data, either complete sources of data (e.g., CAN or GPS or video), or a single dataset. There may be several reasons for missing data, such as hardware issues in the data acquisition system or mistakes made during hardware installation. Potential systematic biases have not been evaluated to date.
- The error codes and floor/ceiling values (and their respective descriptions) for individual measures have not been made available to the UDrive project, and users of the UDrive data must be careful. It is strongly recommended that data ranges, etc. be validated on a measure-per-measure basis—by, for example, studying the distributions of each individual measure and looking for outliers, as well as constant values. Note that large amounts of data need to be studied when performing such analyses. Overall, documentation of recorded data (e.g., CAN) as well as map data is limited, as UDrive did not receive sufficient documentation from the data (source) providers.
- Some "trips" (defined as start of engine to engine off) have been cut into several shorter records. That is, what should have been a trip from engine-on to engine-off is instead only a section of a trip. This was due to the data acquisition system sometimes rebooting while driving. Analysts are highly encouraged to consider the implications of this splitting for any analysis performed.
- Not all camera views are available for all trips, and for some trips video images are upside-down, and in others the video name does not correspond to the video view. These errors are obvious when video is manually reviewed, but not when applying automated processing of video or when annotations are performed, so care should be taken in these situations. For PTWs in particular, a large portion of the collected data has either a forward camera or a rider camera collecting data, but not both. Further, a large portion of the truck data has issues with misaligned cameras.
- Angular rate sensors were sometimes mounted with rotated axes—data users must be careful and check the axis against other measures.
- The speed sensor in PTWs was, unfortunately, not collecting correct data for the first six months of data collection.

2.4 The data management chain

2.4.1 The process of collecting and processing data

The UDrive data flow involved three main stakeholder categories for collecting and managing the data: operation site (OS), local data centre (LDC) and central data centre (CDC). The six OSs (Germany, France, Netherlands, Poland, Spain, and UK) were responsible for installing and de-installing data acquisition systems (DAS) in vehicles, regularly replacing hard drives (HD) in vehicles during data collection, and monitoring data collection. The three LDCs (France, Germany, and Sweden) were responsible for data pre-processing: decryption, conversion, synchronization, harmonization, and (to some extent) data enrichment—adding road features from map matching. Finally, the CDC hosted the complete UDrive dataset and made the data available to analysts using a remote desktop service.

This whole process (data collection, transfer, and processing) was monitored by the UDrive On-line Monitoring Tool (OMT). This UDrive result is a new way to have complete control over how many data have been recorded, where they are located and where they are in the data-processing chain.

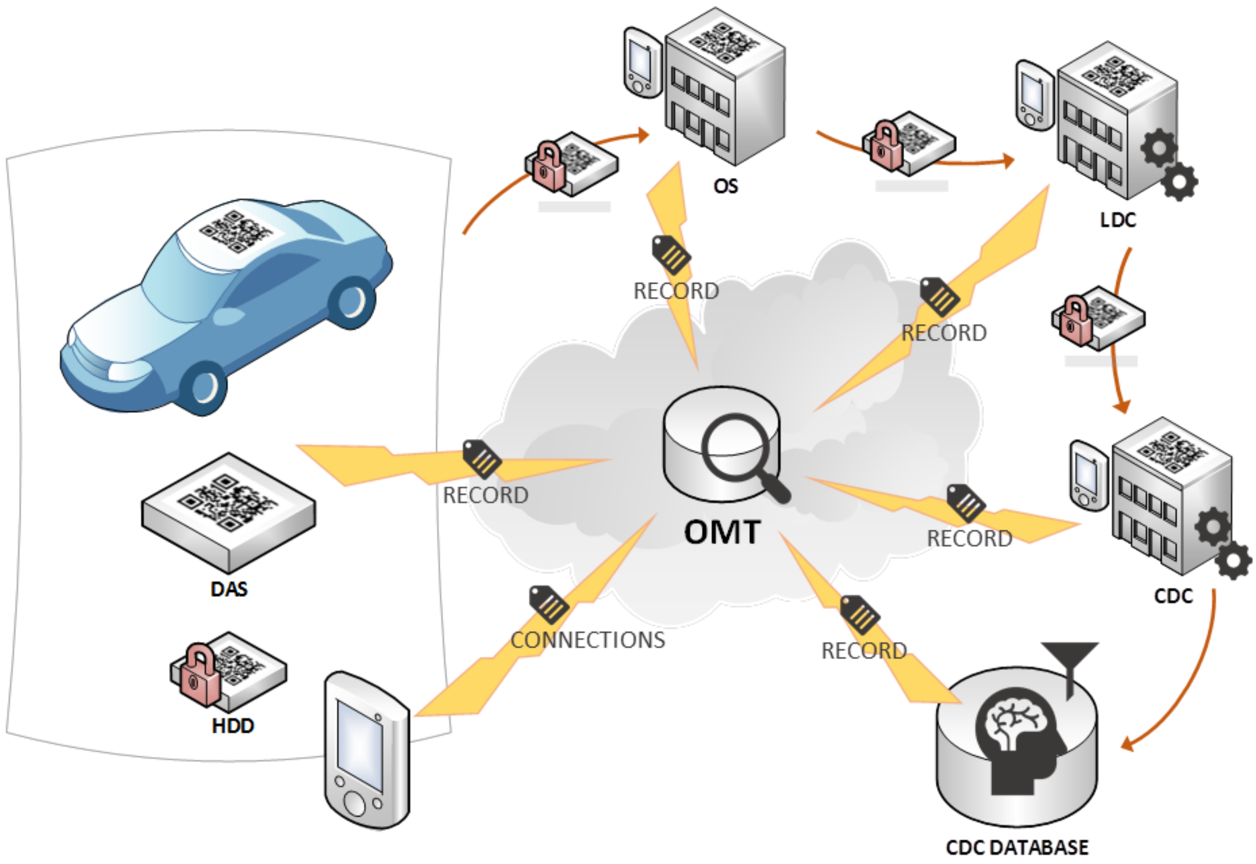

Figure 2.1: A visualization of the OMT, vehicles, LDC, and LDC. The red arrows show the data flow. The yellow flashes represent status uploads for each individual record throughout the data chain. Finally, the QR codes show where/when hardware (e.g., vehicles, DASs, and hard-drives) was explicitly QR-scanned to update its status in the OMT

LDC

The data processing chain started at the LDCs, where the data was pre-processed. The IT resources and setups at the three LDCs had significant differences, but the tools being used were the same. The entire process was controlled and monitored using a small tool, LDC GUI. This tool decrypted data from the disk in the vehicles and, when processing was done, copied the data to large encrypted transfer disks for shipping to the CDC. Several pre-processing components used a common, well-defined protocol as an interface. The final pre-processing component wrote the output to Matlab files (one per trip/record). The different steps in the LDC GUI tool reported to the OMT—setting the processing status of each trip as it moved through the data management chain.

CDC

The data processing chain continued at the CDC, with three steps: importing the data, restructuring them, and preparing them for driver identification. The first step involved decrypting and importing the data to a staging area—a 40 TB temporary network share which hosted the data during the step. The data were then re-organized in a folder structure (by operation_site/vehicle/year/month/record_name), mostly to improve performance when reading directories, but also with access-permission procedures in mind. The next step checked whether the recorded videos had the needed meta-data (proper frame rate and indices). If not, they were corrected. When all videos had the correct format, the tool extracted a snapshot from the driver video view. The snapshot was used in the driver identification step; the driver in each and every record/trip was manually identified to ensure only consenting drivers were used in the analysis; see 2.5.1.

The CDC data flow was monitored in detail by a MySQL table, and the most important parts were also shared with the UDrive OMT. Some meta-data were also uploaded as attributes to the main UDrive database, for use by analysts.

2.4.2 Data storage and management

Records that were verified as from a UDrive consented participant were copied to final storage (a local network share of 50 TB), and were also copied to second-line storage using SweStore, a Swedish national IT resource for research data. Any personal data (i.e. video files) sent to SweStore were encrypted. Some data categories (subjective data from questionnaires, driver identification management, and UDrive analysis project share) were shared on network drives.

Finally, the data was uploaded to the UDrive database using an application programming interface (API) of the UDrive analysis tool, which performed the actual data upload. The UDrive database was hosted on a single powerful server, using MySQL database and InnoDB and TokuDB storage engines. The TokuDB storage engine, chosen specifically for its benefits when using large time series tables, has been very effective in the most common use cases performed by the analysis tool SALSA (see 2.4.4)—using efficient indices and data compression.

Each analysis user had his/her own account, and the users were granted access through grouping. That is, annotators had one set of access/usage rights, while basic analysts had another, and users needing direct access to the MySQL-database had yet another set of rights.

2.4.3 Data protection

The setup of an NDS such as UDrive is affected by a number of different national and international legal and ethical considerations (especially privacy issues), and subsequent requirements. Personal and intellectual property data are collected and handled for use in research; the distributed nature of UDrive poses some unique challenges for data management. The UDrive project therefore developed its own Data Protection Concept (DPC).

The purpose of the DPC was to ensure that data security meets all requirements during and after the project, and to achieve a common understanding of data protection among all partners. The DPC outlines the requirements and constraints for handling data during collection, storage, transfer, and analysis—until the end of the lifetime of the data. For each step in the data handling chain, the concerned stakeholders, the data, and the external requirements were identified (together with the related data protection requirements). Common definitions and procedures form the basis of the DPC. For example, all project partners handling data were required to implement and document their part of the DPC, based on their role in the project. A certification organization oversaw that an adequate level of protection was described at each data-handling step across the project and required a signed application from partners before the implementation (and subsequent data access) took place.

The UDrive DPC is the first comprehensive concept for pan-European field data collection describing how to protect and treat the naturalistic driving data across the data management chain. The concept can be easily updated to furnish templates for other projects, ensuring compliance and improving efficiency by providing step-by-step guidance to all involved partners.

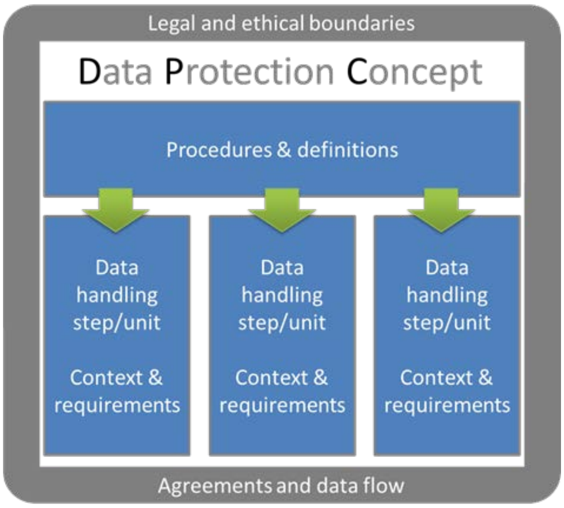

Figure 2.2: A visualisation of the components of the UDrive Data Protection Concept

2.4.4 SALSA: the visualisation and processing tool

In UDrive, data analysis was performed concurrently with data uploading and management. Annotators were manually coding attributes on a set of events, data processing might be running, transformed data might be extracted for analysis, several analysts might be developing new scripts to be included in the next processing, and new data might be in the process of being imported. Additionally, the process evolved over time. New derived measures had to be calculated and new annotations performed as the analysis progressed.

This complexity, added to the scale of the dataset itself (millions of kilometres with very rich data), called for the development of a dedicated tool, SALSA (Smart Application for Large Scale Analysis), based on previously existing developments in previous projects. UDrive developed the SALSA tool to manage the data and the complete data-reduction process (derived measures calculations, events detection and characterisation, and manual annotation); see Figure 2.3. This tool thus results from UDrive.

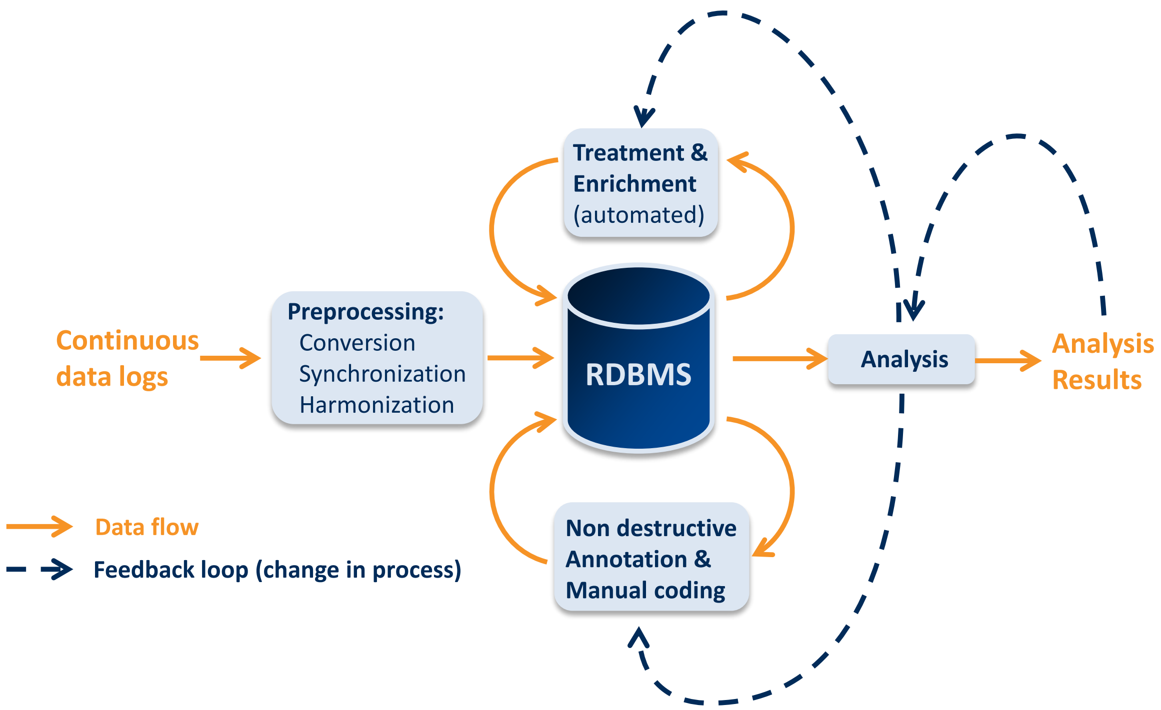

Figure 2.3. The process supported by SALSA

Alongside multiple secondary functionalities, SALSA implements six main features: data querying, visualization (Figure 2.4), annotation, interactive algorithm development, automated database management, and automated data processing.

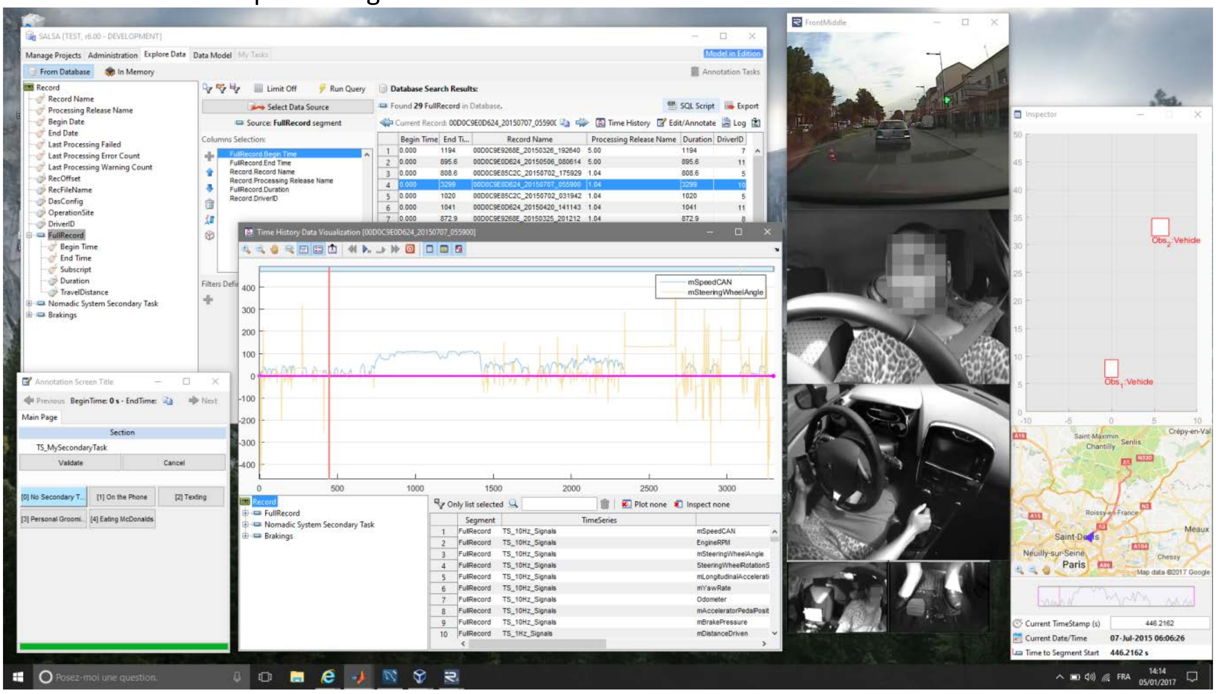

Figure 2.4: SALSA user interface in a typical visualisation and annotation scenario

The features are integrated together with a unified approach, rather than juxtaposed. SALSA provides analysts with "building blocks" which they can combine together, the way they desire, to describe a model of the data and the associated calculations, data segmentations, or annotations. The behaviour of the tool is entirely based on this data model, i.e. with all the definitions iteratively made by users. The tool itself is integrated within MATLAB, and users can define their own algorithms using the MATLAB language.

This data model is at the same time a *relational model* (data containers are organised as a hierarchy; Figure 2.5), in which dependencies (defined by linking scripts and selecting certain built-in behaviours) can span several hierarchical levels. SALSA uses all the definitions and links created by users to determine and optimise its behaviour. As a result, its features are tightly integrated, following shared definitions and rules, which helps user adoption.

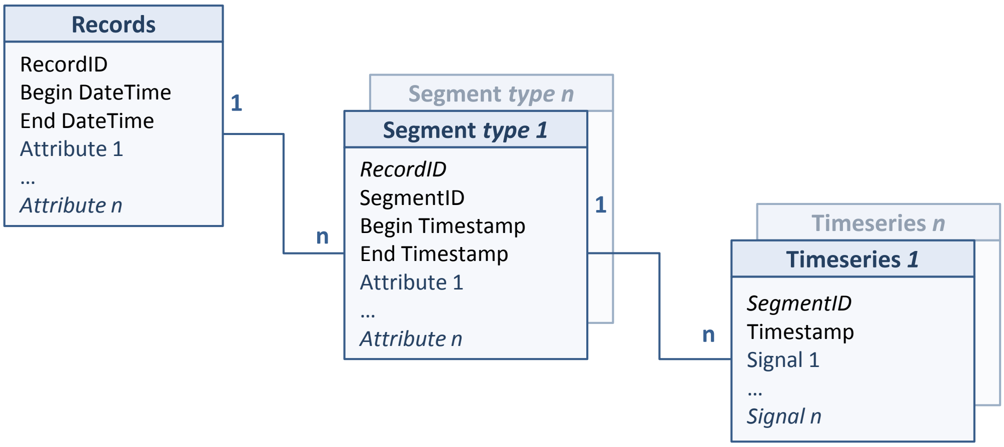

Figure 2.5: Simplified representation of SALSA's relational model

In UDrive, SALSA has been used by 97 different users, in three different projects (i.e. databases and corresponding data models): one for cars, one for trucks, and one for PTWs.

Table 2.1 below demonstrates the number of data model elements which have been defined by SALSA users during data preparation/processing/reduction. These numbers emphasize the massive effort carried out by the project to analyse the data.

Table 2.1: Data model elements count per project/category

	Raw measures	Nodes			Time Series	Derived measures	Segment types	Attributes	Other	Total
		Scripts	*Inputs*	*Outputs*						
Cars	302	509	1968	1385	261	407	92	1617	829	**7370**
Trucks	306	79	583	303	134	130	24	405	386	**2350**
PTWs	60	22	109	114	19	41	8	131	75	**579**

After preparation/processing/reduction, the final analysis was performed using various tools and languages, such as MATLAB, R, Python, and SPSS. That is, SALSA is a tool that supports analysts by facilitating the processing of individual recorded trips. All aggregated analysis (e.g., statistic using data from two or more trips), was (could only be) conducted with tools outside of SALSA.

2.5 The annotation process

2.5.1 Driver identification

For a record/trip to be considered for analysis it has to pass driver identification. The identification process consisted of verifying that the persons driving had given their consent for the UDrive project and assigning a person identifier to the record. Identification was made using the tool UniFOT, developed by Volvo Car in the euroFOT project and applied (modified) to UDrive (Figure 2.6). A total of 18 assistants from three analysis sites performed the manual task of driver identification. After receiving initial training regarding data privacy issues, assistants were instructed how to access and work with the tool. All identified records were double-checked by an experienced assistant in order to assure that only the videos from registered drivers were uploaded into the UDrive database to be further analysed. By May 24th 2017 a total of 306,000 records had been identified (48% car, 50% truck, and 2% PTW). Thirty-four percent of the truck records (representing 30% of the kilometres driven) and 84% of the car records (representing 94% of the kilometres driven) were uploaded to the UDrive database, as they were driven by UDrive consenting drivers who could be identified in the recorded videos. The records not uploaded were either driven by a non-UDrive driver, or, much more commonly, the video of the driver was not available so the annotators could not correctly identify/match the driver with UDrive-driver images. The PTW records were excluded from the driver identification process, as each individual PTW was used by only one rider and thus all records were simply uploaded to the UDrive database.

The identification task started in May 2016 and continued until the last day of the project.

Figure 2.6: Identification tool

2.5.2 Creation of the codebook

The creation of the codebook (Appendix B) was an iterative process. Based on the annotation needs stated in a) the preliminary analysis plan (see UDrive deliverable *UDrive D11.2 - Preliminary analysis plan*), and b) feedback sheets sent to all task leaders within the analysis sub-project, a preliminary list of annotation variables was prepared. This list was discussed, adapted, and completed during several conference calls with all analysis tasks. One major requirement for the UDrive codebook was that it be harmonized and comparable to other standard codebooks—most importantly, the one developed and used for many years at VTTI, which was used for the US SHRP2 NDS (SHRP2, 2010; VTTI, 2015). That is why all variables in the UDrive codebook refer to variables in VTTI's 'Researcher Dictionary for Safety Critical Event Video Reduction Data' version 4.1 of October 5, 2015 (AKA 'VTTI codebook'). Definitions, categories and related coding procedures were developed during conference calls and meetings, taking the needs of different analysis tasks into consideration. Variables needed for several analysis tasks were included in the list of variables for central annotation to be conducted at TUC. Special variables needed by individual analysis tasks had to be locally annotated. However, substantial effort was put into harmonizing variables across tasks.

2.5.3 The annotation process

Annotations were conducted between October 2016 and June 2017 using the SALSA software (see 2.4.4). A total of 19 annotators from three analysis sites were dedicated to this task, which consisted of visualising videos of entire trips (or smaller segments) and setting markers containing information that allowed the driving situation to be characterised. This was done in accordance with the codebook, while taking into account special requests from researchers. Before this task started, annotation panels were created in SALSA and linked to a specific dataset for each type of annotation. These panels, tested to make sure all variables and their respective categories were correctly defined prior to use, were the interface that annotators used to annotate (set the markers) in the videos.

The following describes the annotations (beyond driver identification) conducted at the main annotation site. Additional annotation (e.g., car-to-bicycle interactions) was performed locally, closer to the analysts.

Annotations at the main annotation site were performed for records stored in two distinct databases: UDrive car and UDrive truck. For the truck videos, the focus was on the identification and characterisation of secondary tasks. The variables were annotated in three distinct passes through each video. Pass A (the first to be conducted) was performed on full trips to define the beginning and end, as well as the type of secondary task. In this pass, it was possible to annotate up to three time series of secondary tasks simultaneously. The second, Pass B, broke down the mobile-phone and electronic-device secondary-task segments into specific actions that drivers conducted while interacting with the devices. Pass C characterised the surrounding environment (context) while drivers engaged in a secondary tasks.

Two types of annotations were conducted on the car data: identification and characterisation of secondary tasks (as performed in three passes for the truck videos) and pedestrian (VRU) annotation, which focussed on the interactions between drivers and pedestrians. This latter task consisted of annotating the events that were detected by the MobilEye smart camera (special events).

2.5.4 Quality assurance procedures

Several procedures were used to assure the quality of the annotated data. These included:

- Assistants received initial training. Training consisted of information about the aims of the project and data collection procedures, data privacy, the annotation task, the codebook, the annotation tool, and the communication procedure inside the annotation team. This initial training was performed several times and lasted approximately five hours. Further, in the first two hours of annotation they were accompanied by an experienced assistant/researcher.
- Assistants were recruited for the entire annotation period. Potential assistants expressing an unavailability to stay until the end of the project were not recruited. This not only saved time since recruiting new assistants was not necessary, but also meant the project benefitted from the cumulative experience that annotators gained.
- Both annotation site leaders and senior assistants worked closely with novice annotators and verified their work.
- For the secondary-task annotations, 100% annotation double-check, conducted by an experienced assistant/researcher, was performed for at least the first 5 annotation hours. For the pedestrians, all segments were double-checked to identify (and rectify) any potential disagreement.

Due to project time constraints, it was not possible to use all the planned quality control instruments. Although the annotated videos were verified by an experienced annotator, inter-rater reliability rates were not calculated, either for time-series or categorical variables. The double-check served to identify clear mistakes in the selection of annotated categories and to highlight the variables with higher rates of disagreement among assistants. Intra-rater reliability was not performed, either. Additionally, annotation team meetings were not conducted as frequently as expected; instead, communication consisted mainly of one-on-one meetings or email.

2.6 The UDrive dataset

This section describes the UDrive data in numbers.

2.6.1 Analysable data

Analysable data are the records/trips that have arrived at the CDC (see 2.4), successfully passed through driver identification, and been subsequently uploaded to the UDrive Database. That is, data that the analysts can see and analyse in the database (either directly or via the SALSA tool). The analysable data comprise a subset of the collected data. Figure 2.7-8 show the amount of data collected across the three modalities and the five countries. In UDrive, the gender and age distributions were as shown in Figure 2.9-11. The difference in total driving time across drivers, per modality, is shown in Figure 2.12.

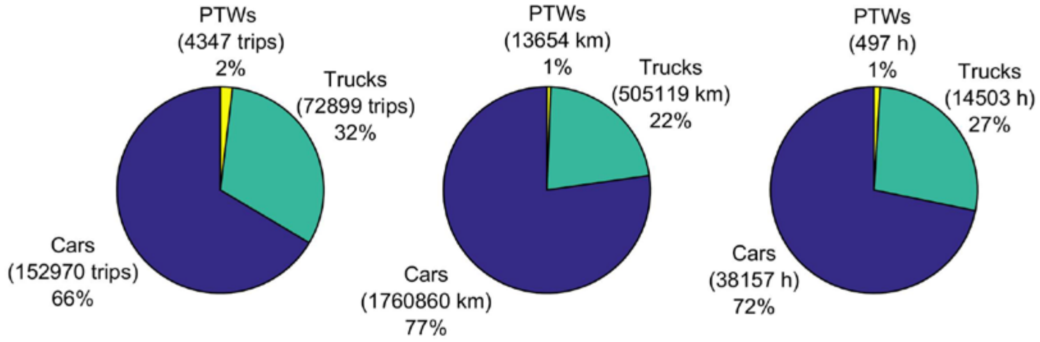

Figure 2.7: The analysable UDrive data for the three modalities

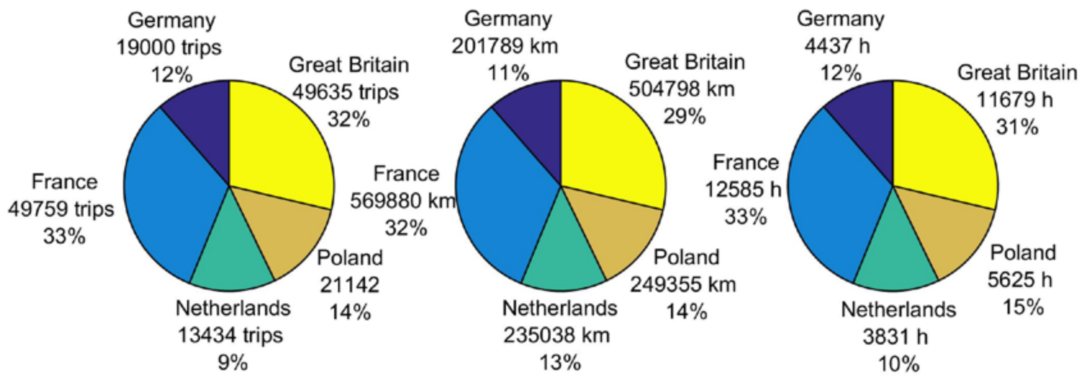

Figure 2.8: The analysable UDrive data across the five passenger car operation sites

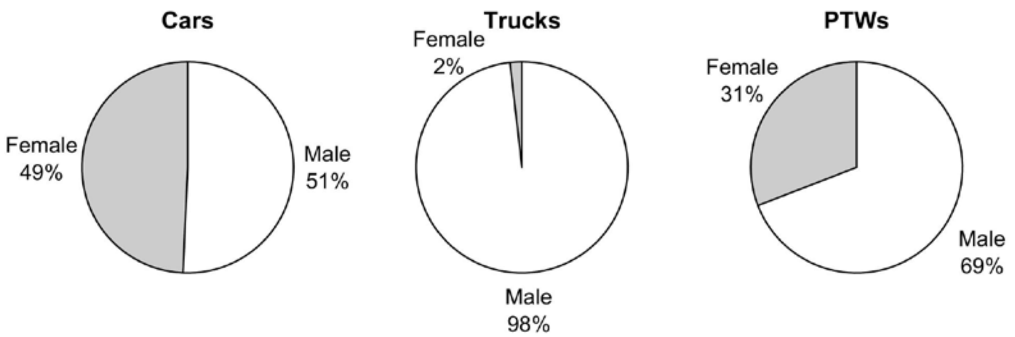

Figure 2.9: Gender distribution per vehicle type, calculated as percent of the number of hours driven (analysable data)

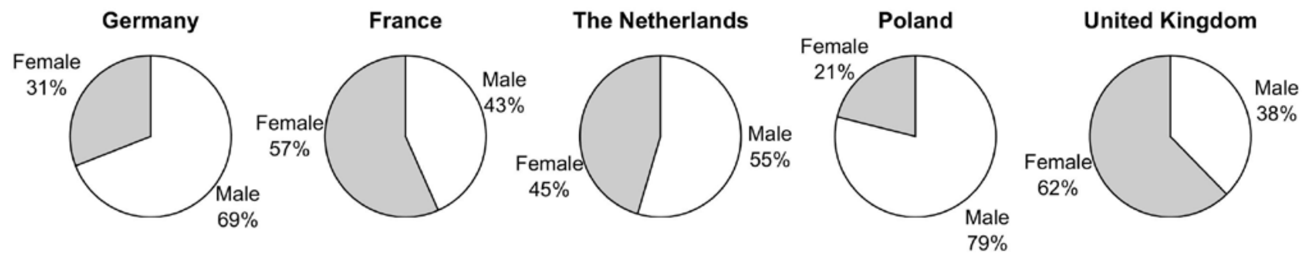

Figure 2.10: Gender distribution per country (for cars), calculated as percent of the number of hours driven (analysable data)

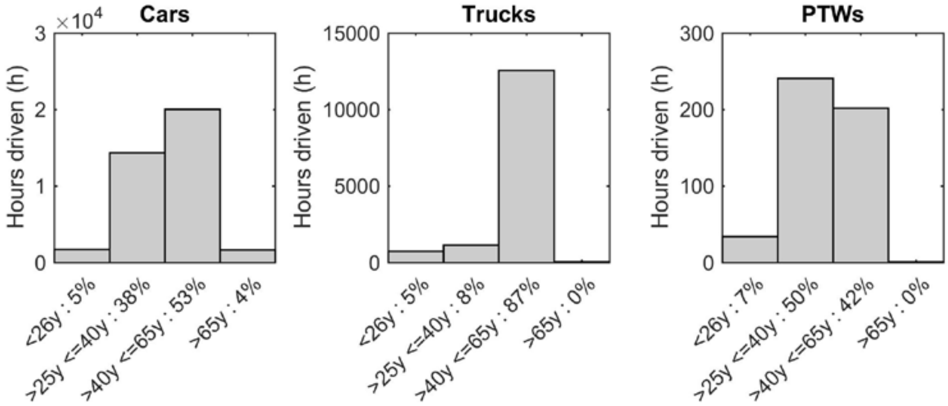

Figure 2.11: Age distribution per vehicle type as number of hours driven in total (analysable data)

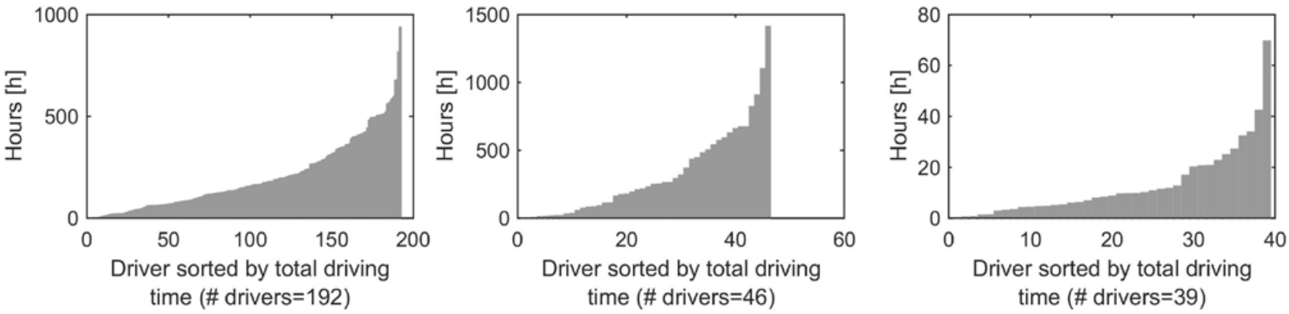

Figure 2.12: Total number of hours driven per driver (analysable data), sorted by increasing distance driven.

2.6.2 Annotations

Table 2.2 gives an overview of the number of videos/segments annotated in the project, up until end of May 2017. It is important to note that some annotations continued until the last day of the project. This means that the final number of annotated videos is higher than that presented in the table. The descriptions of Passes A-C can be found in section 2.5.3.

Table 2.2: Number of annotated videos / segments per annotation task performed

Database	Annotation	Number of annotated videos / segments
truck	secondary task	Pass A: 268 full videos

		Pass B: 203 segments Pass C: 431 segments
	VRU bicycles	Segment duration: ~15 sec Round 1: 1693 segments (quality check) Round 2: 372 segments (infrastructure, traffic, driver behaviour)
car	secondary task	Pass A: 867 full videos (227 hours travelled) Pass B: 375 segments Pass C: 583 segments
	VRU pedestrians	416 segments (20 sec long) for all 35 variables
	VRU bicycles	Segment duration: ~15 sec Round 1: 4415 segments (quality check) Round 2: 2361 segments (infrastructure, traffic, driver behaviour)

2.7 Generalizability

When working with the data it is important to have insight in the representativeness of the data. This section compares the UDrive countries with the other EU countries, followed by a comparison between the UDrive participants, the areas in which they drove, and the population of the corresponding UDrive countries. Finally, the representativeness of the UDrive fleet is evaluated.

2.7.1 Comparison UDrive countries with EU

Data has been collected across six European countries, including the south (Spain, France), east (Poland), and west (UK, Netherlands, Germany) of Europe. Table 2.1 summarizes a number of basic statistics across the UDrive countries, as well as for the entire EU.

Table 2.3: Basic data of participating countries in relation to the 2014/2015 EU average (Source: European_Road_Safety_Observatory, 2016).

Country	Road fatalities per million inhabitants	Vehicles / person	Fleet < 6 years (%)	Fleet > 10 years (%)	Exposure (billion vehicle km)	Gross Domestic Product per capita (k€)	Population density (pp/km^2)	Living in urban area (%)
FR	51	.67	34	33	572	31.5	105	79.5
GER	42	.68	33	36	709	34.1	114	75.3
NL	28	.64	30	41	146	38.7	407	90.5
PL	84	.67	10	71	207	10.9	122	60.5
SP	36	.71	26	43	224	23.1	92	79.6
UK	29	.57	38	37	521	31.1	266	82.6
UDrive average	45	.66	29	44	397	28.2	184	78.0
EU average	51	.62	22	49	122	26.3	114	73.3
EU minimum	12 (ICE)	.29 (RO)	5 (LIT)	19 (LU)	.6 (LU)	5.7 (BUL)	3 (ICE)	14.3 (LIE)
EU maximum	125 (BUL)	.95 (LIE)	51 (LU)	86 (LIT)	709 (GER)	80.5 (LU)	1359 (MAL)	97.9 (BEL)

NOTE: BEL = Belgium, BUL = Bulgaria, FR = France, GER = Germany, ICE = Iceland, LIE = Liechtenstein, LIT = Lithuania, LU = Luxembourg, MAL = Malta, NL = Netherlands, PL = Poland, RO = Romania, SP = Spain, UK = United Kingdom.

Although no data have been collected in Northern European countries (i.e., Finland, Iceland, Norway, Sweden), the ERSO database (European_Road_Safety_Observatory, 2016) shows that the figures for these countries overlap the figures for the UDrive countries on most factors in Table 2.3. There are two exceptions. The Northern European countries have a lower driving exposure (average: 39 billion vehicle km) and a lower population density (average: 14 inhabitants/km^2). With regard to the latter, however, the majority of the population is found in urban areas (average: 86.2%), which is the same order of magnitude as some of the UDrive countries.

In general, the number of road fatalities per million inhabitants in the UDrive countries are centred around the EU average. The Netherlands and the UK have the lowest (best) safety scores (albeit not nearly as low as the fatality rate in Iceland), whereas Poland scores higher (worse) than the EU average (but not as high as Bulgaria). The Netherlands is an atypical EU country, though, in that it has the highest prevalence of bicyclists, and the largest share of bicyclist fatalities (i.e., 25% compared to an 8% EU average). Thus, findings from the Netherlands may not be representative of other countries, especially when concerning interactions with bicyclists in urban areas.

The average Gross Domestic Product (GDP) of the UDrive countries approximates the GDP of the EU, with some countries above the EU average (but not as high as Luxembourg (80.5), Liechtenstein (67.8) or Norway (67.8)), and some countries below the EU average. With the exception of Poland, the vehicle fleet in the UDrive countries (not the instrumented UDrive vehicles) is relatively new compared to the EU average. Since newer cars are becoming more fuel-efficient, the difference in vehicle fleet age may influence the impact of studies on eco-driving. Furthermore, there is a somewhat higher motorisation rate in the UDrive countries compared to the EU average, with the only exception being the UK. The exposure (in terms of vehicle kilometers driven) is much higher in the UDrive countries, except for NL, where there is only a modest difference. On average, the population density and the proportion of the population living in urban areas is higher in the UDrive countries than the EU average. This difference is mainly caused by the relatively high (urban) population density in NL, whereas the other UDrive countries show densities both below and above the EU average (but as stated, not as low as in Northern Europe).

In sum, while some EU country characteristics may not be accurately represented by UDrive, the findings may be generalized to most EU countries.

2.7.1 Representativeness of the population within UDrive countries

There is no reason to expect fundamental differences in characteristics (like response times, fatigue, and how drivers handle secondary tasks) in each of the countries. Therefore, we examined the representativeness of the participants in terms of gender and age, as well as the areas where they drove their instrumented vehicle. Table 2.4 describes the age and gender distribution of the participants across the UDrive countries. The individual countries will be discussed next.

Table 2.4: Distribution of participant gender and age across the UDrive countries (for more information, see deliverable D30.1: 'Overview of the data collection effort').

Veh. Type / OS	Vehicles	Participants	Gender		Age			
			Male	Female	20-29	30-39	40-49	50-65
Cars								
France	30	45	47%	53%	9%	27%	31%	33%
Germany	20	30	63%	37%	17%	24%	7%	52%

UDRIVE
European Naturalistic Driving Study

Netherlands	10	33	55%	45%	9%	30%	27%	33%
Poland	30	31	71%	29%	6%	48%	39%	6%
UK	30	53	49%	51%	15%	28%	19%	38%
Average cars	**120**	**192**	**55%**	**45%**	**11%**	**31%**	**25%**	**33%**
Trucks								
Netherlands	32	48	98%	2%	6%	13%	32%	49%
PTWs								
Spain	40	47	74%	26%	9%	55%	34%	2%
Grand average	**192**	**287**	**66%**	**34%**	**10%**	**32%**	**27%**	**31%**

NOTE : Averages are weighted by the number of participants in each OS. The age category 20-29 includes one 18 year old German participant, and the age category 50-65 includes one 81 year old German participant.

France

The French sample included a total of 45 participants, of whom 30 were main drivers. Participants drove mainly in and around the city of Lyon, except for one who drove mostly around the city of Bordeaux and also around Lyon. All road types are expected to be represented in the French sample, since input on the reasons for their trips were unknown. Male drivers made up 47% whereas women comprised 53% of the sample; therefore we estimate a rather good representation of both groups. Drivers over 40 years old are greatly overrepresented, with 31% between 40 and 49 years old and 33% between 50 and 65 years old. Young drivers are then dramatically underrepresented, with only 9% between 20 and 29 years old. All of the participants were active professionally in companies; no students were recruited.

Germany

German participants drove their cars mainly in and around the city of Braunschweig, although two participants drove in Berlin. The participants drove on different types of roads (urban, rural, and highways), which gives a good representation of the country. However, the driving population was not fully represented, as only Renault vehicles (Megane and Clio) were allowed in the project (see section 2.7.1). A total of 30 drivers participated in the study, including secondary drivers; 19 were men (63.3%) and 11 were women (36.6%). (Men were overrepresented.) Participants' ages varied between 18 and 81 years (45 on average). Since only 13 participants were below 40 years of age, the sample lacked young drivers and is not representative of the car-driving population.

Netherlands

Dutch car drivers drove leased Renault Clio IVs, provided to them free of charge while they participated in the study. They drove in the Netherlands for six months (without restrictions), with a focus on the central and western parts of the country. These areas, predominantly urban, are where most of the Dutch population lives, including the participants. They may not have been typical Clio drivers, because they all owned another car which they drove at least 40,000 km per year. However, the participants committed to using the Clio for the project (they left their own cars in the parking lot). As with the German sample, younger drivers (below below 30 years old) were underrepresented.

The Dutch UDrive trucks were distribution trucks from five different fleet owners, with bases in different parts of the Netherlands. This means that the UDrive trucks more or less covered all types of roads (urban, rural, and highways), and there was no specific area where they did not travel. Truck driving in Dutch cities might be different from other European countries. Infrastructure, culture, and regulation may differ from other European countries, because in the Netherlands there are more bicycles and there is good bicycle infrastructure. These differences may influence the observed driving behaviour. Also, the quality of the trucks and their drivers is highly regulated in the Netherlands. This means, for example, that blind spot mirrors are obligatory. However, driving on non-urban roads (highways and rural roads) is quite representative of Europe. The truck driver sample was representative of the Dutch truck driver population in terms of gender and age, and the participating fleet owners were representative of the average fleet owner in the Netherlands. The only difference between these and other fleet owners is that these were very open to new research and development—and were willing to put time and effort into this project. There is no reason to expect Volvo truck drivers to be fundamentally different from truck drivers of other truck brands. The fleet owners involved in the UDrive project all owned other truck brands as well, and their drivers were flexible to shift between the trucks of different brands (including the UDrive Volvos).

Poland

In Poland, 30% of the 31 car drivers were women, which means that men (70%) were overrepresented. The age of the drivers ranged from 20 to 62 years, with an average age of 39 years. A total of 17 participants were less than 40 years old; therefore, the age groups are well represented. With regard to occupation, 26 drivers work in companies, three drivers are self-employed, and one driver is a student. Therefore, the sample has an overrepresentation of drivers working in companies and an underrepresentation of students. It is estimated that 70% of the driving hours took place on Warsaw streets, and 40% of these were related to commuting. These estimates are comparable to the Warsaw Travel Survey 2015. However, five drivers, all of whom worked in traffic engineering near Warsaw, were exceptions. They drove 75% of the time on intercity roads, of which 30% was commuting. Their mileage was approximately three times higher than that of the other drivers.

Spain

There were 47 PTW participants in total, 12 females (26%) and 35 males (74%). The sample is representative of the Spanish PTW rider population with regard to gender. However, the sample was not representative in terms of age. Data was collected in two waves (two sets of drivers). Many participants in the first wave (first set of riders) were in their 30s and 40s, so a second wave of participants under 35 years old was recruited.

Most of the PTW journeys were urban trips in the city of Valladolid, except for two participants from the city of Palencia and another two from the city of Seville. With a population of 300,000 inhabitants and an area less than 200km^2, Valladolid is not a very large city. The climate of Valladolid is similar to southern European cities. In terms of infrastructure, Valladolid has some vertebral big avenues, two motorway rings around the city, and narrow one-way streets in the residential neighbourhoods. Speed is limited to 50km/h inside the motorway ring, and some residential areas are restricted to 30km/h or 20km/h. The traffic in Valladolid is similar to other Spanish cities, and the PTWs was used mainly for commuting. However, in larger cities, traffic jams are more frequent but the infrastructure (e.g., intersection types) is similar.

United Kingdom

Operations were undertaken in two distinct UK regions, representing typical road networks in the UK (large and small urban areas as well as rural areas). On average the reason for travel is likely to be similar to the UK National Travel Survey (40% commuting); however, there are likley individual deviations. Some of the car drivers were retired and therefore did not make any journeys for commuting. In the case of multi-driver cars, the primary driver tended to use the car to travel to and from work as well as leisure/shopping trips, whereas the secondary drivers were much less likely to use the car for commuting. Some drivers had only a short (< 8km) commute whereas others had a commute > 81km per day. The sample overrepresents multi-car households (33% in UK, 60% in sample).

The sample contains 49% male and 51% female drivers and slightly overrepresents female drivers (licence holders in the UK are 54% male and 46% female). In terms of driver age, the sample distribution matches the national distribution of licence holders aged 20-65 for 20-29 (16%) year-olds and 50-65 year-olds (38%); however, the sample comprises 28% 30-39 year olds, compared to 21% nationally—and 19% 40-49 year olds, compared to 25% nationally.

2.7.1 Representativeness UDrive fleet

This section describes the representativeness of the UDrive cars, trucks, and powered two-wheelers for the overall EU vehicle fleet.

Cars

Based on the vehicle segmentation suggested by the European Commission (1999), the Renault Clio and Renault Megane cars used in UDrive fall within the small and medium car segments, respectively. Together, these segments accounted for 49% of the European Union passenger car market share in 2011 (see Table 2.5). This means the findings of the UDrive car analysis can be generalized to a large part of the European car market. However, not all findings may be generalizable to the other car segments. Recent large and expensive cars are more often equipped with sophisticated driver assistance systems (e.g., lane keeping assistant, adaptive cruise control) than relatively small and cheap cars. Experimental studies have shown that drivers who have such systems at their disposal tend to be more involved with non-driving tasks, to compensate for the relative lack of activation that the automation brings about (Carsten, Lai, Barnard, Jamson, & Merat, 2012). Therefore, the prevalence of driver distraction in UDrive may be an underestimation for cars in segments D, E, F, and S in Table 2.5 (market share: 29%), especially on long motorway trips.

Table 2.5: Passenger car market share as function of vehicle segment (adapted from Thiel, Schmidt, Van Zyl, & Schmid, 2014)

Segment	Segment name	Examples	Market share 2011 (%)
A	Mini cars	Fiat 500, Renault Twingo, Smart Fortwo	8.7
B	Small cars	**Renault Clio**, Opel Corsa, Peugeot 207	26.0
C	Medium cars	**Renault Megane**, Volkswagen Golf, Mazda 3	23.3
D	Large cars	Ford Mondeo, BMW 3-series, Volkswagen Passat	11.0
E	Executive cars	Audi A6, Lexus GS, Tesla Model S	3.3
F	Luxury cars	Mercedes S-class, Maserati Quattroporte	0.3
J	Sport utility cars	Toyota RAV 4, Hyundai Sante Fe, Range Rover, Volvo XC90	12.9
M	Multi-purpose cars	Citroen C4 Picasso, Honda F-RV, Renault Master, Ford Transit	13.1
S	Sport coupes	Mazda MX-5, Porsche 911	1.3

Trucks

It is not possible to state if Volvo FM and Volvo FL are representative in a specific segment of truck-operations, as each truck can be customized and fall in many other truck-operation segments. However, as only distribution trucks were included in the UDrive study, the driving is naturally only representative of distribution driving (and not, for example, long-haul). Trucks from four different fleets were part of UDrive; given the large variety of logistics fleets that operate in the Netherlands, it is difficult to generalize about company safety policies, driving culture, and businesses with four fleets represented. However, it is considered unlikely for there to be any specific systemic bias in our sample of fleets or drivers.

Powered Two-Wheelers

The Piaggio Liberty has been one of the top 5 PTWs sold in Spain for the last 10 years. This 125cc scooter (PTW) is representative of the scooters used for urban trips and commuting. However, it is not representative of other types of PTWs with larger engines (e.g., sport, touring, enduro, trail), which are typically used for leisure and/or long trips.

3. Everyday and risky driving

3.1 Introduction

In driving school, drivers learn a complex set of rules intended to minimise the risk of being involved in a crash. Among others, some of the key rules of conduct are driving within legal speed limits, keeping a safe following distance, driving carefully, anticipating the situation, and not engaging in secondary tasks such as texting or dialling. Crash statistics and other research show that not following these rules of conduct may lead to crashes—as speeding, following closely, and distraction have been identified as main causes. Being caught overstepping these rules is unlikely, and crashes are rare events; therefore, drivers may not receive direct feedback on their actions' relation to safety, making them less likely to follow the rules. Little is known about the prevalence of these risky behaviours. Questions such as whether drivers speed on rare occasions (or deliberately) and whether they always follow a lead vehicle closely (in time or space) are of research interest, as the answers provide information on the prevalence and risk of behaviours disregarding safety precautions.

Naturalistic Driving Studies (NDS) give us a unique opportunity to observe drivers and riders during everyday driving and in risky conditions or behaviour. Although very many hours of driving and riding have been recorded, this is not sufficient to find (enough) crashes to calculate actual risks. Further, in UDrive time constraints made it unfeasible to identify and classify safety-critical events (e.g., near-crashes) for use in risk calculation. Therefore, analysis was refocussed on everyday driving (for example, overtaking on rural roads, speeding, and close following). We also studied hard braking, the use of advanced driving assistance systems (ADAS), and seatbelts—and investigated contributing factors to seatbelt (non-) use. In addition, the self-confrontation technique was applied to investigate risky events in more detail. In UDrive, the technique consisted of showing videos of critical or risky situations (such as secondary task engagement) to the drivers who had experienced them during the UDrive NDS, and following up with interviews and targeted questions. With this technique, the driver's own recollection of events can provide more information about drivers understanding of near-crash and secondary-task engagement situations.

3.2 Safety-Critical Event Triggers

Initially, it was planned to perform risk calculations for a variety of risk factors, such as engaging in different secondary tasks. However, due to delays in the project, little time was left for analysis by the end. Risk calculations in particular depend on video annotation, as very few crashes occurred in UDrive so safety-critical events (SCEs; see Appendix B) were to be used a surrogates. Using SCEs for risk calculations means they need to be identified, classified, and annotated in detail (see Appendix B). Given the UDrive time constraints, the advice of the UDrive Advisory Board was to minimise the analysis of SCEs (and actually shift resources to the analysis of interactions with vulnerable road users, which was done). However, this meant that no risk estimations comparing SCEs to baselines were performed in UDrive. Some work was performed prior to the decision to shift focus, laying the groundwork for performing this analysis after the project. The following describes these preliminary efforts and some results.

The definition of SCE triggers, their safety relevance, and their classification are all important aspects for upcoming SCE analysis. Developing the triggers is an important research aim, since the selection of triggers directly influences the quality of the resulting risk analysis. The UDrive codebook (Appendix B) was developed to minimize subjectivity in SCE classification. The SCE triggers were developed with the priority of capturing as many relevant SCEs as possible with minimum annotation resources, while providing as unbiased a selection of actual SCEs as possible (aiming for a reasonable representativeness of the crash population).

Two approaches were used to define SCEs in the UDrive project. The first approach (using static kinematic triggers) compared data to static threshold values for a set of kinematic measures. This approach relies on drivers' responses to unexpected traffic situations and extreme vehicle kinematics, such as hard braking at a certain time before collision. Methods using weighted sampling were considered, but were excluded from the UDrive scope (when the research changed focus from SCE analysis to everyday driving and vulnerable road users).

In the second approach (using probabilistic trigger thresholds), the trigger thresholds were based on bi-variate distributions of key trigger measures (e.g., speed and acceleration, or speed and time-to-collision). An example of the process of probabilistic trigger selection is given in Figure 3.1. In essence, the probabilistic trigger threshold method is a framework that describes how to derive dynamically changing thresholds from the estimated probability density distribution of the feature space of the involved trigger parameters. The dynamics of the thresholds can be determined as a function of contextual parameters (e.g., speed or other kinematic parameters). The method in its simplest version was applied to the UDrive data set and the corresponding events that were detected. Further work was halted based on recommendations by the UDrive Advisory Board, and efforts were shifted to analysis of everyday driving and interaction with vulnerable road users. Method development will continue and a comparison of both approaches will be performed in future studies.

The intent (before refocus) was to identify all points in the UDrive data exceeding given kinematic trigger thresholds (static or probabilistic, depending on the approach). This sample (SCE candidates) would then have been reviewed by trained video analysts, classifying them as safety-relevant (or not)—thus producing a set of valid SCEs.

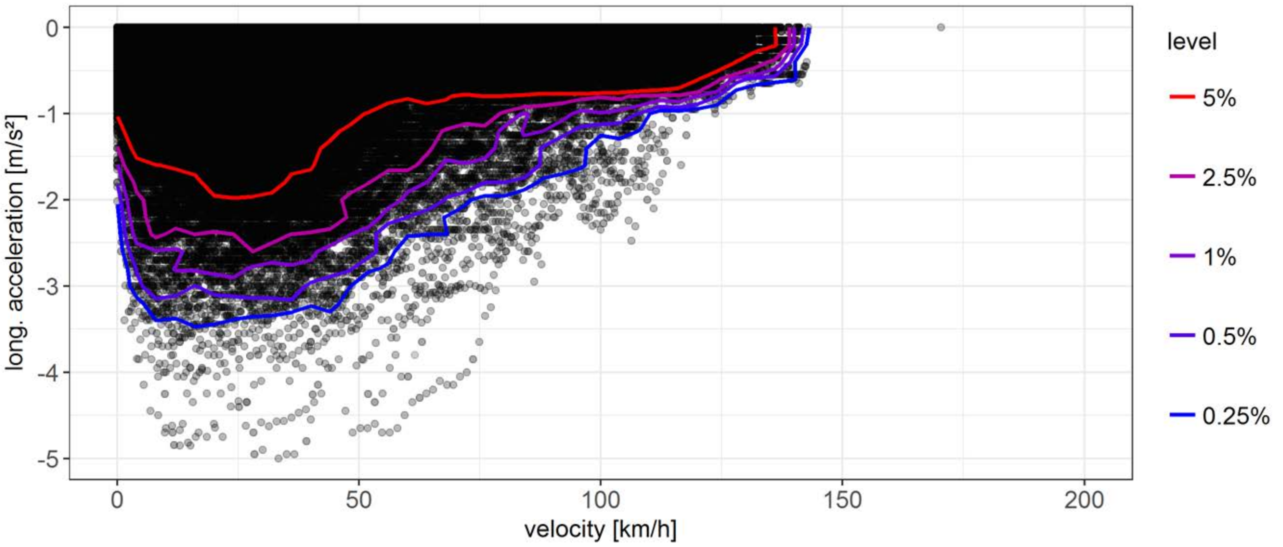

Figure 3.1: Scatter plot of longitudinal acceleration against velocity based on randomly drawn sample of trips. Coloured lines refer to different contour lines of equal cumulative probability levels from 0.25% up to 5% (percentiles). The contour lines can be used to approximate the probabilistic trigger threshold functions.

3.3 Risky driving

The key research questions for the overtaking analysis were:

- *Are there differences in overtaking behaviour between driver factors (gender, country)?*
- *Are there differences in overtaking behaviour between situational factors (passenger presence, overtaking regulation, presence of a bend or an alley, and oncoming traffic)?*

3.3.1 Key results

Overtaking of cars and trucks

The analysis of car-overtaking manoeuvres is based on the data available on March 31st 2017. It includes 2351 overtaking situations. The overtaking manoeuvre was partitioned into the following six phases (see

Figure 3.2): Approaching and following the lead vehicle (phase 0), initiating first lane change (phase 1), ending first lane change (phase 2), overtaking/driving in opposing lane (phase 3), initiating second lane change (phase 4), ending second lane change (phase 5).

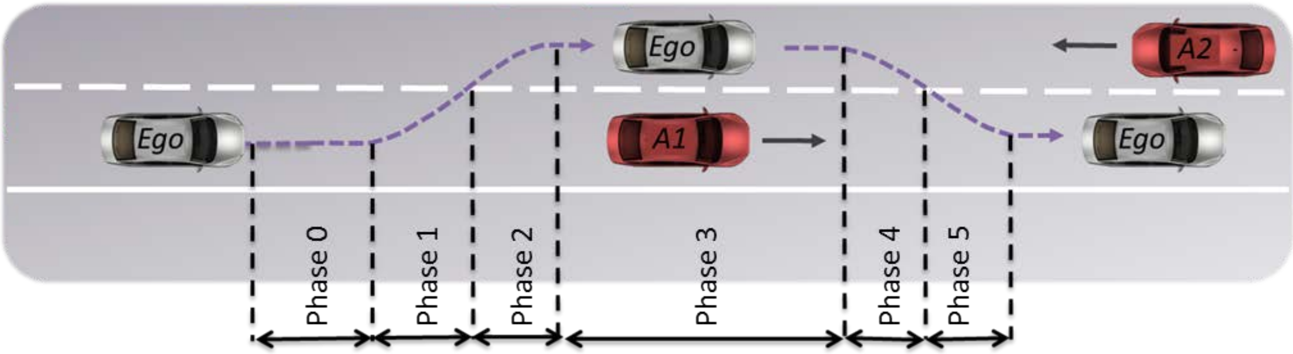

Figure 3.2: Schematic representation of an overtaking manoeuvre showing the division into six phases.

The type of takeover manoeuvre was determined (see Table 3.1: normal, flying, normal and piggybacking, or flying and piggybacking), and it was noted whether the driver engaged in a secondary task while overtaking the lead vehicle(s).

Table 3.1: Overview of types of overtaking manoeuvres

Type of overtaking	Description
Normal	Following another vehicle, then overtaking it
Flying	Approaching and overtaking the other vehicle with vehicle speed relatively constant
Normal and Piggy-backing	Normal while following another vehicle during overtaking
Flying and Piggy-backing	Flying while following another vehicle during overtaking

Table 3.2: Overview of frequencies by type of manoeuvre in total and by as situational factors.

Type of manoeuvre	N	Passenger present		Overtaking Prohibited		Secondary task		Curve		Alley	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Normal	25	11	14	3	22	1	24	3	33	10	15
Flying	15	5	10	0	15	1	14	2	13	4	11
Normal-piggybacking	1	0	1	1	1	0	1	0	1	0	1
Flying-piggybacking	4	1	3	1	3	0	4	0	4	2	2
Total	**45**	**17**	**28**	**5**	**41**	**2**	**43**	**5**	**51**	**16**	**29**

Table 3.2 provides information about situational factors. Results show that most of the overtaking manoeuvres were typed as normal and one third of the manoeuvres were flying manoeuvres. In addition, one normal manoeuvre with piggybacking was observed, as well as four involving flying and piggybacking. In this table, descriptive analysis also provides some more information on situational factors accompanying the takeover manoeuvre. In approximately one third of the overtakings, no passengers were present in the vehicle. All but five of the overtaking manoeuvres were performed when overtaking was permitted. There were only two occasions when drivers engaged in a secondary task while overtaking; one sang and one

interacted with passengers. In addition, most overtaking manoeuvres were initiated and completed with a clear view, occurring in only five instances just prior to an upcoming curve.

The link between driving personality and overtaking behaviours was investigated. All drivers were classified as “overtakers” or “non-overtakers”, based on whether they performed a rural road overtaking manoeuvre. Drivers were also categorised as either “high” or “low”, depending on their scores on each subscale of the subjective measures (given at the outset of the project). The proportion of overtakers and the speeding rate were compared between personality categories

Table 3.3: Overtaking rates per Personality category

Personality questionnaire	Low group: Overtaker %	High group: Overtaker %	Difference
Driver Attitude Questionnaire: Speeding	68	78	10
Driver Attitude Questionnaire: Close Following	64	83	19
Driver Behaviour Questionnaire: Aggressive Violations	66	79	13
Arnett’s Sensation Seeking Scale: Intensity	79	65	13
Driver Skills Questionnaire: Speeding	69	77	8

3.3.2 Conclusions and future work

Results show that how drivers overtake another vehicle is not affected by the presence of passengers, overtaking regulations, road curvature, vegetation, or secondary tasks. On the other hand, it was observed that drivers were conscious of the surrounding circumstances. For example, curves are not suited for overtaking, since vision is usually restricted and the acceleration needed may lead to sliding off the road while turning. It is thus no surprise that less than 10% of overtaking manoeuvres involve a curve. However, drivers appeared to be conscious of the environment by avoiding overtaking in curves, in adverse weather conditions or when traffic was oncoming on the adjacent lane. They also respected overtaking regulations. Only 12% of overtaking manoeuvres were done when prohibited.

Overtaking was more common among drivers who whad high DBQ Speeding scores. Surprisingly, the overtaking drivers had stronger negative opinions towards speeding behaviours, suggesting a disconnect between their attitudes and their behaviours. This may be explained by a stronger negative attitude about close following than about speeding, creating a willingness to overtake a lead vehicle. As we might expect, drivers who overtook on rural roads self-reported more aggressive violations and showed higher sensation-seeking tendencies. Overall, it would appear that the drivers with high risk-taking scores in self-reports actually engage in risky overtaking behaviours in reality too.

However, much of the data are still untouched and can certainly reveal many more insights into when and why drivers choose to overtake, as well as information about the prevalence of overtaking in everyday driving.

3.4 Self-confrontation

Self-confrontation is a method used to investigate risky events which provides more detail than NDD alone. In UDrive, drivers watched the videos of critical or risky situations (i.e., secondary task engagement) that they personally had experienced. The video viewings were followed by interviews. With this technique, drivers’ recollections of events in certain near-crash situations and during secondary task engagements become part of the collected information. The goal was to gain more insight into: a) how and when secondary tasks or risky events occur, b) the sequence of events that led up to them, and c) the driver’s role in this sequence (active or reactive). In addition, the applicability and usefulness of this technique was assessed in the framework of NDS.

3.4.1 Key results

Sixteen of the 30 French drivers were individually interviewed during the de-installation of their vehicle (in April 2017). Interviews, divided into three phases, lasted approximately 1.5 hours for each individual. The first, the longest, consisted of presenting the driver with at least two clips selected from the most recent available videos (dating back to January or February 2017): one presented a secondary task situation (typically a phone call), the other a hard braking event. The objective was to reconstruct as precisely as possible the episode as experienced by the driver, using the self-confrontation method: introduce the global context in the present tense ("Here, Thursday, 5: 00, you just quit your job"), launch the video a few seconds before the critical event, share the driver's field of interest (e.g., look at what he/she is looking at), then stop the video to let the memory take over, using empty content ("and here...") and echo phrases. In short, this phase was meant to stimulate drivers' recall of situations that they experienced as critical. The interview ended with a questionnaire covering all the above items (For example, "I rarely/sometimes/often/always write text messages while driving").

Methodological issues Results suggest that the self-confrontation method is particularly successful in revealing and analysing risky situations. The recall of hard-braking sequences, if they were actually experienced as critical, was relatively effective. However, the method clearly reached its limits for the analysis of secondary task situations. In this case, recall of the memory was much more difficult: it appears that drivers do not always reconnect with a particular situation but that, instead, the video evokes a prototypical memory of the same type of situation. The method should, therefore, be adapted to improve the study of less risky situations.

Driver knowledge Interviews provided data concerning three crashes and described, conversely, factors of intentional risk-takings in situations that remain safe. Reported crashes appear to be essentially related to complex infrastructure configurations which give rise to ambivalent behaviour from the driver or a third party (such as the unanticipated refusal of priority in a roundabout or a false start at a hairpin intersection to gain visibility).

Risk-taking factors were classified into six categories. Concerning secondary tasks, the study showed that the idea of "falling into" a second task is not valid for all drivers. Participants appeared to be basically in a dual task mode, the question being then how to characterize those situations that require their full attention to the driving task.

3.4.2 Conclusions and future work

The contrasting results of the self-confrontation method are not surprising. Indeed, risky situations and secondary task situations differ in their emotional value. The former are highly emotional for drivers while the latter are barely significant. Given its limitations, this method should be used primarily for emotionally striking events (when utilized in longitudinal naturalistic driving studies).

Although the epistemic results replicate data already highlighted by previous studies (e.g., factors of driving distraction), the weight given by drivers to (misleading) infrastructure factors (e.g., roundabouts without visibility) was surprising. However, this type of factor has the advantage of giving rise to clear recommendations: enhance infrastructure as much as possible.

The most promising results are related to drivers' distribution of attentional resources, particularly related to their on-board task management through the different periods and environments of the trip: departure, city context, tiredness sequence, turbulent traffic zone. Interview analysis revealed information about the triggers which prompted the driver's decision to interrupt the secondary task. This information could increase what is known about the risk of second-task activities.

3.5 Everyday driving

This section considers the impact of driver and environmental factors on the occurrence of risky behaviours. Driver factors include gender, age, driving experience, and various personality metrics; environmental factors include high-level factors such as road type and speed limit. The link between these factors and a range of risky behaviours (including speeding, close following, overtaking, harsh braking, ADAS use, and seatbelt use) was investigated.

The key research questions for the everyday driving analysis were:

- Who engages in risky driving behaviours?
- What driver factors influence engagement in risky driving behaviours?
- What environmental factors influence engagement in risky driving behaviours?
- How does traffic culture or country influence engagement in risky behaviours?
- How and when do drivers engage with ADAS?
- What driver and trip characteristics influence seatbelt use?

Data used for the analysis of risky driving behaviours (speeding, close following and harsh braking) in everyday driving are based on the UDrive data query of April 21st, 2017. The prevalence of speeding behaviours was studied, as well as when drivers decided to speed. The degree of speeding was determined by calculating the difference between the posted speed limit and the driven speed. Speeding was defined as travelling at least 11% over the speed limit for more than 10 seconds. For the purpose of the analysis, speeding was grouped into three categories:

- Light speeding = Exceeding the speed limit by 11%-15%
- Severe speeding = Exceeding the speed limit by 16-20%
- Extreme speeding = Exceeding the speed limit by 21% (no events found)

Close following was defined as travelling behind another vehicle with a time headway less than 1.5 seconds for at least 1.5 seconds.

Three thresholds were defined for hard braking events, describing (three harsh braking event types of)increasing severity; deceleration of 1 m/s^2 for at least 2.0 seconds, deceleration of 3 m/s^2 for at least 0.5 seconds, and deceleration of 5 m/s^2 for at least 0.3 seconds.

3.5.1 Key results

Car speeding

The speeding data (see Figure 3.3) shows that light speeding events were more frequent than severe ones (12-31%). (The frequency of speeding events was weighted by exposure.) Results show that more speeding events take place in low-speed-limit zones (1-30km/h) than in any other zone, and approximately half of all speeding events take place at speed limits of 50km/h or less. Note that more than a third of all kilometres driven on 30km/h roads are over the speed limit.

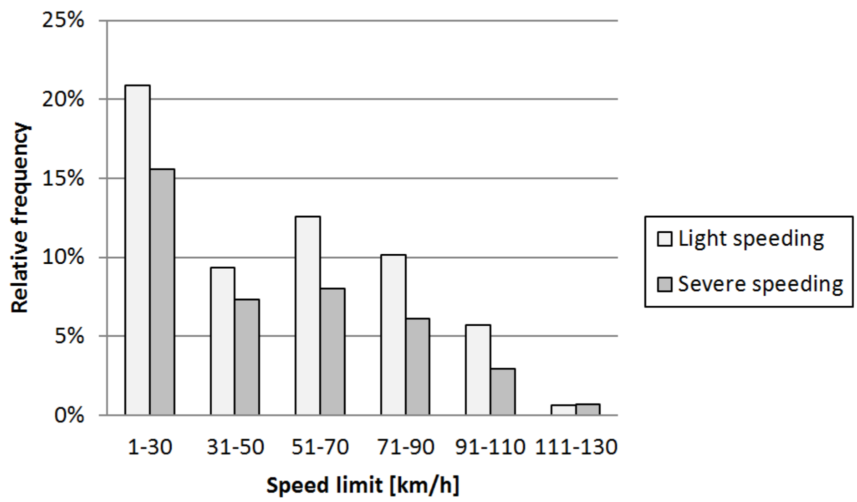

Figure 3.3: Relative frequency of speeding events by posted speed limit (from map data). Frequencies are weighted by exposure of time driven under a specific speed limit.

With respect to time of day, speeding events were mostly observed during late night hours (0:00-6:59; ~32%). In addition, speeding was also frequently observed in the afternoon (13:00-18:00) and in the morning (06:00-10:00; Figure 3.4). About 40% of all speeding events were observed during these two time frames.

Gender differences were observed in speeding behaviour, although the distributions between the genders were fairly equal. Females were more frequently involved in light speeding and males in severe speeding (Figure 3.5).

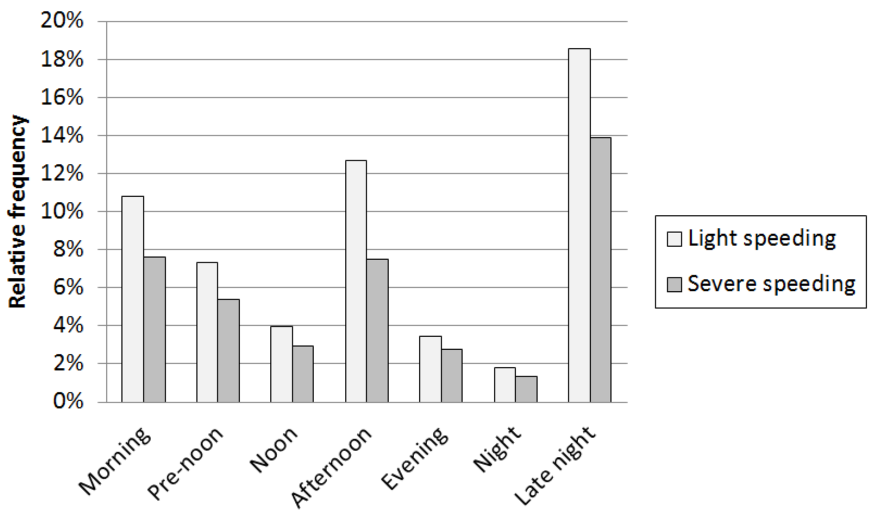

Figure 3.4: Relative frequency of speeding events by time of day. The frequencies are weighted by exposure of time driven during a specific time of day.

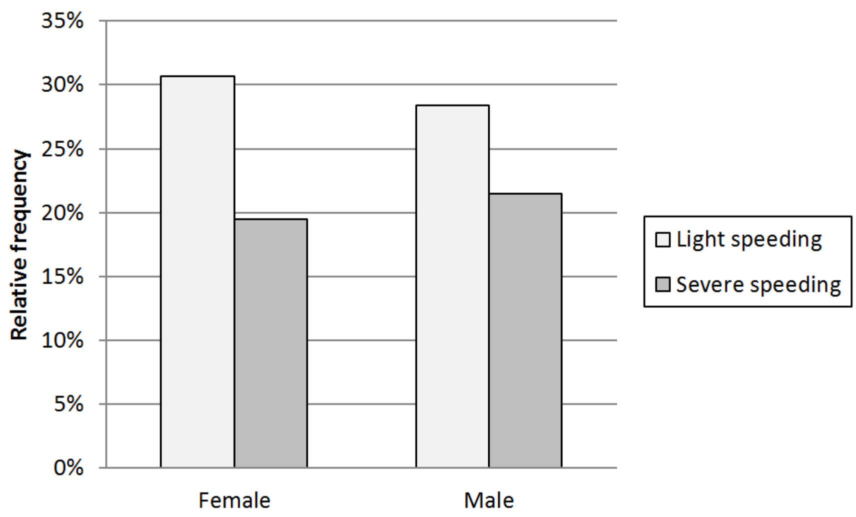

Figure 3.5: Relative frequency of speeding events by gender. The frequencies are weighted by exposure of time driven for each gender.

Drivers were categorised into two categories, high and low, depending on their scores on each questionnaire subscale. Speeding rates were compared between these categories (Table 3.4). Drivers who committed at least 20 excessive speeding violations had a higher score on a composite scale of negative driving personality traits. Self-reported speeding behaviour was also a good predictor of the likelihood of a driver having a high number of excess speed occurrences. Drivers who frequently broke the speed limit also reported a high level of both aggressive and ordinary violations, and self-reported a high level of 'deviant' behaviours.

Table 3.4: Speeding rates per Personality category

Personality questionnaire	Low group: Speeder %	High group: Speeder %	Difference
Composite negative driving traits	48	59	+11
Driver Skills Questionnaire: Speeding	43	62	+19
Driver Skills Questionnaire: Deviance	47	58	+11

Close following of cars

The analysis of close-following events revealed that most of them happened within speed limits of 31-50km/h (66%), followed by speed limits of 51-70km/h (13%) and 71-90km/h (9%; Figure 3.6). The results show that, on average, male drivers had a 0.1s longer time headway (M = 2.34 s) than female drivers (M = 2.25 s; Figure 3.7).

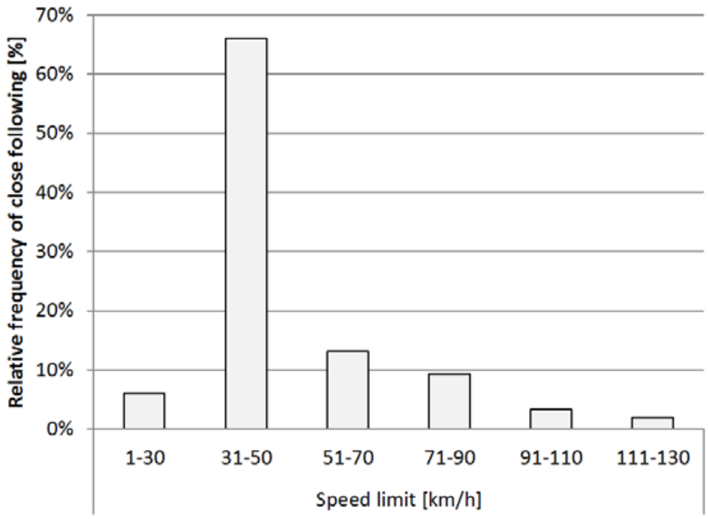

Figure 3.6: Relative frequency of close-following events by posted speed limit (from map data). Frequencies are weighted by exposure of time driven under a specific speed limit.

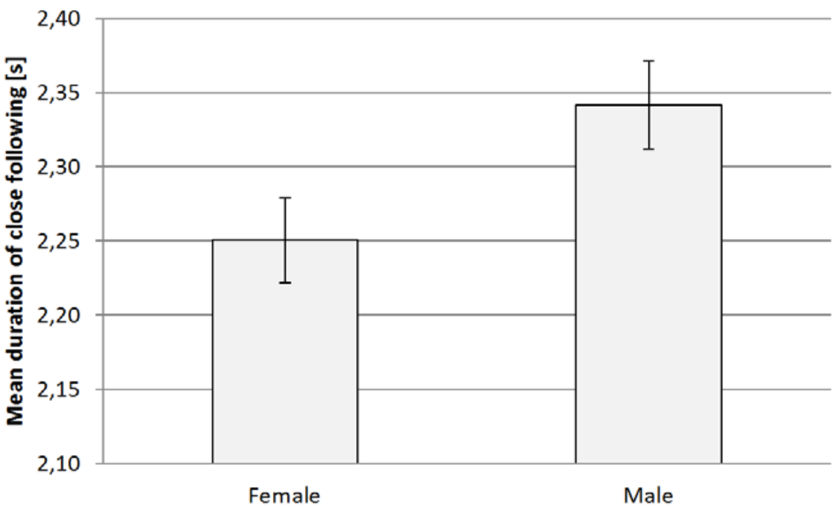

Figure 3.7: Mean duration of close-following events by gender. Error bars represent +/- 1 SE.

An analysis by country revealed a tendency for an effect of the minimum time headway, which is smaller in France (M = 1.13s) and the Netherlands (M = 1.13s) compared to Germany (M = 1.18s), Poland (M = 1.19s), and the UK (M = 1.16s; Figure 3.8).

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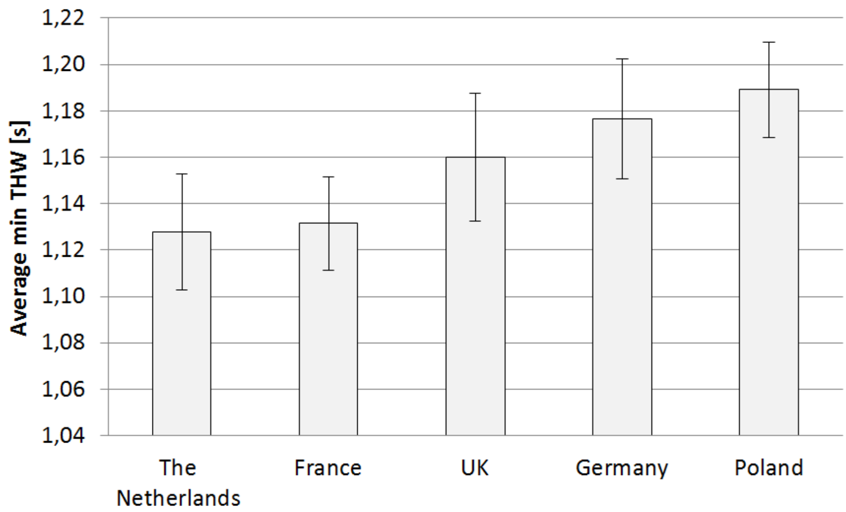


Figure 3.8: Average of the minimal time headway per country. Error bars represent +/- 1 SE.

Harsh braking of cars

There was a clear difference in the number of harsh braking events observed across countries. The fewest instances of harsh braking were seen in Germany, with the most being observed in the Netherlands and France. When harsh braking events are considered as a fraction of all braking events, German and UK drivers show a lower incidence of harsh braking events (Figure 3.9 and Figure 3.10).

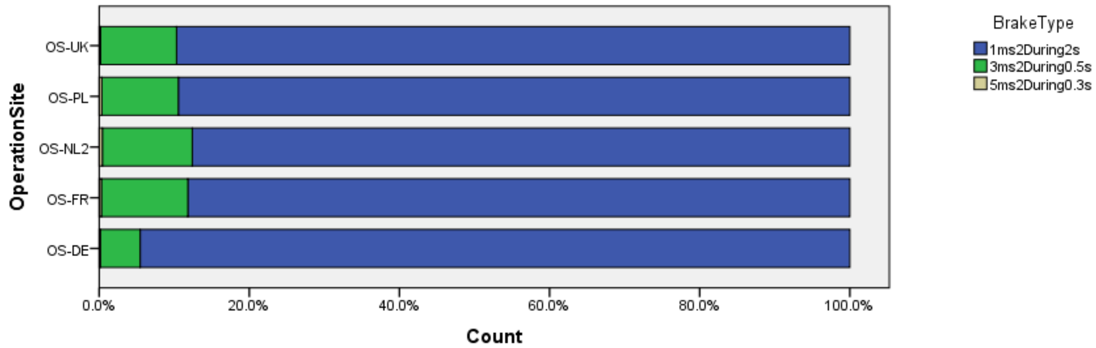


Figure 3.9: Harsh braking events per Operation Site

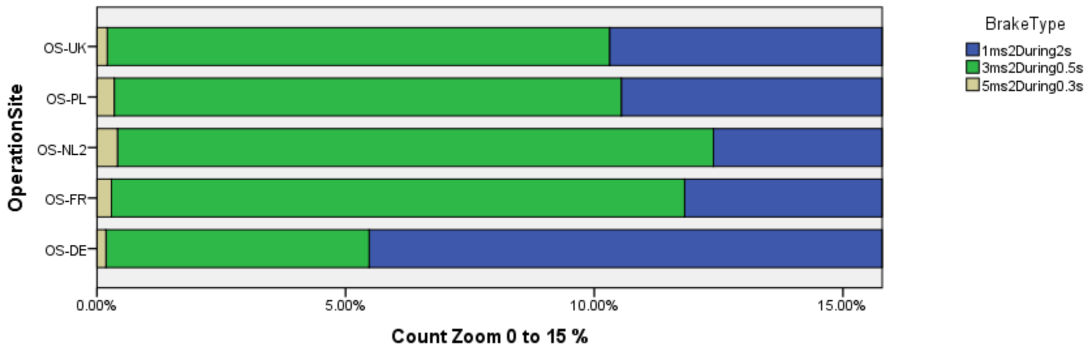


Figure 3.10: Harsh braking events per Operation Site (zoomed to show two highest severity event categories)

Lower-speed-limit areas showed the highest proportion of harsh braking events, with 50-77% of harsh braking events (in any country) occurring on 34-62 km/h roads. Harsh braking events were also more common at certain types of road infrastructure, with more instances of harsh braking observed at roundabouts and intersections than at other road layouts. There were no significant effects of time of day or weather condition on harsh braking occurrence, while the impacts of age and gender varied across operation sites (e.g. females show more harsh braking than males in the UK, with the reverse true in Germany).

ADAS usage

In vehicles equipped with cruise control or speed limiter systems, most trips are made without activation of these systems (88%). Cruise control systems are more widely used than speed limiter systems, and the two are rarely used together. However, speed limiter systems are used for a longer duration on average (11.1 km) than cruise control systems (2.8 km). Both systems are activated only rarely on short distance trips. Urban motorways see the highest proportion of both cruise control usage and speed limiter usage, while urban roads see the least use (Table 3.5).

Table 3.5: ADAS usage by Road Type

Road type	CC usage [%]	SL usage [%]
Slip road	7.1	0.6
Urban motorway	18.7	12.3
Country motorway	4.5	8
Rural	6.4	5.6
Urban road	3.7	3.2

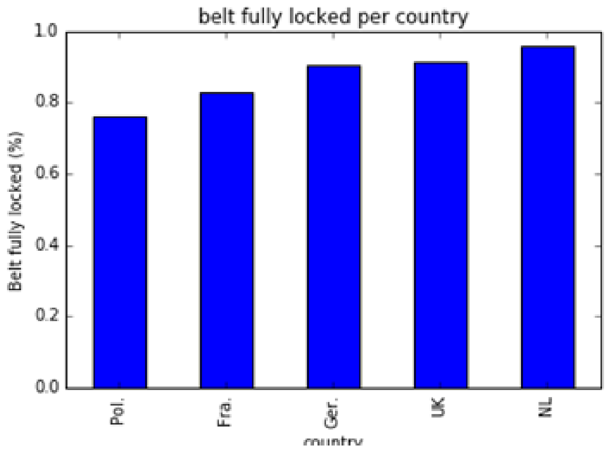
In addition to the evidence relating to low usage of ADAS, there was a high rate of driver confusion regarding the ADAS available in the vehicle, with nearly 1 in 5 drivers incorrectly reporting whether or not their vehicle had a cruise control or speed limiter system (Table 3.6).

Table 3.6: Confusion matrix illustrating driver knowledge of ADAS installed on their vehicle

"is your car equipped with CC/SL"	Answer= no	Answer= yes
Car not equipped with CC/SL	32	1
Car equipped with CC/SL	21	67

Seatbelt usage

Across the entire participant sample, 87% of trips are driven with the seat belt fastened for the duration of the trip. However, there are considerable differences in seat belt usage rate across countries, with only 76% of Polish trips involving the seatbelt being fastened from start to end of the journey, compared to 96% of Dutch trips (Figure 3.11). A decision tree analysis of seatbelt fastening behaviour showed that French drivers had a lower usage rate than all other countries. For all remaining countries, the gender of the driver had a significant impact on whether the seatbelt was fastened for the entire trip, with females more likely to use the seatbelt for the whole trip compared to males. Further categorisation of male drivers showed that those with a smoother driving style were more likely to fasten their seatbelt for the duration of the trip. Another important factor in determining whether the seatbelt was fastened for the whole trip was trip distance, with trips of less than 325m showing a higher rate of non-compliance than longer trips.



Country	Percentage of belt fully locked
Poland	76.1%
France	82.9%
Germany	90.4%
UK	91.3%
NL	95.6%

Figure 3.11: Seatbelt usage rates per country

3.5.2 Conclusions and future work

Speeding of cars

The analysis of speeding behaviour showed that drivers tended to speed more frequently in low-speed-limit zones. Fewer speeding events at higher speed limits may indicate a preferred travelling speed. Drivers appear to be willing to overstep regulations in favour of getting closer to their target speed. However, drivers still appear to be aware of the increased crash risk and/or penalties that accompany heavy speeding, since light speeding events were more frequent than heavy ones. Speeding is not something that only men or women did, but their speeding behaviours were different. Females sped more cautiously, with more light speed violations. Male drivers, on the other hand, drove more slowly than female drivers in general, but their observed violations were more severe. The highest number of speeding events took place late at night, followed by morning and afternoon. Compared to other times of day, late-night driving is the least frequent, but drivers tend to speed more at night. This observation may be explained by the fact that traffic density is low at night, and the chance of being caught speeding is also low. Other prominent times of day are morning and afternoon: rush hours. It appears drivers ignore speed limits when they drive to and from work. Time pressure may contribute to these speed limit violations. This hypothesis could be tested by comparing speeding events during the week with those on weekends. Since the UDrive dataset will be available after the project, this can be addressed in follow-up studies.

Excessive speeding events (>16%) seem to be more prevalent on high-speed-limit roads, while severe speeding events (11-15%) were seen more often in lower-speed-limit areas. There were a greater proportion of excessive speeding events in France than in other countries. It would be interesting to further explore the driver and environmental factors that lead to the riskier speeding events.

Certain driver personality types are more prone to committing speeding violations, particularly when considering repeated, rather than single, instances of exceeding the speed limit. Drivers appear to be aware of their speeding behaviour, as those who self-report as speeders are also those who show the highest levels of excessive speeding. The fact that drivers are conscious of their non-compliance with speed limits suggests the need for additional educational or enforcement measures to reduce the incidence of this risky behaviour. Drivers who reported higher levels of other deviant behaviours were also more likely to commit excessive speeding violations. This finding suggests that bad behaviours may cluster together, and that a driver who performs one type of risky driving behaviour is also more likely to engage in other types of risky behaviour. It is probable that there are specific driver groups that could be targeted for remedial measures relating to risky driving behaviour.

Close following of cars

Most close-following events were observed within posted speed limits of 31-50km/h (see Figure 3.5). How can this be explained? Speed limits between 31 and 50km/h are common on main urban roads, which are characterized by high traffic volume and propensity to congestion. Commuting bumper-to-bumper may explain the high frequency of close-following events. In contrast, low-speed zones are often in urban areas on minor roads with far less traffic volume. This may explain the low number of close-following events in these zones. In addition, as seen in Figure 3.3, the higher the posted speed limit, the lower the observed frequency of close-following events. Outside of urban areas, it appears that drivers adjust their following distances to travelling speed (i.e., the higher the speed, the greater the following distance).

Harsh braking of cars

The finding that the highest levels of harsh braking events occur on the approach to roundabouts and intersections suggests that drivers may be underestimating their stopping distances or incorrectly assessing the likelihood of needing to stop. It should be investigated whether driver anticipation is an area of behaviour that could be improved to reduce the incidence of harsh braking events and the associated rear-end collision risk.

ADAS usage

The analysis of ADAS usage showed that cruise control and speed limiter systems are used relatively infrequently, and they tend to be used during longer-duration trips. Urban motorways see the highest proportion of both cruise control usage and speed limiter usage, while urban roads see the least. This difference may be due to the lower speed limits and higher speed variation (due to road layout and congestion) in urban areas, which makes interaction with the ADAS less convenient. Surprisingly, a high proportion of drivers do not know that their vehicle is equipped with ADAS. This is an important finding, as it highlights a potential for improvement in speed limit compliance and safety simply by educating drivers about systems that are already available for their use.

Seatbelt usage

There are considerable differences in seatbelt usage rates across countries, which imply a potential benefit from the sharing of ideas regarding educational and enforcement campaigns to increase seatbelt use. There is clear evidence to suggest that the UK and the Netherlands have been particularly successful in this regard. Those drivers categorised as having a less smooth driving style were also less likely to fasten their seatbelt. This group of drivers could be particularly targeted by efforts to improve seatbelt compliance, as their driving style suggests that they may be at greater risk of accident and hence could benefit more from using a seatbelt.

4. Distraction and inattention

In UDrive, the major focus of the work on driver inattention and distraction has been on obtaining a better understanding of drivers' engagement in secondary task activities—when they choose to engage, what tasks they select, whether they adjust their activity to different situations, and whether they are willing to surrender secondary task activities when the primary task of driving becomes more demanding. In other words, the focus is on self-regulation: how drivers manage their secondary task activity in the context of the dynamics of the traffic and road situation. That management includes deciding not to engage in such tasks in the first place or only to engage in some particular activities. NDS are particularly suited to such an investigation, unlike experimental studies in driving simulators and even on test tracks, which tend to suffer from an instruction effect (participants are typically instructed to carry out an activity at a given moment). Although such experimental studies provide insight into how driver attention, driver information, and driving performance are affected by secondary tasks, they are less useful when research is focussed on drivers' management of task activity.

4.1 Car driver engagement in secondary tasks

The major questions here were: What activities are drivers engaging in while driving? and Are there differences by driver category and country?.

4.1.1 Key results

The car drivers spent 10.2% of their driving time engaged in some kind of secondary task, mostly one task at a time; however, there were also rare instances when they were engaged in two tasks simultaneously. The most frequent activity for car drivers was mobile phone use, followed by smoking and talking/singing (Figure 4.1).

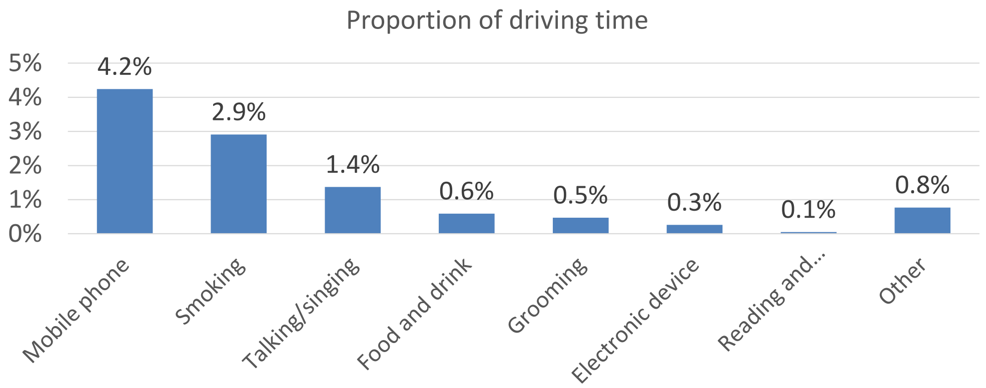


Figure 4.1: Proportion of driving time spent engaged in secondary tasks

Males were somewhat more likely than females to engage in secondary tasks (10.8% compared to 9.5% of driving time). There were also some differences between men and women in their activity patterns: men did a lot more smoking and talking to passengers or singing, while women exhibited more mobile phone activity and personal grooming (Figure 4.2).

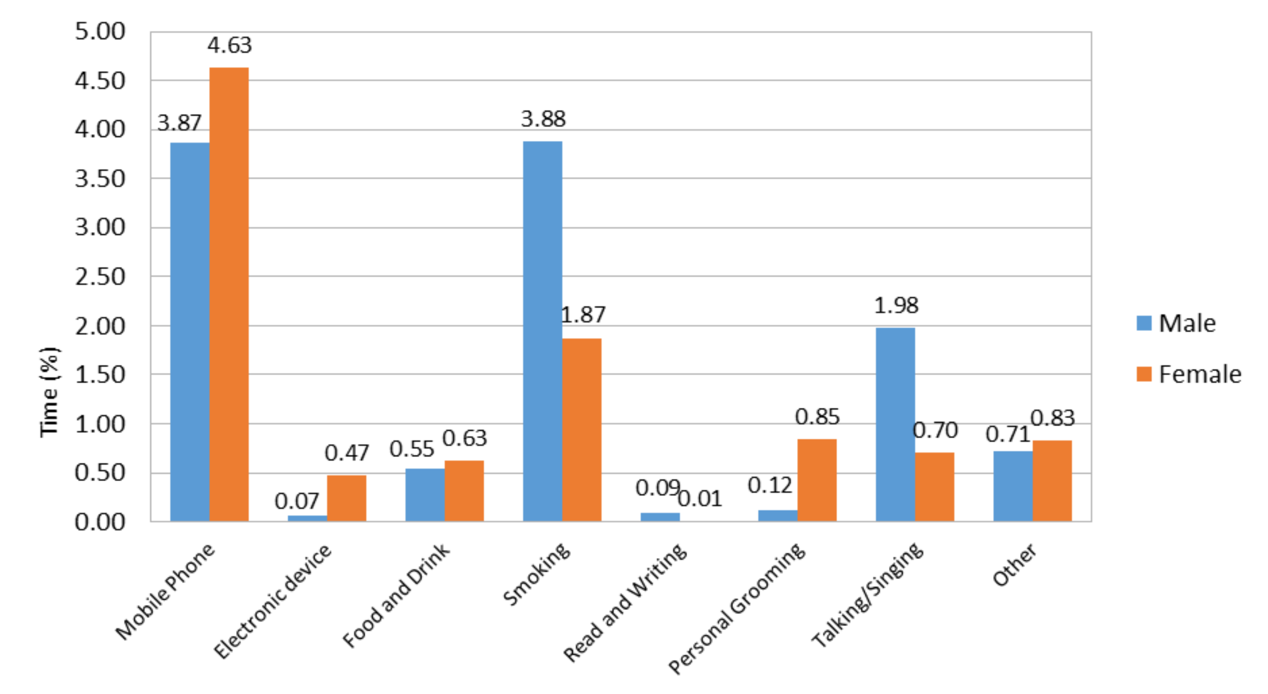


Figure 4.2: Proportion of driving time engaged in secondary task by type of task and gender

Regarding mobile phone activities, the most time (38.4%) was spent on hands-free interaction, which typically involved occasionally touching the screen while the device was in a cradle (for example, interacting with a navigation app). Next were hands-free conversation (22.6%) and handheld interaction, such as texting (22.0%). The last is the most concerning, as it involves visual-manual interaction with the device—a highly risky activity because drivers tend to take their eyes off the road for a substantial time.

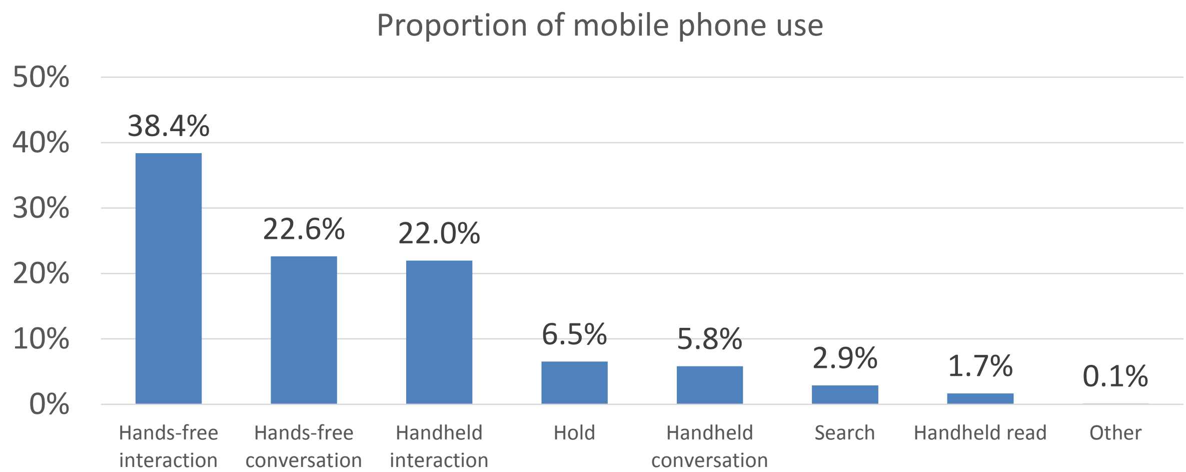


Figure 4.3: Mobile phone activities as a proportion of overall mobile phone use

Again, there were differences by gender in the proportions of specific mobile phone activities. Males were far more prone to spend time interacting with hands-free phones, while females spent more time in hands-free conversation and handheld interaction (such as texting). Men spent a higher proportion of time in handheld conversation than women.

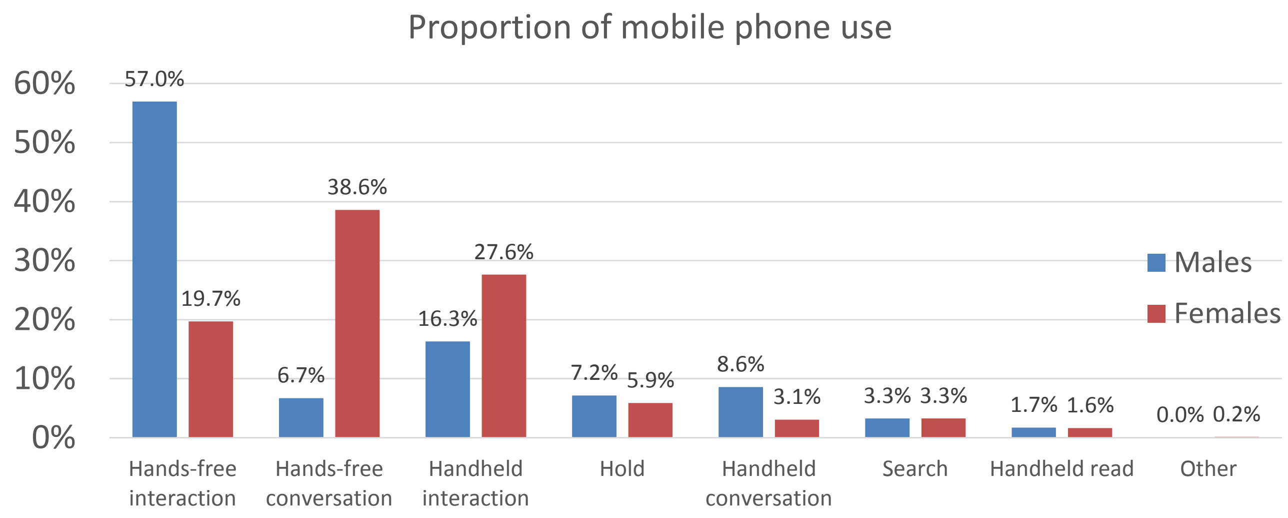


Figure 4.4: Mobile phone activities as a proportion of overall mobile phone use by gender

By country, participants from Poland spent a substantially higher proportion of their driving time in secondary task activities—almost 20%. Next were the participants from France and the UK, with the German drivers having the lowest level of engagement at 1.9%.

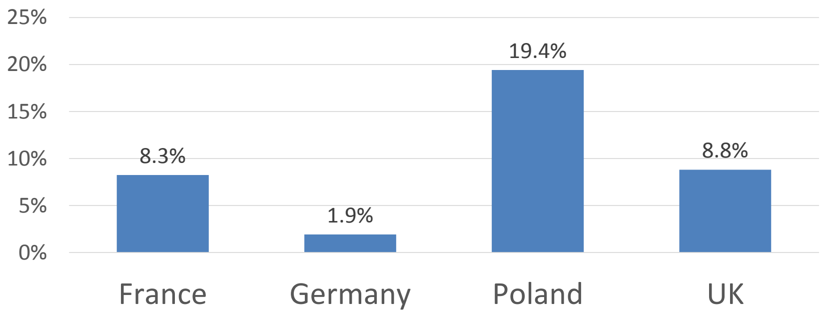


Figure 4.5: Proportion of driving time spent engaged in secondary tasks by country

The rank order for mobile phone use by country was similar. Again Poland was the highest at nearly 10%, followed by France and the UK at less than half of that. The proportion of time spent on a mobile phone was remarkably low for the German drivers at 0.1%.

4.1.2 Conclusions and future work

There were indeed substantial gender- and country-related differences, which future research should take into account when considering generalizability of results. Future work should also include the data from the Dutch site, which was not available at the time of analysis.

4.2 Truck driver engagement in secondary tasks

The major questions here are *What activities are drivers engaging while driving?* and *To what extent were truck driver activities different from those of the car drivers?*

4.2.1 Key results

The various activities performed by the truck drivers are summarised in Figure 4.6, which shows the total time spent by all the drivers in the activities (both as a percentage and as the number of hours per task). The total number of hours of driving analysed was 83. The total time spent in all the secondary tasks equals about 20% of the total annotated driving time. With the data it is possible to deduce, for example, that the time spent in phone-related activities is about 25% of the total time spent performing secondary tasks.

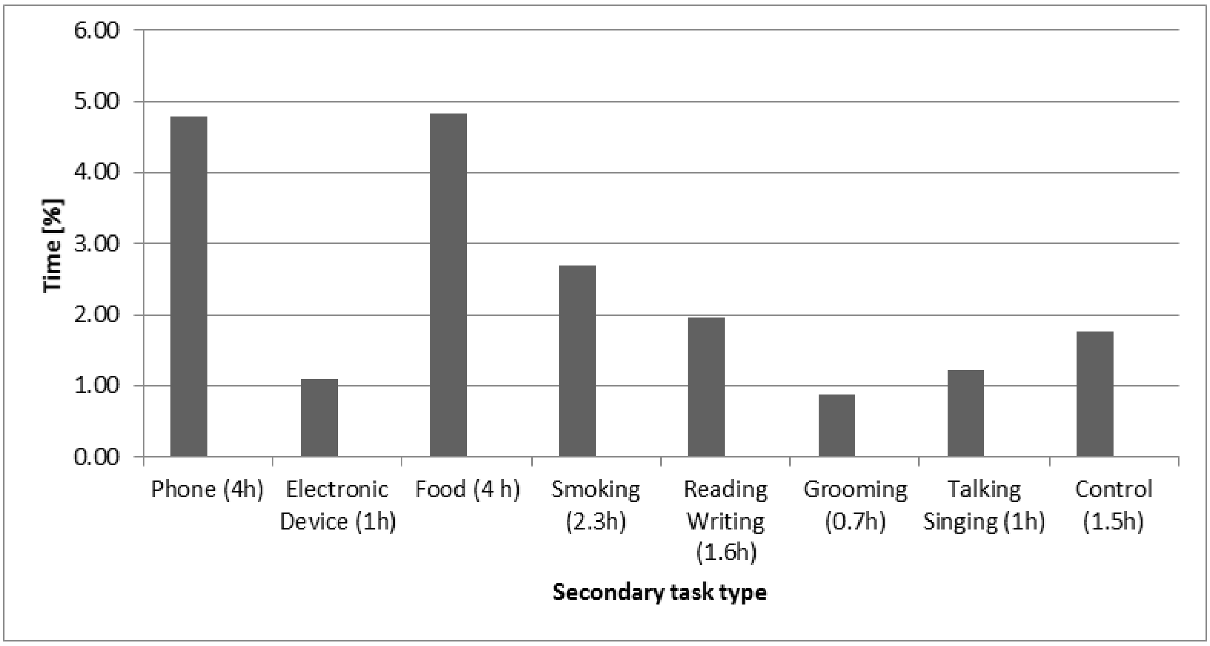


Figure 4.6: Percentage of the total driving time spent on tasks

Figure 4.7 shows a bar plot of the average total task time (TTT) across all drivers for each task. Note that to avoid having drivers with many tasks influencing the average disproportionately (bias results), the mean TTT was first calculated for each driver, after which the overall average was calculated. To evaluate the effect of this imbalance, the figure shows both the average of averages (bias removed), and also the simple overall average task duration (average across all tasks). Inspection of the data revealed that there was one very long-lasting occurrence of a smoking task (30 minutes in total) which led to the large difference in duration of the smoking task between the two types of average in the figure. Also note that only one-third (eight) of the drivers smoked at all while driving. Worth noting is the electronic device interaction, which does not feature at all for the car drivers. These devices are part of the working environment in trucks, especially in this sample, because all the trucks were being used for deliveries.

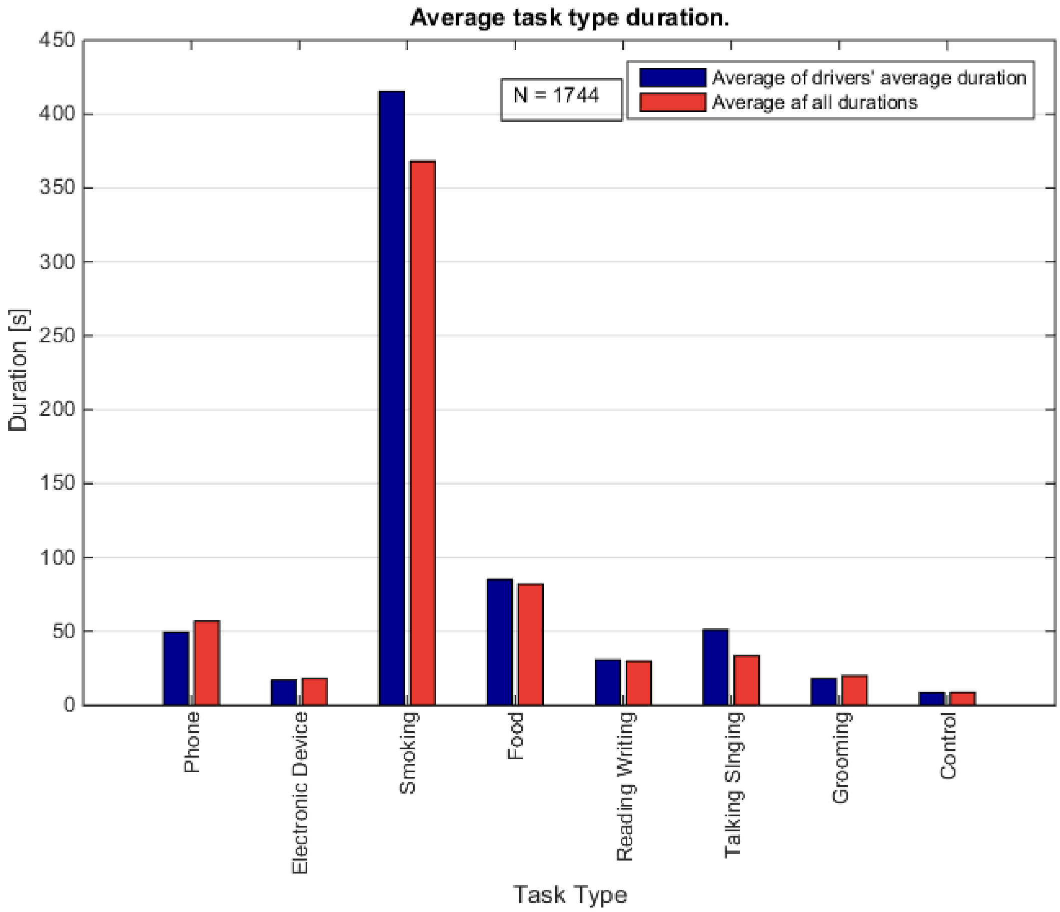


Figure 4.7: Average task duration by task

Figure 4.8 and Figure 4.9 show the distribution of the engagement in phone-related secondary tasks, divided into sub-categories. The most frequent task was handheld interaction, which accounted for about 2% of the total annotated driving time and about 35% of the phone sub-tasks. This is potentially concerning, as it involves visual-manual interaction. Note that annotators found it hard to distinguish hands-free talking from talking/singing. However, the annotators separated these categories to the best of their ability, coding the task as hands-free when they could reliably observe that the driver was making a phone call. As a result of this difficulty, it is possible that some hands-free talking tasks were erroneously categorised as talking/singing.

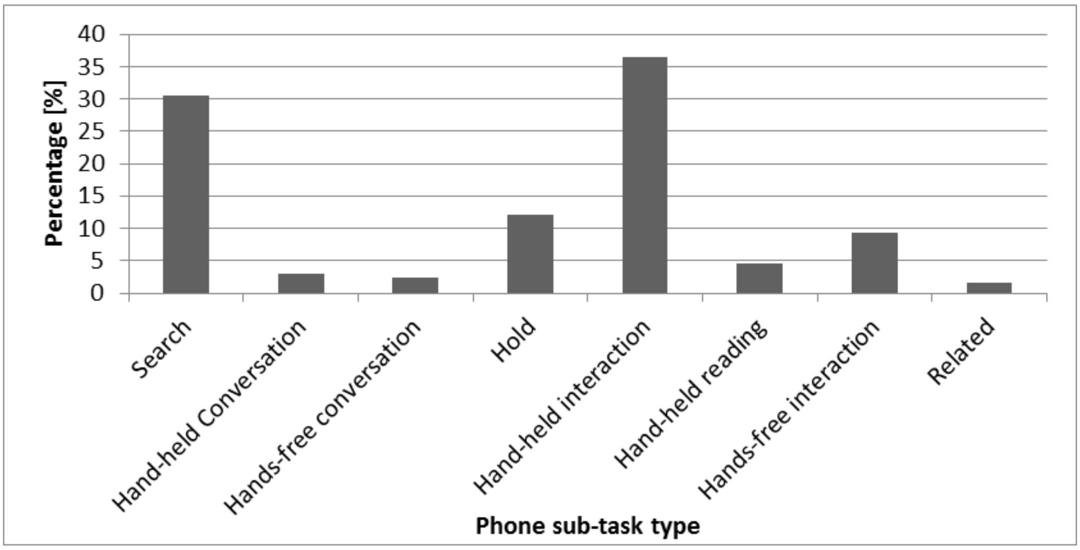


Figure 4.8: Distribution of the phone sub-tasks

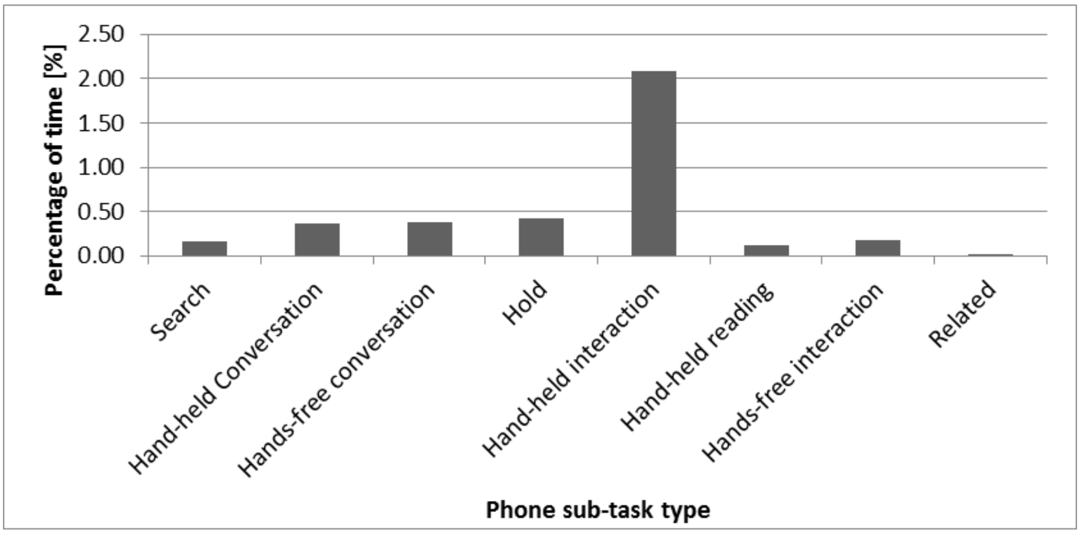


Figure 4.9: Percentage of engagement time by type of sub-task

4.2.2 Conclusions and future work

Perhaps not surprisingly, there are large differences between the activities of the car drivers and the truck drivers. There are clearly instances of more risky activities involving visual-manual interactions for truck drivers. Future work should include a comparison between the Dutch car drivers and Dutch truck drivers.

4.3 Car driver attitudes and engagement in secondary tasks

Knowing what the motivators are for inattention and distraction can help the development of targeted countermeasures, aimed at particular segments of the population. The issue here was understanding to what extent personality factors play a role in determining motivators.

4.3.1 Key results

A set of questionnaires probing driver attitudes and self-reported behaviours was collected from the participants on recruitment. An overall score (composite personality score) of driver propensity for a negative attitude towards safety, combined with risky self-reported behaviours, was calculated from the answers. Drivers were coded 0/1/2 on each of twelve factors, so that the maximum score (most risk-prone) was 24. The drivers were divided into those that engaged in a particular task and those that did not. As can be seen from Figure 4.10, there were some large differences in the average composite personality score as a result. Mobile phone use, smoking, eating and drinking, grooming, and dual-task engagement all stand out.

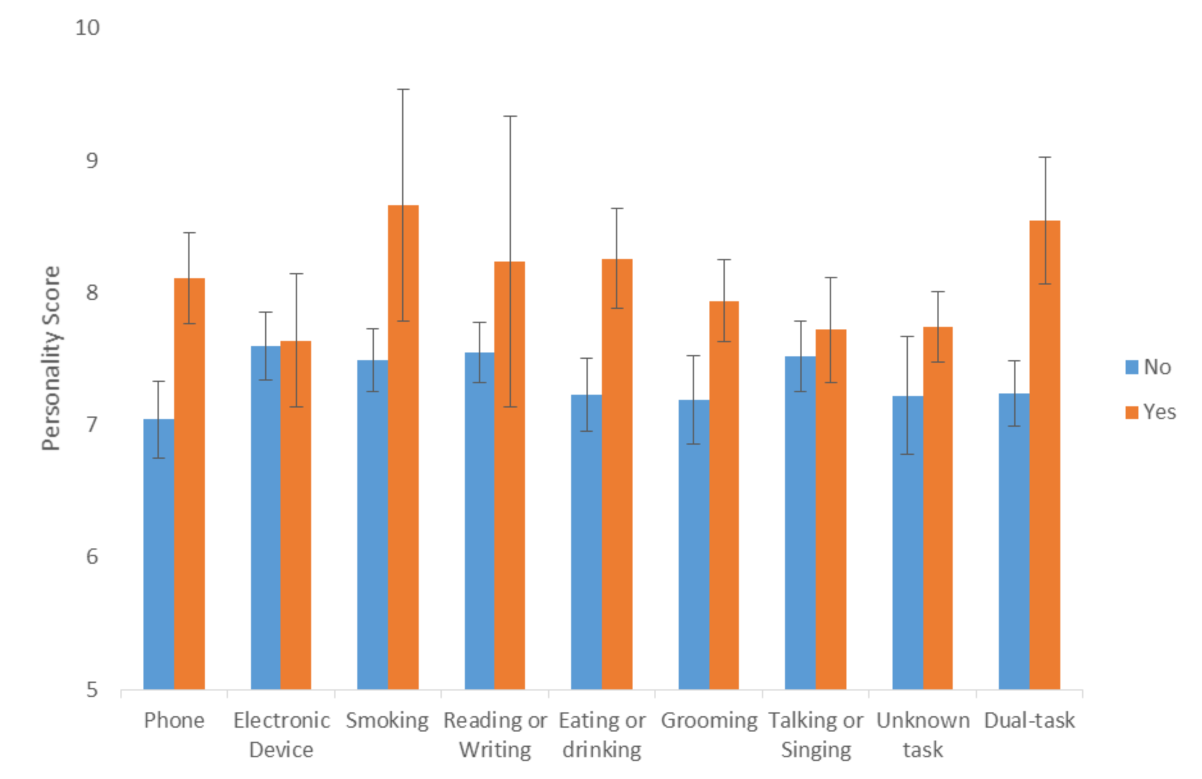


Figure 4.10: Mean composite personality score for drivers who did and did not engage in various activities

4.3.2 Conclusions and future work

Personality and attitude have been shown to have a clear influence on propensity to engage in secondary tasks. Future work could investigate more refined personality scoring and more detailed aspects of engagement, such as willingness to engage in specific tasks in specific situations.

4.4 Did driving task complexity and secondary task complexity influence the decision to engage in secondary tasks?

If drivers do decide to engage in secondary tasks, one would hope that they would consider their current driving activity, the external driving situation and the difficulty of the secondary task in deciding whether or not to carry out the activity at a particular moment. In other words, one would hope that they would self-regulate. This analysis was only performed for car drivers.

4.4.1 Key results

There were signs of adaptation of engagement. A coding scheme was applied to classify task complexity and manoeuvre complexity. As can be seen in Figure 4.11, secondary task duration was affected by manoeuvre complexity: task duration was longer in easy conditions and shorter in medium and hard conditions.

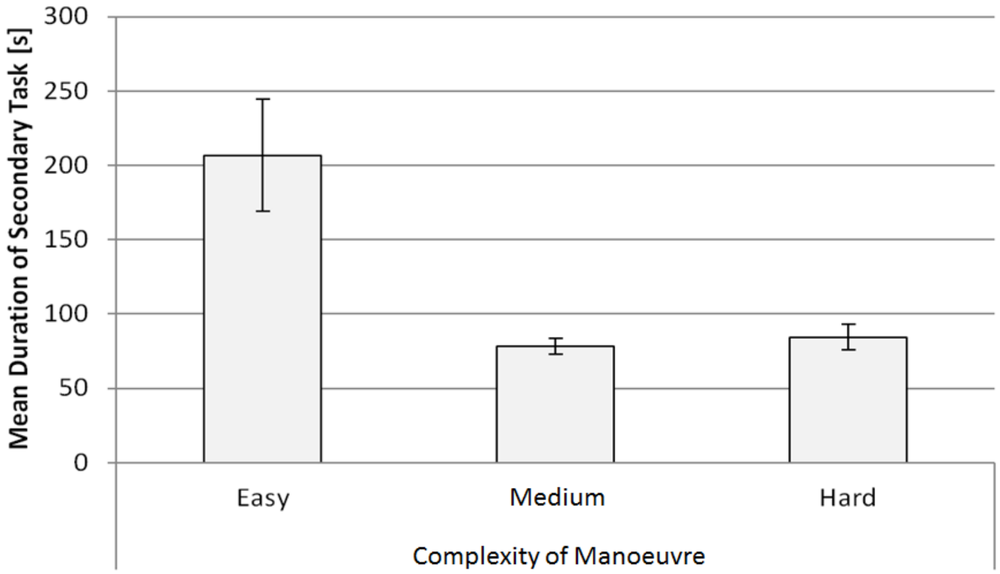


Figure 4.11: Mean duration of secondary task classified by complexity level of the driving manoeuvre (error bars indicate the standard error)

However, drivers did not adapt as well to overall conditions (not just manoeuvre) and to secondary task difficulty. As can been seen from Figure 4.12, easier tasks were indeed dropped as the road environment shifted from easy to hard, but more demanding secondary tasks tended to be more frequent when conditions were hard.

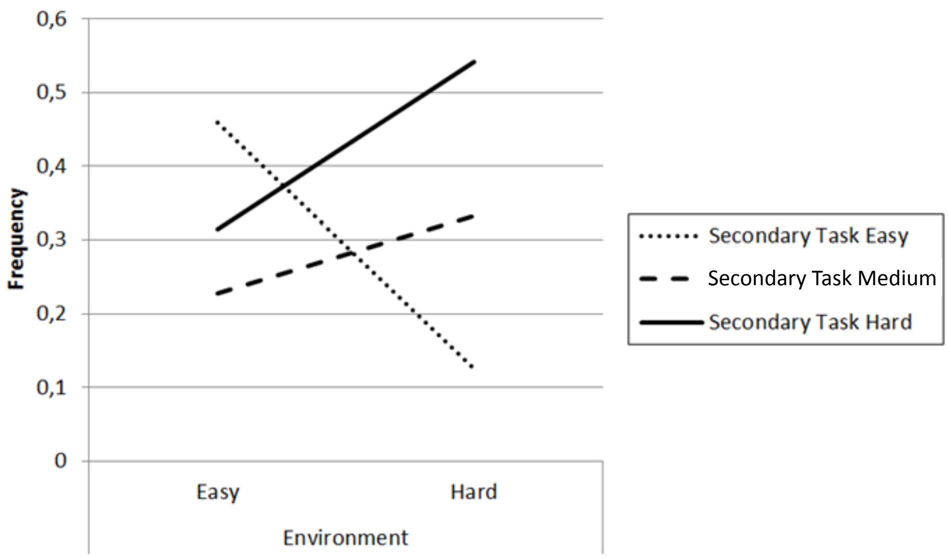


Figure 4.12: Relative frequency of secondary tasks with environment split by complexity levels

4.4.2 Conclusions and future work

There are some signs of adaptation by drivers, in particular when performing a manoeuvre. However, appropriate adaptation was not always pursued—drivers were seemingly more willing to perform medium and difficult tasks when the situation was more demanding. However, these results need to be confirmed by more extensive analysis of the UDrive database.

4.5 Do drivers adapt their safety margins for performing secondary tasks?

By analysing driving in the periods before, during, and after the performance of a secondary task, it is possible to determine to what extent drivers increase their safety margins. Knowing that their reactions might be slower while performing a secondary task and that they need to compensate, drivers might slow down and/or increase their distance to a lead vehicle.

4.5.1 Key results for car drivers

The analysis for the car drivers focussed on the task that is most demanding in terms of attentional focus—visual-manual interaction, such as texting. As can be seen in Figure 4.13, most drivers carried out this type of interaction while stationary, although a substantial number of interactions took place while moving.

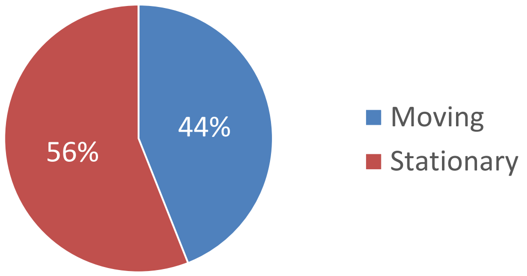


Figure 4.13: Proportion of visual-manual tasks carried out while moving

In line with this finding, Figure 4.14 shows that speeds tended to be lower in the task period than in the preceding baseline period, but this was mainly due to the propensity to carry out visual-manual tasks while stopped. There are some interactions that took place at high speeds. Overall, the mean speed in the task period was approximately 20km/h.

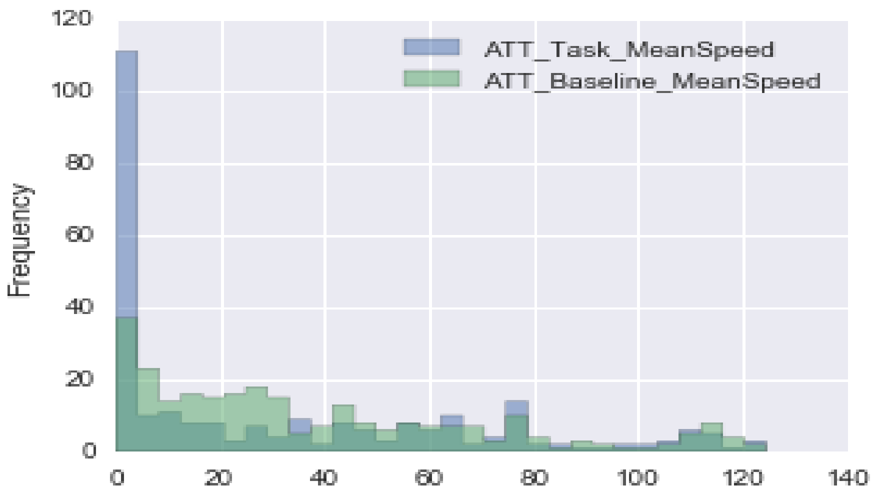


Figure 4.14: Speed distribution for task period and matched baseline periods

Similarly, while most drivers slowed down to perform visual-manual tasks, others drove faster during the task period than the baseline period (Figure 4.15). For those that slowed down, the mean change was −13km/h; for those that sped up, the mean change was +7km/h.

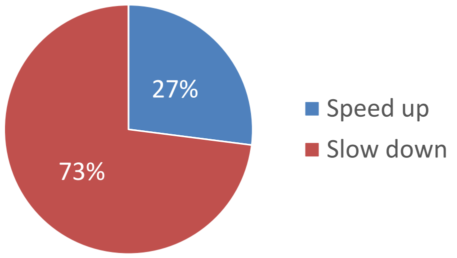


Figure 4.15: Proportion of visual-manual tasks for which drivers sped up or slowed down

4.5.2 Key results for truck drivers

Figure 4.16 compares the speeds at phone task initiation to the speed distribution across all annotated trips. This can be seen as a representation of when drivers feel more comfortable engaging in secondary tasks compared to everyday driving (when not performing a task). The figure shows that the majority of the phone tasks were initiated at low speeds (at or below 40km/h) or when standing still. The speed range with the highest frequency of phone task initiations (but also most time spent driving) is 80km/h and above. This may be when the environment is less complex and the driver may even have support systems, such as cruise control, engaged. Drivers in this study initiated phone-tasks less often at standstill and at 70km/h, and more often at 5 and 20km/h. Note the large difference (Figure 4.16 vs Figure 4.13) in the proportion of phone task initiations at standstill for cars and trucks. Car drivers seems to stop to perform visual-manual tasks, while truck drivers perform visual manual task while driving.

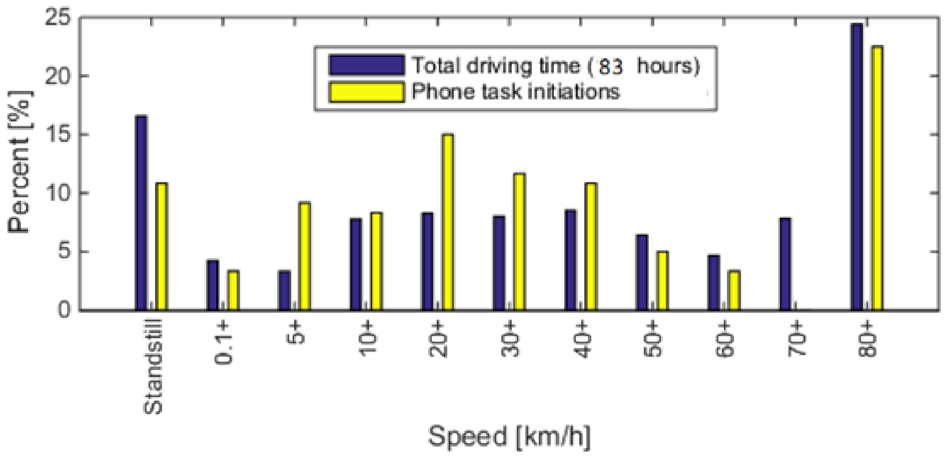


Figure 4.16: The speed at initiation of phone tasks (all forms) compared to the speed distribution across all data used in the analysis

A more detailed analysis examined seven distinct points in time before, during, and after the start of a secondary task. Hereafter these points are called analysis points (APs). The APs are shown in Figure 4.17.

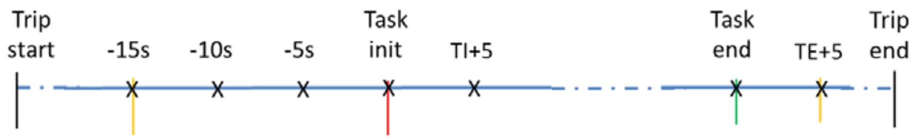


Figure 4.17: A visualization of the seven points used in this analysis, as well as the start and end of the trip

Note: The dotted section of the time-line represents a variable length, while the solid lines represent 5s equal separation between points.

When all tasks were considered together, the results showed a significant speed decrease between the first two time-points: −15s and −10s before task start (−.21 and −1.07km/h, respectively) and task start. This may appear to be due to drivers self-regulating, but further analysis showed that stopped vehicles affected the results. When the secondary tasks (all annotated tasks) with at least one zero-speed AP were removed, there was no decrease in speed before the task start. Instead, speed increased during the period between 15s before the task start until task end, and 5s after the task end. That is, drivers did not significantly decrease the speed before or during the task, but did increase their speed after it was completed. Figure 4.18 shows the speed changes from one point to another along with their *t*-test significance values. In the analysis for this figure, any tasks with a speed of zero in the analysis period have been removed.

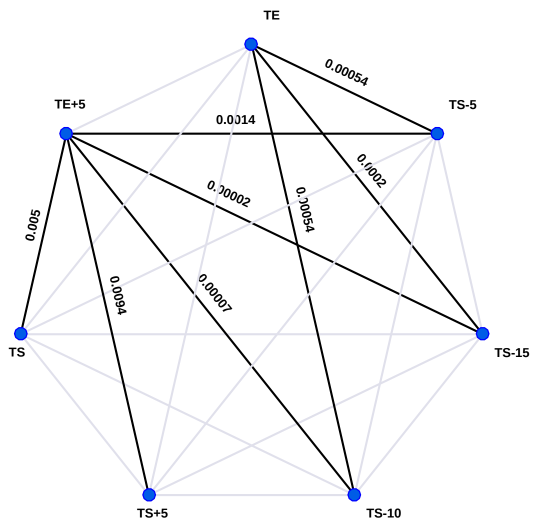


Figure 4.18: A visual representation of the *t*-test combinations, with significant comparisons shown in black. TS=task start. TW=task end. Numbers after TS/TE is the number of seconds before or after, respectively.

For phone tasks, the picture was similar: there was a significant increase in speed between a) before and up to five seconds into the task, and b) the end of or after the task. That is, drivers seem to have self-regulated by increasing their speed after the phone task ended, rather than reducing it before the task was initiated. Note that after the tasks performed while stopped were removed, the trends were the same. One way of interpreting the speed differences with and without standstill over the seven points, in relation to the low proportion of task initiations at standstill, is that drivers who stop and interact with their phones do not stop until after they have actually initiated the phone interactions.

4.5.3 Conclusions and future work

There are some indications of self-regulation by drivers, but there are also instances of activity at high speeds. Further analysis is needed to get a better understanding of the circumstances of the high-speed activity, for both car and truck drivers. Similarly, the situations in which car drivers sped up after ending a task also need to be analysed in more detail.

4.6 Methodology: potential of automated video analysis to support or replace manual annotation

Currently, manual annotation is needed to identify secondary tasks, and searching for them in naturalistic data is a real challenge due to their low frequency in normal driving. An automated procedure has been applied to provide candidate cases of secondary tasks for manual annotators.

4.6.1 Key results

The automatic annotation tool is based on deep learning algorithms. First, frame-by-frame detection of secondary tasks was performed using a Convolution Neural Network (CNN) model. LAB used French UDrive pilot data to develop the tool. The development included manual annotations to create a learning database to train the CNN model. The tool output was the probability that the driver was texting/phoning for each frame. The probability was turned into a prediction (“secondary task ongoing”/ “no secondary task ongoing”) by comparing it to a threshold value, which was derived from the Receiver Operating Characteristic (ROC) curve of the CNN model: an optimal point was defined by giving true positive rate and false positive rate the same weight. Using these thresholds, the results for handheld phone call detection on the test (pilot) data were a true positive rate of 0.94 and a false positive rate of 0.04. For texting, the true positive rate was 0.80 and the false positive rate was 0.15. The tool was implemented on the UDrive database and a first set of trips was processed. The automatic annotation is now included in SALSA and can be compared to manual annotations in future studies.

4.6.2 Conclusions and future work

The results for the pilot database are promising. The first potential enhancement will be to add hysteresis to the frame-by-frame detection. This evolution would benefit from the temporal nature of the data (multiple consecutive video frames with each tasks) and potentially increase the performance compared to simple frame-by-frame detection. The next step of our approach will then be to evaluate the model using UDrive data and tune it with data from other Operation Sites to further increase performance. Manual annotation from the UDrive dataset will be used in the following months as a ground truth to adapt the thresholds and tune the algorithms. Performance will be assessed using the manual annotations, and the automatically realised detections will be used for further studies on the behaviour of drivers engaged in secondary tasks.

5. Vulnerable road users

5.1 Introduction

Within UDrive there has been a specific focus on pedestrians, cyclists, and powered two wheelers (PTW). These groups of road users are particularly vulnerable in traffic because they lack the protective shell provided by an automobile that helps those involved in a collision avoid serious injury. In addition, these transport modes have several features that make them more prone to being involved in a crash—features related to reduced conspicuity and, for the two-wheelers, the difficulty of maintaining balance, either or not in combination with high speeds. These features mean that pedestrians, cyclists, and PTW users have a high risk of getting fatally or seriously injured in traffic. Through UDrive, a large amount of naturalistic data was collected in order to get more in-depth insight into the interactions of these groups with passenger cars and trucks. The aim was to identify and understand not only the everyday behavioural patterns in these interactions, but also the circumstances behind conflicts and safety-critical events that occur.

The starting point for the analysis of the pedestrian and cyclist interactions was the UDrive database, with data from 186 car drivers in Great Britain, France, Germany, Poland, and the Netherlands, and from 48 truck drivers in the Netherlands. By April 2017, the database consisted of a total of 42,724 hours of car data and 41,397 hours of truck data. The 859 hours of data on PTWs come from 47 PTW (125cc) riders in Spain. Note that these numbers may be slightly different from other UDrive deliverables, as the dataset was still growing at the time of writing the deliverables. The analyses were conducted on a part of the database that fulfilled the selection criteria (e.g., right-turning manoeuvres, urban areas), depending on the exact research question to be answered.

5.2 Drivers interacting with bicyclists

The key research questions in UDrive about drivers' interactions with bicyclist were:

- *What are the contributory factors to critical events and accidents involving cars and trucks versus bicycles?*
- *Which factors influence whether car drivers perform a shoulder check before a right turn (UK: left turn) in an urban intersection or before an exit manoeuvre at an urban roundabout?*
- *When do car drivers cast their last sideways glance towards a potential cyclist to the right before they enter the encroachment zone in a right turn (UK: left turn) manoeuvre in an urban intersection? Which factors influence the timing of the glance behaviour?*
- *Which factors influence whether truck drivers perform a shoulder check before a right turn on an urban intersection, or before an exit manoeuvre at an urban roundabout?*
- *Which factors influence the lateral distance when a car starts to overtake and passes a cyclist?*

5.2.1 Key results

The analyses of the cyclist data looked at interactions between cyclists and both passenger cars and trucks.

Safety-critical event interactions

We investigated which behavioural and situational factors contributed to the occurrence of safety-critical events (SCEs). A near-crash was defined as a situation which was not planned and required an immediate, urgent evasive manoeuvre by at least one of the conflict partners to avoid a crash. A collision warning signal was used to identify potential SCEs. The analysis on car drivers was based on 41 warnings of collisions with cyclists in just over 13,200 hours of car data from 125 drivers collected in Germany, Great Britain, France, Poland, and the Netherlands. The analysis on truck drivers was based on 64 warnings of collisions with cyclists in approximately 6,000 hours of truck data from 41 drivers collected in the Netherlands.

The analysis of the collision warnings revealed 11 SCEs: three interactions with a car, and eight with a truck. All were near-crashes; no actual crashes have been found in the database. All SCEs took place on urban roads with a speed limit of 50km/h or less, perhaps because there are fewer encounters between cyclists and motorised vehicles on higher speed roads. Given the small number of SCEs, only a qualitative analysis was conducted. It indicated that the identified SCEs were caused by a combination of infrastructure features (a curve or a too-narrow road), manoeuvre features (often overtaking), the presence of other traffic, and an error or unexpected behaviour by the cyclist (slowing down). Drivers did not seem to make any judgment or performance errors in the observed SCEs: none of the drivers was involved in a secondary task or exceeded the speed limit when they started their evasive manoeuvre and nearly all drivers avoided a collision by decreasing their speed.

Interactions at intersections and roundabouts

We analysed the looking (glance) behaviour of car drivers who turned right (left in the UK), crossing the path of a (potential) cyclist going straight through the intersection or roundabout. This is the typical scenario for a blind-spot crash. The final dataset consisted of 961 intersection manoeuvres by 69 drivers from France, the Netherlands, Poland, and United Kingdom and 826 roundabout manoeuvres by 46 drivers from France, the Netherlands, and United Kingdom. Approximately half of the data came from the United Kingdom, because it was available early in the project. The results show that, on average, car drivers actively check the blind spot by looking over their shoulder in approximately 8% of the cases at intersections and approximately 4.5% of the cases at roundabouts; see Figure 5.1. Car drivers usually (between 65% and 95% of the cases) looked in the direction of the road into which they intended to turn, followed by the directions ‘elsewhere’ and ‘sidewalk’. The ‘blind spot’ was checked least often. There was a large difference between the investigated countries. On average, at intersections, Dutch car drivers checked their blind spot six times more often than drivers in the other three countries (in 27% of the cases), and at roundabouts they did so 21 times more often (in 19% of the cases). The most logical explanation for this difference is that in the Netherlands the prevalence of cyclists is higher.

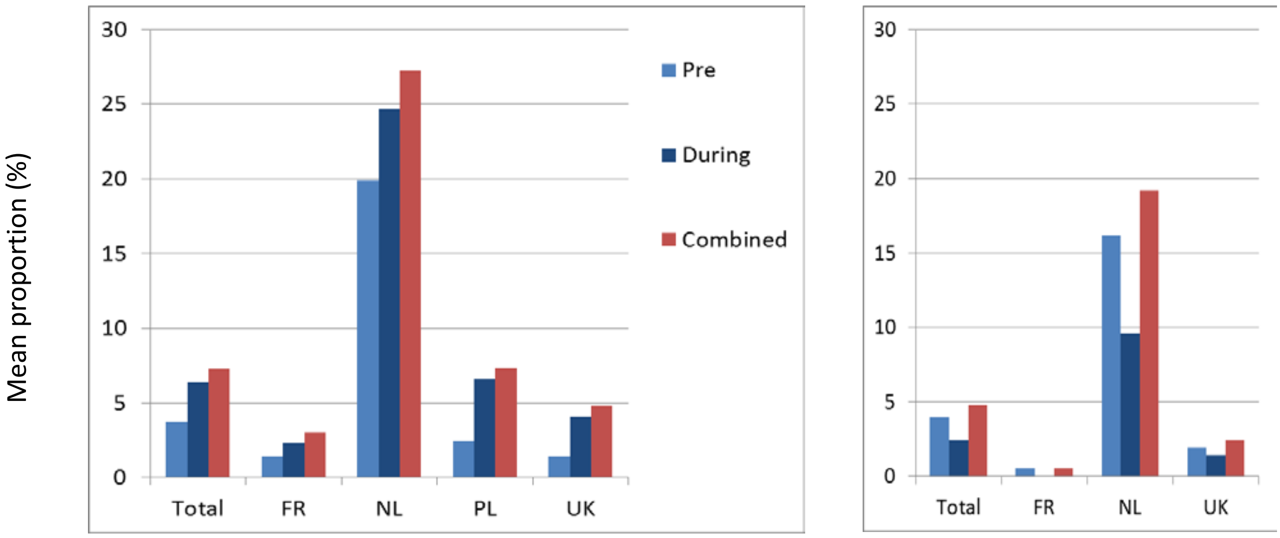


Figure 5.1: Mean proportion of manoeuvres with at least one blind spot check across car drivers, stratified per country (left: intersections, right: roundabouts). NOTE: FR = France, NL = Netherlands, PL = Poland, UK = United Kingdom. Pre = time window 6 seconds prior to the manoeuvre onset, During = during the manoeuvre, Combined = time window of 6 seconds prior to the manoeuvre onset until the end of the manoeuvre. Roundabout manoeuvres have not been examined in Poland.

A second analysis of the interactions and roundabouts focussed on the looking behaviour of truck drivers. For this analysis the final dataset consisted of 159 right-turn manoeuvres by 10 truck drivers and 209 roundabout manoeuvres by largely the same 10 truck drivers. All of the drivers were Dutch, driving in the Netherlands. On average, truck drivers were observed to check the blind spot in 19% of the cases at intersections and in 27% of the cases at roundabouts; see Figure 5.2. Compared to Dutch car drivers, the

Dutch truck drivers checked their blind spot somewhat less often at intersections, and somewhat more often at roundabouts. It should be noted, however, that some of the trucks may have had in-vehicle camera information, and hence the drivers may have been checking the blind spot even without demonstrating the head or eye movements which would signal a blind spot check to the video annotators.

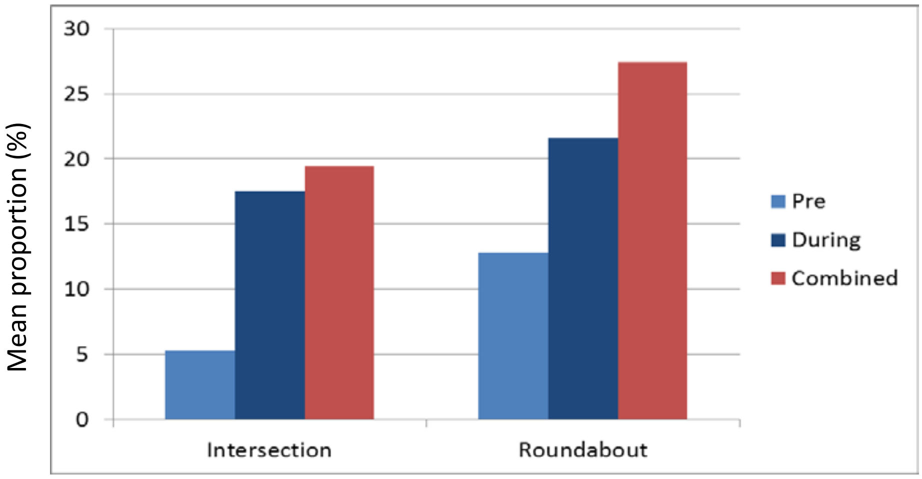


Figure 5.2 Mean proportion of manoeuvres with at least one blind spot check across truck drivers. NOTE: Pre = time window 6 seconds prior to the manoeuvre onset, During = during the manoeuvre, Combined = time of 6 seconds prior to the manoeuvre onset until the end of the manoeuvre.

Overtaking manoeuvres

Finally, we looked at car-cyclist interactions during overtaking manoeuvres. A total of 147 overtaking manoeuvres were analysed, consisting of manoeuvres by 41 car drivers from France, Germany, Poland and United Kingdom, on rural roads only. It was found that, on average, overtaking manoeuvres took 9.3s (± 3.5s) and the car speed during overtaking was 61km/h (± 15km/h).

A distinction was made between 'flying' overtaking and 'accelerative' overtaking. In flying overtaking, the speed of the overtaking vehicle speed remains more or less constant before and during the overtaking. In accelerative overtaking, the overtaking vehicle first stays behind the cyclist and then starts overtaking by increasing its speed (accelerating). Approximately 70% of the overtaking manoeuvres were flying; however, in Poland approximately 50% of the overtaking manoeuvres were flying.

The main variable of interest in this analysis was the lateral distance between the car and the bicycle during the actual overtaking manoeuvre. The average lateral distance was 1.65m (± 0.64m). This is close to the lateral distance of 1.5m that most European countries require by law for overtaking. There were several factors, however, that affected the actual lateral distance. The distances were larger when the speed of the car was higher, when the speed of the cyclist was higher, when the lane was wider (for flying manoeuvres), and when the overtaking vehicle was piggybacking (following another vehicle). Lateral distances were smaller when the cyclist was positioned further away from the edge of the road (towards the centre of the road), when the car driver was a woman (for the flying overtaking manoeuvre), and when there was an oncoming vehicle (for accelerative overtaking manoeuvres).

5.2.2 Conclusions and future work

The UDrive database is very rich, and many more questions can be studied using the currently available data. In addition, some of the analyses reported here would benefit from additional analyses. An example is the finding concerning the blind spot checks of car and truck drivers in turning manoeuvres. The data indicated that relatively few car and truck drivers actively checked the blind spot for cyclists when making a right (left in the UK) turn at an intersection or roundabout. It would be useful to explore whether specific road or traffic conditions can be identified that affect the visual search strategies of drivers.

5.3 Drivers interacting with pedestrians

The key research questions in UDrive on drivers' interactions with pedestrians were:

- *What characterises conflicts involving motorised traffic and pedestrians?*
- *How do car drivers behave in the presence of pedestrians?*
- *Does an ADAS with pedestrian detection capabilities have the potential to reduce the risk associated with driver-pedestrian conflicts?*

5.3.1 Key results

The analysis was based on just over 400 Pedestrian Collision Warnings (PCWs) in car data from Great Britain and France. Speed choice and speed management are key factors in all conflicts—in particular, in conflicts involving pedestrians. Therefore, speed is the most natural choice for clustering PCWs. Four clusters, which correspond to the PCWs were found, see Figure 5.3:

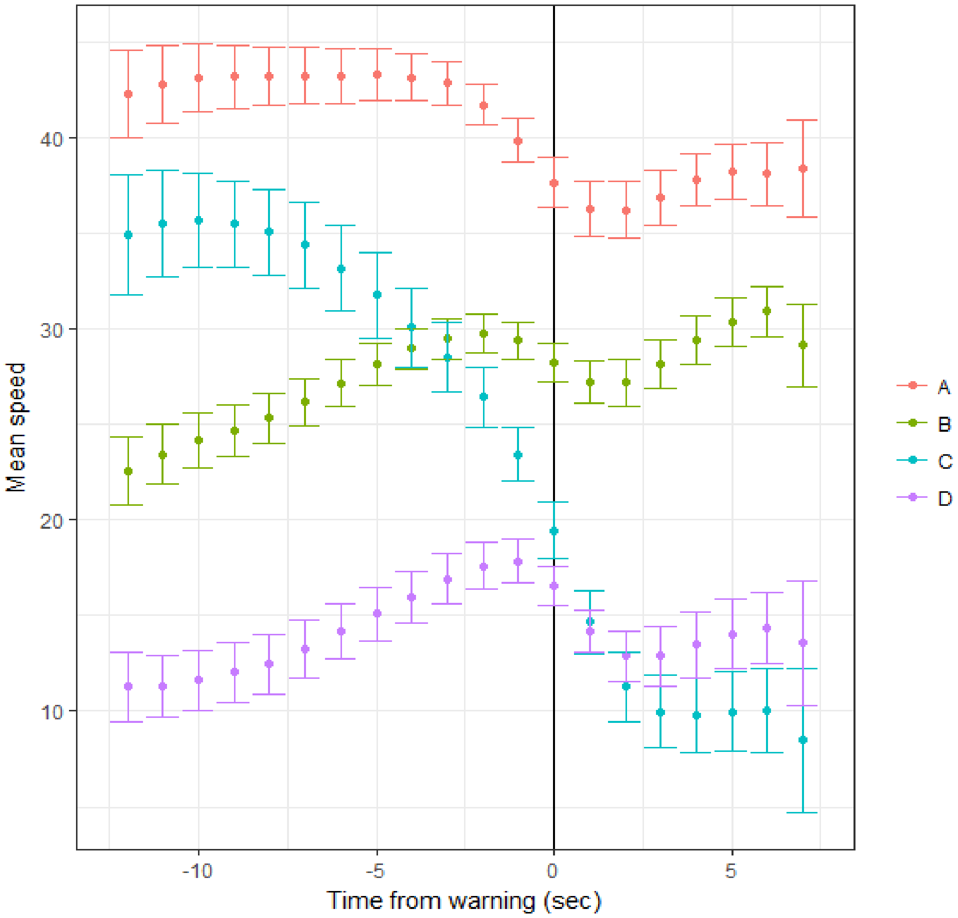


Figure 5.3: Clusters of PCW according to longitudinal speed distribution.

E. Conflicts that involved the highest speed group mainly concerned a situation in which the pedestrian (still) was on the pavement.

F. Conflicts that involved a group of car drivers that had just increased their speed before the conflict occurred; again generally a conflict conflicts in which with a pedestrian was who (still) was on the pavement.

G. Conflicts in which the high speed drivers probably had noticed the potential conflict well in advance, and had reduced speed to avoid a collision.

H. Conflicts in which the car driver had not reduced speed until very late, seemingly because he had not at all noticed the pedestrian. This group of potential conflicts contained the highest percentage of real conflicts (SCEs).

These four clusters provide a clear and distinct speed choice behaviour around the occurrence of the PCW. The most interesting is the cluster in which the drivers do not reduce their speeds until the actual onset of the conflict, meaning that drivers were not aware of the conflict until it actually occurred. This cluster has the highest percent of SCEs (i.e., 22 of the 67 identified SCEs) and the lowest proportion of VRU facilities.

5.3.2 Conclusions and future work

Speed, infrastructure, and surprise are the three most important factors associated with driver-pedestrian conflicts. In most conflicts at least two were present. High speed, lack of VRU facilities, and the sudden appearance of a pedestrian all increase the probability and severity of a potential conflict.

Two factors, pedestrians' presence and technology, play an important role in keeping drivers aware of and alert towards potential conflicts with pedestrians:

- According to the PCW sample, in more crowded places the initial speed of the driver was very low and no conflicts were observed.
- The few cases available showed the potential benefit of an early alert by the ADAS (Mobileye) system. In these situations, relatively harsh braking begins only after the onset of the PCW alert.

A future analysis should involve SCEs generated by kinematic variables (yaw rate, acceleration, and speed) during both day and night-time. During the day it will be possible to compare the actual events with the PCWs and evaluate the percent of overlap. This comparison will shed light on the false negative errors of the MobilEye, when the MobilEye didn't indicate a PCW but there was a clear conflict. Night-time analysis is needed in order to understand driving behaviour at night—both in general and specifically when pedestrians are around (the MobilEye is doesn't identify VRUs at night).

A more detailed analysis, comparing normal driving without any pedestrians (location based (LB) control), normal driving with pedestrians (DZ), and driving with a possible collision with pedestrians (MobilEye pedestrian collision warning; PCW) should further increase the understanding of the various contributing factors. Finally, personal driver characteristics, as well as exposure and cultural (country-based) comparisons, should also be analysed.

5.4 Powered two-wheelers

The key research questions in UDrive with respect to analysis of powered two-wheelers were:

- *Which circumstances related to rider, infrastructure and trip have an impact on the occurrence of safety-critical events?*
- *What characterises the riding speed and g-forces of PTW riders in common traffic scenarios at urban intersections?*
- *Do car drivers keep PTW riders at a different distance then other motorized traffic on straight road sections, and if so does rider conspicuity play a role in this difference?*

5.4.1 Key results

The identification of safety-critical events

Obviously, PTWs have their own very specific dynamics, posing specific requirements of the data collection equipment and the interpretation of the collected data. One of the challenges with naturalistic riding data is the identification of safety-critical events (SCEs). In our study, SCEs were identified by looking at a set of kinematics-related variables and identifying the extremes or outliers: the high-g events. For these events, the video material was studied to assess if there had actually been an SCE, and if there had been, to identify the circumstances related to the rider, other traffic, and infrastructure.

Analyses were based on 497 hours of data (equalling 13,654 kilometres driven) from 39 riders in Spain. A total of almost 1300 potentially relevant events were identified based on the motion-related variables, of which around 500 were evaluated. The vast majority of the identified events appeared to be related to a non-safety-relevant manoeuvre, such as a speed bump, a tight curve, starting from or braking to a stand-still, entering or leaving a parking lot, etc. In other words, there were many false alarms. Only two safety-relevant events were identified among these high-g events. One was based on an extreme longitudinal deceleration (harsh braking) in a one-directional, two-lane situation where the view of a pedestrian who started to cross at a zebra crossing was blocked by vehicles in the other lane. The other was based on an extreme lateral acceleration (swerving) due to a car entering from a side road into the path of the rider.

Characteristics of everyday riding behaviour

This analysis of everyday riding behaviour focussed on speed choice and acceleration by PTW riders in four common urban intersection scenarios: free flow followed by a right or left turn, and full stop followed by a right or left turn. The analysis was based on 7350 manoeuvres by 32 riders. Most scenarios were significantly different from each other on all measures (speed at manoeuvre start, speed at manoeuvre end, average speed, maximum speed, minimum speed, acceleration at manoeuvre start, average positive and negative acceleration, and maximum positive and negative acceleration). Across riders, significant differences were found in speed choice and acceleration during manoeuvres, as well as in the time window surrounding full stops prior to the manoeuvres. Furthermore, riders appear to decelerate constantly in the five seconds preceding a full stop, but the magnitude of the deceleration varies across riders; see Figure 5.4. These findings suggest that riders have individual riding styles (i.e., preferences regarding speed and acceleration).

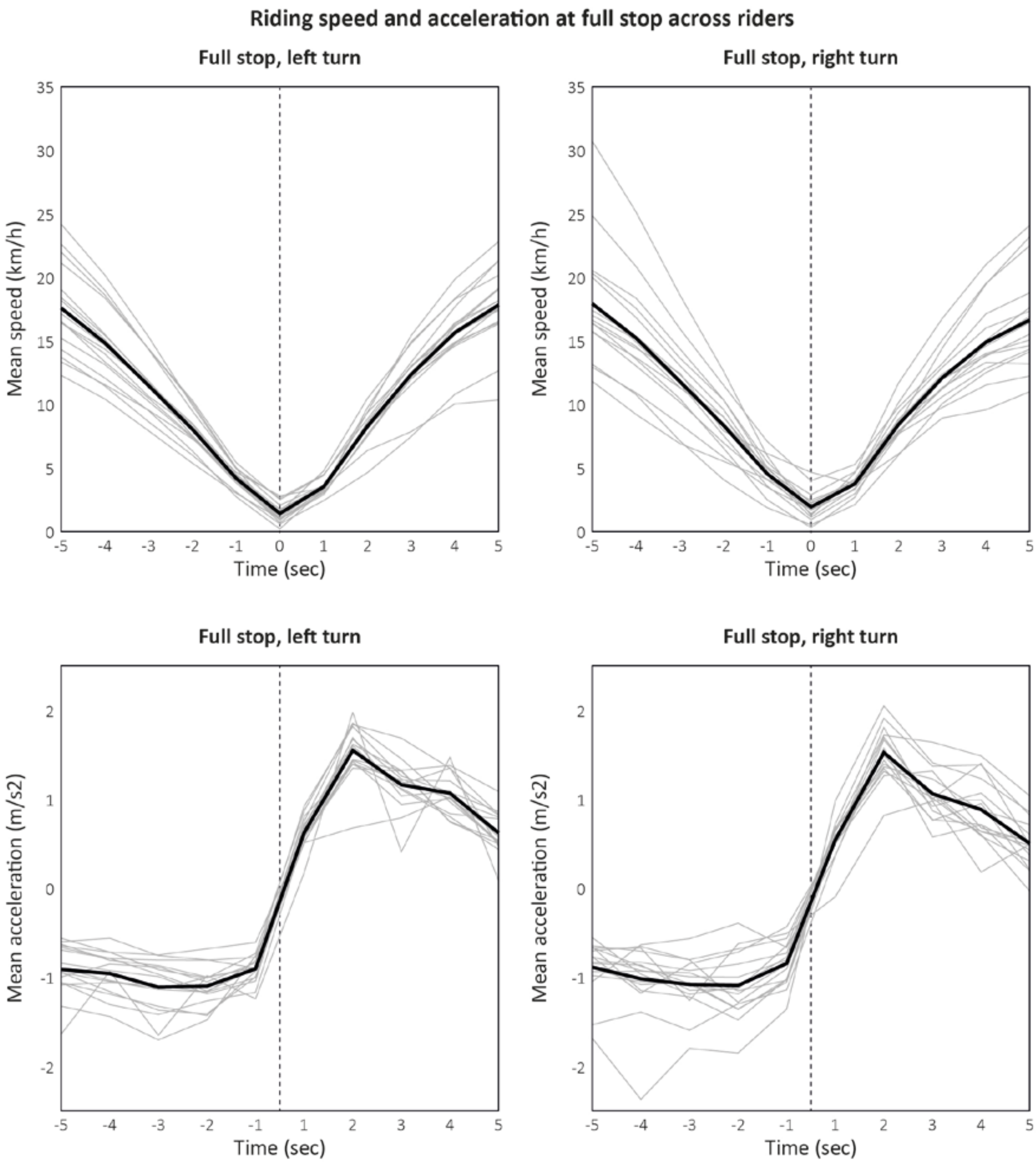


Figure 5.4: Speed and acceleration as function of time in full stop scenarios preceding left turns (left panels) and right turns (right panels). NOTE: t=0sec corresponds to the last moment at which the full stop occurred. Speed below 1km/h has been removed. Timestamps at acceleration correspond to bins of 1 second relative to t=0sec. Grey lines: average speed/acceleration of individual riders. Black lines: average speed/acceleration across riders.

Time headway between cars and PTWs

This analysis compared the time headway (the following distance expressed in seconds) on straight sections of roads between cars and PTWs to the time headways between two cars and between cars and trucks. For this analysis the starting point was the car. The data, from 140 car drivers from France, Germany, Netherlands, Poland, and the United Kingdom who had driven almost 650,000km, were searched to identify relevant interactions. Final analyses included over one hundred million situations in which the car was behind another car, over six million situations in which the car was behind a truck, and almost 370,000 situations in which the car was behind a PTW. Different road types with different speed profiles were included in the analysis. The data did not show that car drivers tend to follow PTWs closer than cars or trucks. In fact, there was even an indication that car drivers followed PTWs at a longer distance.

5.4.2 Conclusions and future work

For subsequent analyses, it is advisable to modify the methods for defining and identifying safety-relevant events. Correctly identifying relevant events was a special challenge for these vehicles. Using triggers based on severe g-forces produced large amounts of false alarms, which are probably related to the characteristics of PTWs, but to some extent may also reflect the characteristics of the riders.

If preferences in speed choice and acceleration indeed exist, they may inform the development of intelligent warning systems capable of determining the differences between 'normal' and 'abnormal' riding behaviour. Furthermore, preferences would warrant further research to explore whether groups of riders share similar preferences. This research could employ a bottom-up (data-driven) approach, such as cluster analysis, or a top-down approach (using behavioural questionnaires, for example).

The hypothesis that *Car drivers keeping less time headway behind PTWs is the reason for rear-end collisions* has to be rejected, according to the results of this research. However, the hypothesis that short time headway is responsible for rear-end collisions of powered two-wheelers cannot be rejected by this research. The required time headway for a car behind a PTW is not necessarily equal to the safety gap required for cars behind other cars or trucks. On the contrary, the smaller silhouette of a PTW reduces the size change of its projection on the iris. Hence, it might be that driving behind a PTW requires more time headway than driving behind a passenger car or a truck because it is harder to perceive a change in relative distance. Unfortunately, issues of PTW conspicuity could not be answered by the data available. With more safety-critical events, it would have been possible to analyse whether conspicuity of the bike and its rider has an impact on the timely recognition of a sudden decrease in the distance. However, this analysis would ideally be conducted as a controlled experiment in a laboratory.

5.5 Conclusions across VRU modes of transport

Subsequent analyses of the UDrive data would allow for further identification of safety-critical events and their circumstances. Unfortunately, for the current analyses only limited opportunities were available for identifying (potential) safety-relevant events in pedestrian/cyclist-vehicle interactions and for PTWs. These efforts produced a fairly limited number of safety-critical events for cyclists and PTW riders. For pedestrians and cyclists, the current study had to rely on data gathered by the naturalistically instrumented cars and trucks, and only potential conflicts occurring in the daytime would be identified. As a result, it is only possible to study their behaviour in these interactions. Even though many of the fatal pedestrian and cyclist crashes do indeed occur in collisions with vehicles, Dutch data show that a large share of cyclists' serious-injury crashes occur as a result of a collision or fall without the (direct) involvement of a motorised vehicle (Weijermars, Bos, & Stipdonk, 2016). These crashes' circumstances render them invisible when only vehicle-cyclist interactions are available. Though far less documented, pedestrian-vehicle incidents could call for similar reasoning.

Instrumenting cyclists and pedestrians in order to register their everyday trips (naturalistic cycling and naturalistic walking) would provide more insight into their participation in traffic and the problems they encounter—from their own perspective. In addition, it would facilitate the identification of safety-relevant events in interactions with motorised traffic when the driver did not react (or barely reacted), because these events would otherwise remain undetected (see also previous section). There have already been several initiatives for naturalistic cycling in Europe (Dozza & Werneke, 2014; Schleinitz, Petzoldt, Franke-Bartholdt, Krems, & Gehlert, 2017), and it would be great if efforts across Europe could be aligned and fed into a joint database. Naturalistic walking, the unobtrusive collection of data through instrumenting pedestrians, might be more difficult to realise, but it would be worthwhile to consider the options of a 'light' version of naturalistic data collection. Finally, the Naturalistic Riding (PTW) studies so far (e.g., Pommer, Winkelbauer, & Donabauer, 2014; Weare, Reed, & ... 2011), as well as the current study in the UDrive framework, showed that it is not at all obvious how to collect reliable and robust data for this type of vehicle. However, the current study can provide a useful base for further development of naturalistic riding methodology and equipment.

6. Eco-driving

6.1 Introduction

Eco-driving in the context of this study denotes a driving style associated with low fuel consumption. Some of the golden rules of eco-driving are:

- shift gears up as soon as possible, between 2000 and 2500 revolutions per minute
- anticipate traffic flow (to minimise dynamics and limit braking)
- maintain a steady speed
- decelerate smoothly by coasting

Unique to UDrive (unlike a generic collection of velocity data from random drivers such as the WLTP database, a worldwide, unified, light-duty test-cycle database with, for example, speed and acceleration information) is the augmentation of the velocity data with driving circumstances, like road type, speed limits, headway, and in-vehicle information. This allows driving behaviour to be placed in context, and personal driving style to be distinguished from behaviour imposed by traffic conditions. The UDrive analysis used the continuous signals of the full dataset for cars, consisting of 13,500 hours of driving by 154 drivers. The overall objectives in analysing passenger car data were to:

- improve understanding of the variation in driving styles and the contribution of different driving styles to average driving behaviour, in relation to eco-driving;
- assess the fuel consumption and CO_2 emission-reduction potential associated with adopting an eco-driving style. Improve insight into the overall potential for eco-driving at the national and EU levels by studying different parts of the driver sub-population, different road types and traffic situations, and different vehicle applications.

To assess the fuel consumption reduction potential, it is crucial to separate personal driving style from infrastructure and from congestion while driving. The bandwidth of personal driving style is the bandwidth of eco-driving. Infrastructure and congestion will be the main influences on fuel consumption during a trip. In this analysis, the challenge is to uncover other influences which can be manipulated to encourage a fuel-economising driving style

6.2 Driving styles

The following research questions were used to define personal driving styles:

- *How much do drivers deviate from the speed limit in free-flow situations?*
- *Why do drivers deviate from the speed limit in free-flow situations?*
- *When do drivers brake and is it necessary to brake in each instance?*
- *Do drivers shift gears to avoid high engine speeds and high fuel consumption?*

6.2.1 Key results

The bandwidth of the most frequent velocity between drivers is up to 20km/h under and over the speed limit. Figure 6.1 gives an example of the velocities at different speed limits for a single driver. The variation in velocity, which causes extra fuel-consuming dynamics, varies similarly, between 0 and 20km/h. The selection of data from trips on straight roads without intersections or a vehicle in front does not yield significantly different results. The question why drivers deviate from the speed limit remains unanswered, since there is no clear correlation with road obstructions or congestion.

One expects that the more headway a driver keeps, the less he needs to brake because he has time to anticipate the traffic. Indeed, more headway corresponds with less braking. Also, the higher the velocity, the lower the average time headway and the lower the braking energy. The same conclusion can be drawn when comparing braking and headway averages for all drivers. In conclusion, drivers lose the most energy braking at low velocities and in urban driving. The bandwidth between drivers is very large, up to 70% from the average, or 120% between the best and worst driver.

There is also a large bandwidth in average engine speed at the gear-shifting moment between drivers. The eco-driver advice is to change gears between 2000 and 2500 RPM, but drivers shift at engine speeds from 1400 to 3000 RPM, depending on the vehicle type and the gear—but mostly on driver behaviour.

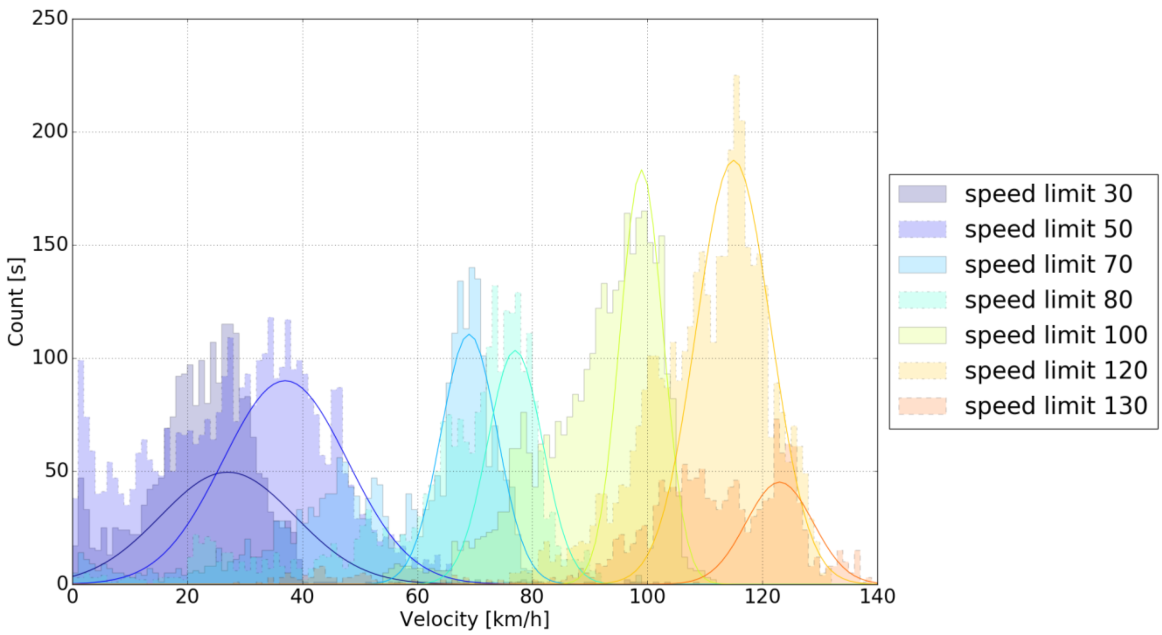


Figure 6.1: Velocity distributions per speed limit for one driver in The Netherlands, with a fit of the most frequent velocities

6.2.2 Conclusions and future work

The velocity difference between drivers is up to 20% from the speed limit, both below and above it. The dynamics show an even larger spread, up to 50%. Drivers that keep a larger time headway (either due to personal driving style or absence of traffic) tend to lose less energy braking. When straight roads without intersections and without a vehicle in front were selected, the braking energy does not decrease, although the difference between individual drivers increases. This finding indicates a difference in personal driving style larger than the difference due to driving circumstances. The difference between better and worse eco-driving behaviour is most easily recognised in the gear-shifting analysis.

A more detailed study of driving circumstances, by studying velocity behaviour in very specific traffic situations, for example, could yield more information on the reason for the personal speed choice. A more reliable definition of free-flow data (excluding congestion and infrastructure obstructions) would give a cleaner free-flow velocity distribution that better represents a driver's personal style. The information given by the drivers in the questionnaires would provide insight into their reasons to overspeed or drive more slowly than the speed limit.

6.3 Effects of driving styles on Eco-driving

The most important factors influencing personal driving style are combined in order to define an eco-driving score that facilitates an overall comparison between drivers. Furthermore, the correlation between other ways of defining driving style (e.g., safe vs aggressive) and eco-driving are studied:

- *How do the differences in driving style translate into differences in fuel consumption?*
- *Are eco-driving and safe driving correlated?*

6.3.1 Key results

For most drivers, braking energy is the main energy consumer at low velocities, larger than rolling resistance or air drag. The difference in lost braking energy between the best and worst driver is on the order of 120%, resulting in a difference in energy consumption of up to 10%.

Engine losses are not negligible for passenger cars. Idling in urban areas occurs an average of 15% of the time, within a range of 0-50%. The idle CO_2 emission associated with low engine losses is typically 0.3-0.5 g/s. With higher engine speeds, up from idling at 800-1000 RPM, engine losses increase. Some drivers shift much earlier than others, even in the same type of vehicle. This large variation in gear shifting behaviour means there is quite a bit of room for improvement of eco-driving behaviour. The estimated difference in fuel consumption due to different engine speeds can be as high as 20-25%.

The following residual values are averaged to get an eco-driving score:

- Braking energy at 50-60km/h
- Engine speed when shifting from second to third gear
- Most frequent (peak) velocity at speed limits between 95 and 120km/h
- Width of the peak around the most frequent velocity at speed limits between 95 and 120km/h
- Weighted mean of the absolute acceleration at speed limits between 95 and 120km/h

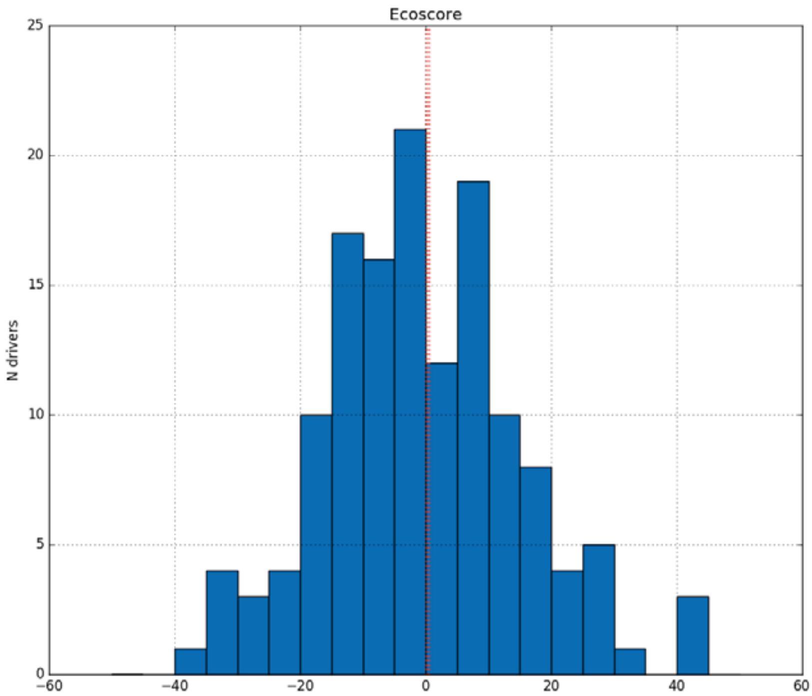


Figure 6.2: Distribution of eco-driving scores of all drivers, for straight sections and free-flow conditions

The average of the residual percentage values gives an eco-score that is negative for better and positive for worse eco-drivers. Since it is expected that a correction for driving circumstances would have a large influence on driving behaviour, a selection is made on free-flow circumstances (based on headway), excluding trajectories with bends and intersections. The distribution of the eco-score per driver, shown in Figure 6.2, varies within a bandwidth of 80%.

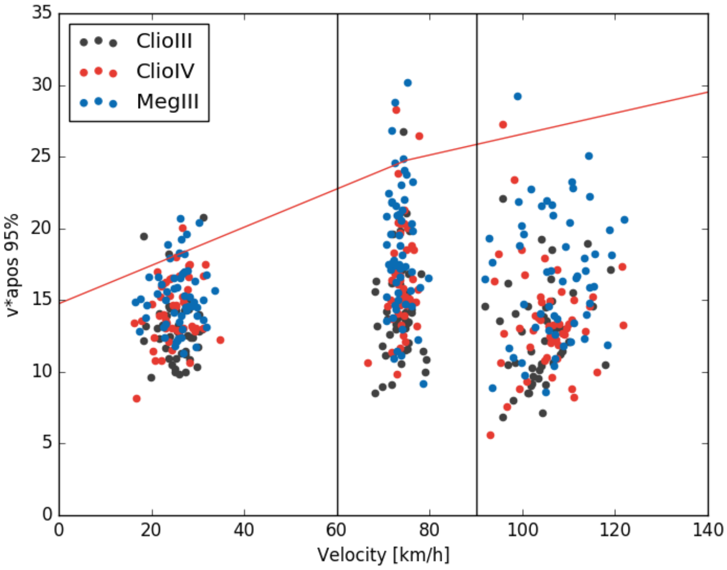


Figure 6.3: v*a positive [m²/s³] at 95 percentile in three different velocity ranges, for all drivers per vehicle type. The red line indicates the current upper limit for the Real Driving Emission legislation

The variable velocity times positive acceleration (vapos), shown in Figure 6.3, provides an estimate of safety. This variable is commonly used for validating the driving behaviour in emission testing, to distinguish between aggressive and tame driving profiles. This safe-driving variable and the ecoscore per driver are clearly correlated.

6.3.2 Conclusions and future work

Braking, gear shifting, and the velocity choice and dynamics on the motorway can all change the fuel consumption by 10% or more for a vehicle with traditional technology. This study did not attempt to arrive at a generic number, as it would depend strongly on individual vehicle technology. Due to the sparsity of the data related to very specific research questions, the correlation of different findings must be considered indicative.

The correlation between safe driving and eco-driving relies on velocity-related parameters, which means there must be a good correlation between the two. It would be interesting to see how the analysis of safety-critical events correlates with the eco-driving score per driver.

6.4 Potential effect of eco-driving

The key research questions in UDrive with respect to the potential effect of eco-driving were:

- *Is eco-driving an observable characteristic of certain drivers?*
- *What is the potential effect of eco-driving, given the bandwidth in driving styles between drivers?*

6.4.1 Key results

The eco-driving potential could be described as the difference between the scores of the worst and the best drivers (after correcting for driving circumstances). The 80% difference between drivers indicates that eco-driving, as defined by this score, is an observable characteristic of certain drivers. It should be noted, however, that fuel consumption does not linearly depend on this eco-driving scoring.

There is a substantial difference in the average score in different countries. This can be seen in Figure 6.4. The Netherlands are on the low side, with better eco-driving behaviour, whereas Polish drivers score worse on this eco-driving scale. Note, however, that the underlying data consists of only tens of drivers. Since there is not enough diversity in the data to correct the data per country for underlying effects such as different road types and vehicle types, one cannot conclude that these differences are due to personal driving style.

Figure 6.5 illustrate the results grouped by vehicle. The difference between the vehicles could be caused either by different driving behaviour in those vehicles, or by the larger engine and vehicle size. The same analysis, grouping the drivers by gender and by age group (per 10 years), did not yield significant differences between the groups.

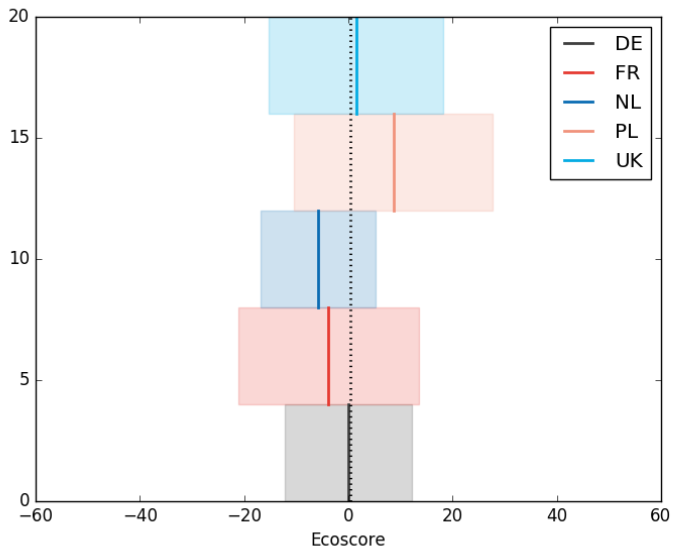


Figure 6.4 Residual eco-score with respect to average of all drivers, grouped by country, for straight sections and freeflow

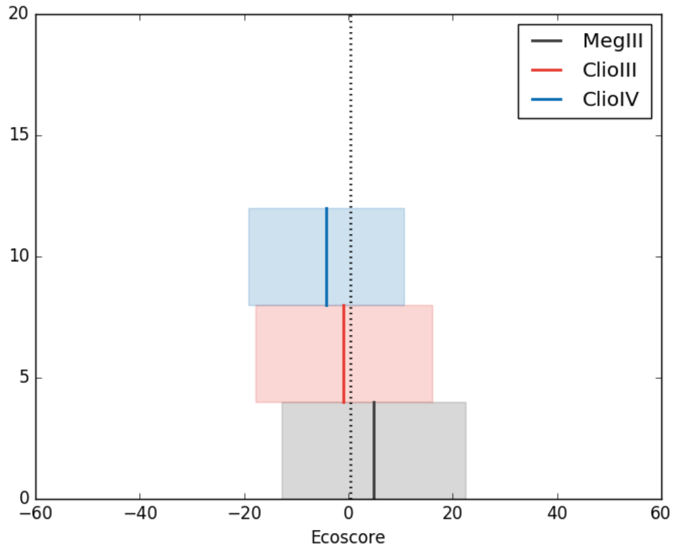


Figure 6.5 Residual eco-score with respect to average of all drivers, grouped per vehicle type, for straight sections and freeflow

6.4.2 Conclusions and future work

Grouping the results with respect to country, driver age, and driver gender did not yield strong correlations that we can say with certainty are independent of infrastructure, vehicle type, and other factors.

The more general the results, such as the velocity distribution around the speed limits on the motorway, the more data can be combined. This practice yields more robust results, which can be generalized to the European average with more confidence. The major drawback of these generalizations is the limited traffic information which may fail to disclose an unknown bias. The poor quality of the headway signal is the main cause of the problem with separating different traffic situations that affect driving behaviour. Generalizing the results to a European average is therefore partly blind to important aspects which can affect driving behaviour, because it is based on the assumption that the traffic situations are representative of the European average.

For more statistically significant results, future naturalistic driving data collection should include more different drivers and more different vehicle types, even if this means that less data are available per driver. In addition, a well-calibrated and continuous headway signal (along with other crucial parameters such as road gradient, vehicle payload, and road surface) should be available.

7. Conclusions

UDrive is a large European naturalistic driving study sponsored by the European Commission (FP7). Nineteen partners across Europe have come together to pursue the aims of UDrive: to contribute to developing a far better in-depth understanding of road user behaviour, and to facilitate the identification and development of measures aimed at reaching the traffic safety and emission targets set by the EU. In UDrive the aims has been achieved by conducting a large-scale European Naturalistic Driving Study (NDS), creating a database with the data, analysing the data, and applying the findings to specific areas according to the relevant aims.

This deliverable describes the UDrive dataset and key results from the data analysis part of the project (sub-project/SP 4). The dataset includes passenger car data from Germany, France, the Netherlands, Poland and the United Kingdom; truck data from the Netherlands; and powered two-wheeler data from Spain. Analysis was conducted on risky and everyday driving, secondary tasks while driving, car/truck interaction with vulnerable road users, and eco-driving. The UDrive dataset is described in Chapter 2 and key analysis results in Chapters 3-6. The performed analyses are extensive; thus this deliverable only provides a few (key) results as examples—details are provided in four separate deliverables (one for each research topic).

In conclusion, the UDrive analysis and its corresponding results both confirm previous work and extend traffic safety and eco-driving research in Europe, with a few surprises. Results range from showing a large variability across European countries for a number for traffic safety indicators, to showing (for example) large differences in the prevalence of secondary task engagement between car and truck drivers.

The UDrive dataset is unique in that it captures naturalistic driving/riding data from three vehicle types on European roads (with car data collected in five countries). The dataset has been partially annotated in UDrive, and the data is ready to be used for research after UDrive. A few UDrive partners plan to host the entire UDrive dataset, and the dataset will probably continue to provide Europe with valuable research findings for both traffic safety and eco-driving for years to come.

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List of abbreviations

DAS : data acquisition system

FOT: field operational test

NDD: naturalistic driving data

NDS: naturalistic driving study

NFOT: naturalistic field operational test

THW: time headway

TTC: time to collision

VRU: vulnerable road user

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Appendix A The UDrive data acquisition and map variables

Table A.1: A list of the variables/measures collected in the UDrive data acquisition system, as well as the map (geographical information system; GIS) map attributes associated with the data.

Record	(CAR, TRUCK, PTW)
	RecOffset
	RecFileName
	DasConfig
	OperationSite
	DriverID
	RecSize
	RecPath
ExternalData	**(CAR)**
	VID_FRONT_LEFT
	VID_FRONT_CENTER
	VID_FRONT_RIGHT
	VID_DRIVER_ACTION
	VID_CABIN
	VID_DRIVER_FACE
	VID_DRIVER_FEET
ExternalData	**(TRUCK)**
	VID_FRONT_LEFT
	VID_FRONT_CENTER
	VID_FRONT_RIGHT
	VID_LEFT
	VID_RIGHT
	VID_CABIN
	VID_DRIVER_FACE
	VID_DRIVER_FEET
ExternalData	**(PTW)**
	VID_FRONT
	VID_DRIVER_FACE
	VID_LEFT
	VID_RIGHT
	VID_REAR
DataSegement	**FullRecord (CAR, TRUCK, PTW)**
	Duration
	TravelDistance
Timeseries	**MAP_MatchingOutput (CAR, TRUCK, PTW)**
	MAP_TIMESTAMP
	MAP_MAP_MATCHED_LAT
	MAP_MAP_MATCHED_LON
	MAP_HEADING
	MAP_SPEED
	MAP_SEGMENT_ID
	MAP_COUNTRY_CODE
	MAP_SEGMENT_LENGTH
	MAP_DRIVING_DIRECTION
	MAP_CURVILINEAR_ABSCISSA_ON_SEGMENT
	MAP_IS_ONE_WAY
	MAP_SPEED_LIMIT
	MAP_NB_LANES_NEG_DIR
	MAP_NB_LANES_POS_DIR
	MAP_WAY_CATEGORY
	MAP_WAY_TYPE
	MAP_WAY_AREA_TYPE
	MAP_INTERSECTION
	MAP_DIST_TO_NEXT_INTERSECTION

Timeseries	TS_Mob_Signals_10Hz (CAR, TRUCK) cont.
	Number_Obstacles
	Obstacle1_Age
	Obstacle1_Angle
	Obstacle1_Blinker
	Obstacle1_Brake_Lights
	Obstacle1_Category
	Obstacle1_Cut_In_and_out
	Obstacle1_Flag_Cipv
	Obstacle1_ID
	Obstacle1_Lane
	Obstacle1_Length
	Obstacle1_Obj_Accel_Long
	Obstacle1_Position_Lat
	Obstacle1_Position_Long
	Obstacle1_Rad_Match_Confidence
	Obstacle1_Rad_Position_Long
	Obstacle1_Rad_Velocity_Long
	Obstacle1_Radar_Match_ID
	Obstacle1_Rate_Angle
	Obstacle1_Rel_Vel_Long
	Obstacle1_Replaced
	Obstacle1_Scale_Change
	Obstacle1_Stat
	Obstacle1_Val
	Obstacle1_Width
	Obstacle2_Age
	Obstacle2_Angle
	Obstacle2_Blinker
	Obstacle2_Brake_Lights
	Obstacle2_Category
	Obstacle2_Cut_In_and_out
	Obstacle2_Flag_Cipv
	Obstacle2_ID
	Obstacle2_Lane
	Obstacle2_Length
	Obstacle2_Obj_Accel_Long
	Obstacle2_Position_Lat
	Obstacle2_Position_Long
	Obstacle2_Rad_Match_Confidence
	Obstacle2_Rad_Position_Long
	Obstacle2_Rad_Velocity_Long
	Obstacle2_Radar_Match_ID
	Obstacle2_Rate_Angle
	Obstacle2_Rel_Vel_Long
	Obstacle2_Replaced
	Obstacle2_Scale_Change
	Obstacle2_Stat
	Obstacle2_Val
	Obstacle2_Width
	Obstacle3_Age
	Obstacle3_Angle
	Obstacle3_Blinker
	Obstacle3_Brake_Lights
	Obstacle3_Category
	Obstacle3_Cut_In_and_out
	Obstacle3_Flag_Cipv
	Obstacle3_ID
	Obstacle3_Lane

	MAP_CURVE_RADIUS
	MAP_AVERAGE_SPEED
	MAP_ROAD_INCLINATION
	MAP_TUNNEL_BRIDGE
	MAP_TRAFFIC_SIGN_1_MAP_MATCHED_LAT
	MAP_TRAFFIC_SIGN_1_MAP_MATCHED_LON
	MAP_TRAFFIC_SIGN_1_CURVILINEAR_ABSCISSA_ON_SEGMENT
	MAP_TRAFFIC_SIGN_1_DIST_TO_EGO
	MAP_TRAFFIC_SIGN_1_SIDE
	MAP_TRAFFIC_SIGN_1_APPLICABLE_VEHICLES
	MAP_TRAFFIC_SIGN_2_MAP_MATCHED_LAT
	MAP_TRAFFIC_SIGN_2_MAP_MATCHED_LON
	MAP_TRAFFIC_SIGN_2_CURVILINEAR_ABSCISSA_ON_SEGMENT
	MAP_TRAFFIC_SIGN_2_DIST_TO_EGO
	MAP_TRAFFIC_SIGN_2_SIDE
	MAP_TRAFFIC_SIGN_2_APPLICABLE_VEHICLES
	MAP_TRAFFIC_SIGN_3_MAP_MATCHED_LAT
	MAP_TRAFFIC_SIGN_3_MAP_MATCHED_LON
	MAP_TRAFFIC_SIGN_3_CURVILINEAR_ABSCISSA_ON_SEGMENT
	MAP_TRAFFIC_SIGN_3_DIST_TO_EGO
	MAP_TRAFFIC_SIGN_3_SIDE
	MAP_TRAFFIC_SIGN_3_APPLICABLE_VEHICLES
	MAP_TRAFFIC_SIGN_4_MAP_MATCHED_LAT
	MAP_TRAFFIC_SIGN_4_MAP_MATCHED_LON
	MAP_TRAFFIC_SIGN_4_CURVILINEAR_ABSCISSA_ON_SEGMENT
	MAP_TRAFFIC_SIGN_4_DIST_TO_EGO
	MAP_TRAFFIC_SIGN_4_SIDE
	MAP_TRAFFIC_SIGN_4_APPLICABLE_VEHICLES
Timeseries	Phidget_Accel_Signals (CAR, TRUCK, PTW)
	PTW_PhidgetSpatial_acc_x
	PTW_PhidgetSpatial_acc_y
	PTW_PhidgetSpatial_acc_z
Timeseries	Phidget_Gyro_Signals (CAR, TRUCK, PTW)
	PTW_PhidgetSpatial_gyro_x
	PTW_PhidgetSpatial_gyro_y
	PTW_PhidgetSpatial_gyro_z
Timeseries	Phidget_Compass_Signals (CAR, TRUCK, PTW)
	PTW_PhidgetSpatial_compass_x
	PTW_PhidgetSpatial_compass_y
	PTW_PhidgetSpatial_compass_z
Timeseries	GPS_streamOutput (CAR, TRUCK, PTW)
	GPS_Latitude
	GPS_Longitude
	GPS_Speed
	GPS_Bearing
Timeseries	TS_Mob_Signals_10Hz (CAR, TRUCK)
	Active_Vers_Number_Section
	Angle_Pitch
	Angle_Yaw
	App_Vers
	Armed_FLA
	Blinker_Reminder
	Blinker_Reminder_Active
	CA_Construction_Zone
	Close_Car
	Dist_To_Lane_left
	Dist_To_Lane_right
	Err_Active
	Err_Code

Obstacle3_Length
Obstacle3_Obj_Accel_Long
Obstacle3_Position_Lat
Obstacle3_Position_Long
Obstacle3_Rad_Match_Confidence
Obstacle3_Rad_Position_Long
Obstacle3_Rad_Velocity_Long
Obstacle3_Radar_Match_ID
Obstacle3_Rate_Angle
Obstacle3_Rel_Vel_Long
Obstacle3_Replaced
Obstacle3_Scale_Change
Obstacle3_Stat
Obstacle3_Val
Obstacle3_Width
Obstacle4_Age
Obstacle4_Angle
Obstacle4_Blinker
Obstacle4_Brake_Lights
Obstacle4_Category
Obstacle4_Cut_In_and_out
Obstacle4_Flag_Cipv
Obstacle4_ID
Obstacle4_Lane
Obstacle4_Length
Obstacle4_Obj_Accel_Long
Obstacle4_Position_Lat
Obstacle4_Position_Long
Obstacle4_Rad_Match_Confidence
Obstacle4_Rad_Position_Long
Obstacle4_Rad_Velocity_Long
Obstacle4_Radar_Match_ID
Obstacle4_Rate_Angle
Obstacle4_Rel_Vel_Long
Obstacle4_Replaced
Obstacle4_Scale_Change
Obstacle4_Stat
Obstacle4_Val
Obstacle4_Width
Tsign1_Filter_Category
Tsign1_Position_X
Tsign1_Position_Y
Tsign1_Position_Z
Tsign1_Supplementary_Sign_Category
Tsign1_Vision_Only_Sign_Category
Tsign2_Filter_Category
Tsign2_Position_X
Tsign2_Position_Y
Tsign2_Position_Z
Tsign2_Supplementary_Sign_Category
Tsign2_Vision_Only_Sign_Category
Tsign3_Filter_Category
Tsign3_Position_X
Tsign3_Position_Y
Tsign3_Position_Z
Tsign3_Supplementary_Sign_Category
Tsign3_Vision_Only_Sign_Category
Tsign4_Filter_Category
Tsign4_Position_X
Tsign4_Position_Y
Tsign4_Position_Z
Tsign4_Supplementary_Sign_Category
Tsign4_Vision_Only_Sign_Category
Tsign5_Filter_Category

	Fail_Safe
	FCW_Active
	FCW_m
	Fix_Horizon
	General_Ped
	GO
	Hi_Low_BeamCntrl
	HW_Measurement
	HW_Repeatable_Active
	HW_Valid
	HW_Warn_level
	HW_Warn_Level
	L_Close_Range_Cut_In
	Lane_Cat_Left
	Lane_Cat_Right
	Lane_Config_Left
	Lane_Config_Right
	Lane_Curve
	Lane_Head
	LDW_Av_Left
	LDW_Av_Right
	LDW_Detect
	LDW_Off_m
	LLDW_active
	LLDW_m
	Maint
	PCW_Peddz_m
	Protocol_Vers
	R_Close_Range_Cut_In
	Rain_Headway
	Rain_HW_Active
	RLDW_Active
	RLDW_m
TimeSeries	TS_10Hz_Signals (CAR)
	mSpeedCAN
	EngineRPM
	mSteeringWheelAngle
	SteeringWheelRotationSpeed
	mLongitudinalAcceleration
	mYawRate
	Odometer
	mAcceleratorPedalPosition
	mBrakePressure
TimeSeries	TS_1Hz_Signals (CAR)
	mDistanceDriven
	FuelLevel
	ExternalTemp
	AbsoluteTimeSince1rstIgnition
StateChange	TS_Veh_CC_SL_State (CAR)
	CruiseControlStatusDisplay
StateChange	TS_Veh_CC_SL_SetSpeed (CAR)
	RequestedSpeedDisplayReq
StateChange	TS_Veh_CC_SL_Overspeed (CAR)
	OverspeedIndicationDisplayReq
StateChange	TS_Veh_Front_Wiper_Status (CAR)
	mWipersActivity
	Tsign5_Position_X
	Tsign5_Position_Y
	Tsign5_Position_Z
	Tsign5_Supplementary_Sign_Category
	Tsign5_Vision_Only_Sign_Category
	Tsign6_Filter_Category
	Tsign6_Position_X
	Tsign6_Position_Y
	Tsign6_Position_Z
	Tsign6_Supplementary_Sign_Category
	Tsign6_Vision_Only_Sign_Category
	Tsign7_Filter_Category
	Tsign7_Position_X
	Tsign7_Position_Y
	Tsign7_Position_Z
	Tsign7_Supplementary_Sign_Category
	Tsign7_Vision_Only_Sign_Category
	Sign_Category_1
	Sign_Category_2
	Sign_Category_3
	Sign_Category_4
	Sound_Category
	Speed_Zero
	Supplementary_Sign_Cat_1
	Supplementary_Sign_Cat_2
	Supplementary_Sign_Cat_3
	Supplementary_Sign_Cat_4
	Time_Indic
	Timestamp
	TSR_Active
	TSR_warn_level
	Warning_Cat
	Yaw_Fixed
TimeSeries	TS_10Hz_Signals (TRUCK)
	mAcceleratorPedalAPPosition
	mAcceleratorPedalPosition
	mBrakePedalPosition
	mSpeedCAN
	mEngineRPM
	mSteeringWheelAngle
	mSteeringTurnCounter
	mYawRate
	mLongitudinalAcceleration
	mLateralAcceleration
	mRetarder_Activity_ER
	mRetarder_Activity_R
	mSpeed
	mTachoVehicleSpeed
	mTachoOutputShaftSpeed
TimeSeries	TS_1Hz_Signals (TRUCK)
	mDistanceDriven
	mFuelLevel
StateChange	TS_Veh_Left_Flasher (TRUCK)
	mTurnIndicatorSignal_L
StateChange	TS_Veh_Right_Flasher (TRUCK)
	mTurnIndicatorSignal_R
StateChange	TS_Veh_Current_Gear (TRUCK)
	mGear

StateChange	TS_Veh_Brake_Pedal_Status (CAR)
	mBrakePedalPosition
StateChange	TS_Veh_Clutch_Switch_Min_Travel (CAR)
	mClutchUp
StateChange	TS_Veh_Clutch_Switch_Max_Travel (CAR)
	mClutchDown
StateChange	TS_Veh_Flashing_Indicator_Status (CAR)
	mTurnIndicatorSignal
StateChange	TS_Veh_Position_Lights (CAR)
	PositionLightsRequest
StateChange	TS_Veh_Low_Beam (CAR)
	LowBeamRequest
StateChange	TS_Veh_High_Beam (CAR)
	HighBeamRequest
StateChange	TS_Veh_Front_Fog (CAR)
	FrontFogLightsRequest
StateChange	TS_Veh_Rear_Fog (CAR)
	RearFogLightsRequest
StateChange	TS_Veh_Rear_Defrost (CAR)
	RearDefrostRequest
StateChange	TS_Veh_ABS_Regulation (CAR)
	ABSinRegulation
StateChange	TS_Veh_ASR_Regulation (CAR)
	ASRinRegulation
StateChange	TS_Veh_AYC_Regulation (CAR)
	AYCinRegulation
StateChange	TS_Veh_Crash_Detection (CAR)
	mAirbagDeployment
StateChange	TS_Veh_Driver_SafetyBelt_Status (CAR)
	DriverSafetyBeltSwitch
StateChange	TS_Veh_FrontPassenger_SafetyBelt_Status (CAR)
	FrontPassengerSafetyBeltSwitch
StateChange	TS_Veh_RearCenterPassenger_SafetyBelt_Status (CAR)
	RearCenterPassengerSafetyBeltSwitch
StateChange	TS_Veh_RearLeftPassenger_SafetyBelt_Status (CAR)
	RearLeftPassengerSafetyBeltSwitch
StateChange	TS_Veh_RearRightPassenger_SafetyBelt_Status (CAR)
	RearRightPassengerSafetyBeltSwitch
StateChange	TS_Veh_MM_Customer_Action (CAR)
	MMCustomerAction
StateChange	TS_Veh_Light_Sensor (CAR)
	Luminosity
StateChange	TS_Veh_ClimateCooling_Status (CAR)

StateChange	TS_Veh_Trailer_Connected (TRUCK)
	mTrailerConnected
StateChange	TS_Veh_CC_SL_State (TRUCK)
	mCruiseControlStatusDisplay
StateChange	TS_Veh_CC_SL_SetSpeed (TRUCK)
	mRequestedSpeedDisplayReq
StateChange	TS_Veh_SeatBelt (TRUCK)
	mSeatBelt
StateChange	TS_Veh_Wiper (TRUCK)
	mWiper
StateChange	TS_Veh_BreakSwitch (TRUCK)
	mBreakSwitch
StateChange	TS_Veh_EngineCoolTemp (TRUCK)
	mEngineCoolTemp
StateChange	TS_Veh_EngineFuelTemp (TRUCK)
	mEngineFuelTemp
StateChange	TS_Veh_EngineOilTemp (TRUCK)
	mEngineOilTemp
StateChange	TS_Veh_EngineTurboChargerTemp (TRUCK)
	mEngineTurboChargerTemp
StateChange	TS_Veh_EngineInterCoolTemp (TRUCK)
	mEngineInterCoolTemp
StateChange	TS_Veh_EngineInterCoolThermTemp (TRUCK)
	mEngineInterCoolThermTemp
StateChange	TS_Veh_ClutchSwitch (TRUCK)
	mClutchSwitch
StateChange	TS_Veh_ClutchLifeRemaining (TRUCK)
	mClutchLifeRem
StateChange	TS_Veh_AxleWeight (TRUCK)
	mAxleWeight
StateChange	TS_Veh_TrailerWeight (TRUCK)
	mTrailerWeight
StateChange	TS_Veh_CargoWeight (TRUCK)
	mCargoWeight
StateChange	TS_Veh_TotalEngineHours (TRUCK)
	mTotalEngineHours
StateChange	TS_Veh_TotalFuelUsed (TRUCK)
	mTotalFuelUsed
StateChange	TS_Veh_ServiceDistance (TRUCK)
	mServiceDistance
StateChange	TS_Veh_TachoDirectionIndicator (TRUCK)
	mTachoDirectionIndicator
StateChange	TS_Veh_TachoOverspeed (TRUCK)

	ClimateCoolingRequest		mTachoOverspeed
StateChange	TS_Veh_RearGear_Status (CAR)	StateChange	TS_Veh_TachoPerformance (TRUCK)
	mGear		mTachoPerformance
		StateChange	TS_Veh_Main_Beam (TRUCK)
			mMain_Beam

Appendix B The UDrive annotation codebook

This is the UDrive Codebook as developed in the project.

UDRIVE

European Naturalistic Driving Study

EUROPEAN COMMISSION

SEVENTH FRAMEWORK PROGRAMME

FP7-SST-2012.4.1-3

GA No. 314050

eUropean naturalistic Driving and Riding for Infrastructure and Vehicle safety and Environment

Title	UDRIVE D41.1 The UDrive dataset and key analysis results - Appendix B: Annotation codebook	
Dissemination level	Public	
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Status	Final	05-06-2017

Revision History

Version	Date	Comments
V0.1	2015-12-17	Ines Heinig: Document created based on partners agreed list of variables (v10, GA 2015-10-14)
V0.2	2016-03-04	Tina Schneidereit: comments
V0.3	2016-05-25	Ines Heinig: updated version
V0.4	2016-07-15	Ines Heinig: updated version based on review comments from DLR, SVOW, SAFER, KFV, and LEEDS, Modified variables: intersection type, secondary task, VRU variables, conflict partner type. Added variables: Conflict Partner crash and Conflict Partner Crash type.
V0.5	2016-09-08	Ines Heinig: incorporated comments from SVOW
V0.6	2016-11-08	Ines Heinig: incorporated comments from SVOW (added two conflict types for PTW), TUC, SAFER (UDRIVE_Codebook_SecondaryTask_WP43_v03.doc)
V0.6	2016-11-17	Minor correction/ typing errors
Pre-final	2016-11-21	Minor correction/ typing errors
Final	2017-06-05	Minor correction/ typing errors

Table of contents

1.1 Introduction

In the introduction, please specify consecutively

- The UDRIVE project
- The place of the reported work within UDRIVE
- Background and aim/(research) questions of the work at hand
- The contents and structure of the Deliverable

1.2 Codebook

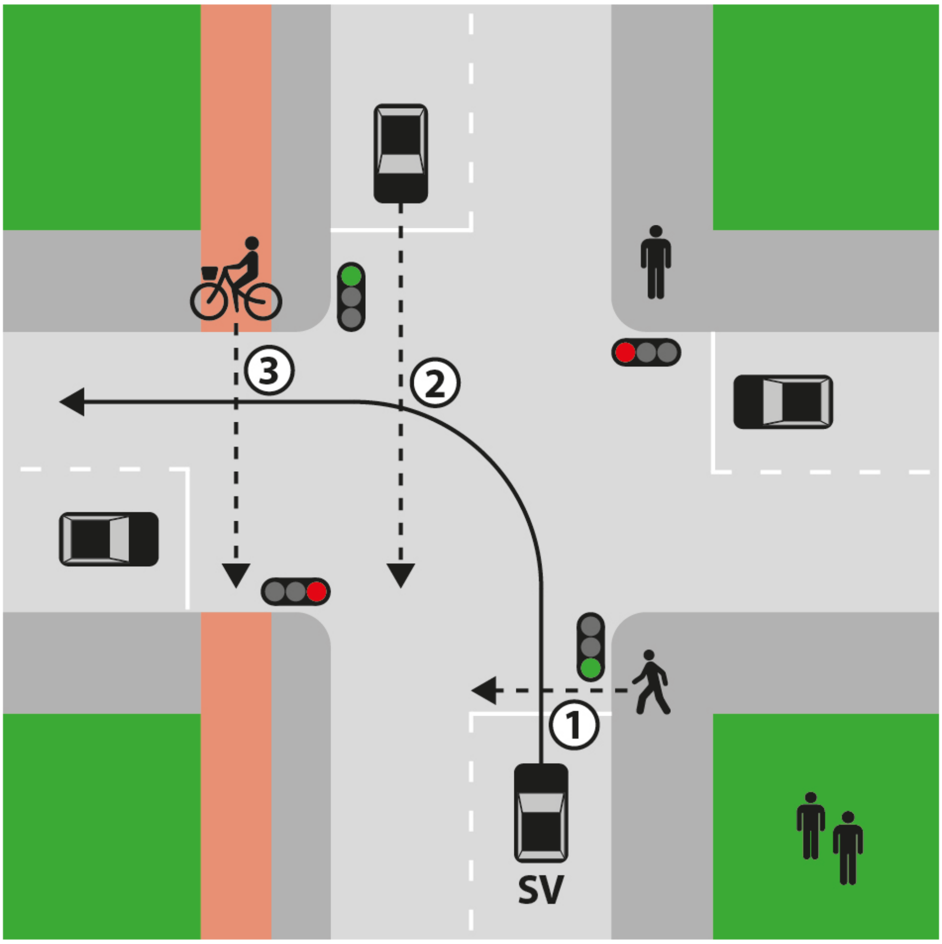
Guideline for conflict related variables in SCE and position-based annotations

For SCEs only events classified as classical conflicts or road departures will be further coded for conflict type, conflict partner type and so on. Those events which have been classified as Non-conflicts or Proximity events are not further coded.

For position-based annotation which mainly focus on interactions rather than near-crashes with VRU at intersections even Non-conflicts or Proximity events will be further coded. Instead of parallel working with number of VRUs, interacting intersection partner and conflict partners and then trying to trace/ link back which intersection partner is a VRU and/or conflicting partners the following method is proposed.

Anchor at and start with Conflict class which could be a 'Non-conflict', hence interaction.

Example:



Here are several cars and VRUs at an intersection. Only the marked ones are interesting because of a <u>clear interaction with the SV</u> (the others are just standing/ waiting). The number of conflicts here is 3:

1. Distracted pedestrian supposed to wait at red light steps on the street and is barely missed by the SV. However, the shocked pedestrian stumbles and falls.

2. Oncoming vehicle which the SV let pass bevor turning.

3. Bicyclist crossing which has been overlooked by SV – evasive braking of one or both conflict partners, no contact.

The coding would look like:

Conflict #	Conflict Class	Conflict Outcome	Conflict Type	Conflict partner Type	Conflict partner crash	VRU Type	VRU Age	VRU …	VRU …
1	Proximity Conflict	n/a	Straight crossing path	VRU	Yes	Pedestrian	Teenager	…	…
2	Non-conflict	n/a	Turn across path	Car	no	Stop coding here			
3	Classical Conflict	Near-crash	Turn across path	VRU	no	Bicycle	Adult	…	…

An additional variables (above in blue) has been added which applies only if the conflict partner collides with other than SV: Conflict Partner Crash (yes, no, n/a or unknown). That allows filtering for those type of secondary crashes like e.g. pedestrian falling due to conflicts with SV. Those events then could be annotated in a second step by making the conflict partner to the subject and using the standard coding schema.

(However for feasibility reasons it is clearly dissuaded from coding not only conflict partner crashes but even near-crashes. That means only code if the conflict partner really crashes (or falls in our example). Don't code if the conflict partner has a near-crash that is NEARLY falling in the way of an oncoming bicycle which has to steer around and nearly hitting a car which brakes hard and nearly causing a rear-end collision…)

1.3 Administrative Variables

Administrative variables will be coded for all events regardless if SCEs, baselines/ controls or position-based events.

1.3.1 Annotator ID

Variable Definition:

The unique identification of the annotator

Variable/ Input Type:

Text

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

-

1.3.2 Driver ID

Variable Definition:

The unique identification of the driver.

Variable Type:

Text

Input Type:

Text

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Participant ID

1.3.3 Video 1, 2, 3, 4, … Quality

Variable Definition:

The variable describes whether the video recordings are of sufficient quality for an analysis

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

-

Category	Definition	Example and Hints
Good	Sufficient quality for annotation and analysis.	
Partly	Sufficient quality for some but not all annotation and analysis.	
Upside down	Video appears upside down in annotation tool.	
Bad	Insufficient quality for annotation and analysis.	
Not Applicable	No camera installed	

1.4 Environment and Infrastructure Variables

Environment and Infrastructure variables will be coded for all events regardless if SCEs, baselines/ controls or position-based events and can be used for filtering relevant events for position-based annotations.

1.4.1 Weather

Variable Definition:

Weather conditions during the event

If inside a tunnel or parking facility, code the conditions inside the facility, regardless of the weather conditions outside.

Variable Type:

Categorical or time series

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Weather ('Clear/ Partly Cloudy' and 'Overcast' have been collapsed here to 'No Adverse Condition'), added 'Wind Gusts' in version 0.8 (according VTTI codebook version 4.1)

Category	Definition	Example and Hints
No Adverse Conditions	The weather is clear, partly cloudy or cloudy/ overcast. There are no adverse atmospheric conditions at the start of the event (no conditions described in other categories).	
Wind Gusts	Wind is gusting so as to affect vehicle dynamics and/or cause objects or debris/sand to blow outside.	If wind gusts and other adverse weather condition (e.g. rain) appears at the same time then code the condition which has the biggest impact on the event.
Fog	There is fog visible at the start of the event.	
Mist/Light Rain	There is mist in the air or light rain at the start of the event.	
Raining	It is raining steadily at the start of the event. (Code wet road in Surface Condition.)	Check for wiper use.

Snowing	It is snowing at the start of the event. (Code snow or slush on road in Surface Condition.)	
Sleeting	It is sleeting at the start of the event. (Code ice on road in Surface Condition.)	
Rain and Fog	It is both raining and foggy at the start of the event. (Code wet road in Surface Condition.)	
Snow/Sleet and Fog	It is both snowing and foggy at the start of the event. (Code snow on road in Surface Condition.)	
Other	There is some type of adverse atmospheric condition present, not described in other categories, at the start of the event.	Ex. smog, blowing sand, blowing snow (not falling from sky), crosswind, hail, sand/dust, smoke
Unknown	Cannot determine the weather at the start of the event due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.4.2 Light Condition

Variable Definition:

General light conditions during the event, taking into consideration the existence of external roadway illumination fixtures

If inside a tunnel or parking facility, code the conditions inside the facility, regardless of the lighting conditions outside.

Variable Type:

Categorical or time series

Input Type:

Single choice from list or single choice over time

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Lighting

Category	**Definition**	**Example and Hints**
Dawn	The time of day during the event is sunrise.	It is just starting to get light, but is still mostly dark.

Daylight	The event occurs in daylight, such as occurs in after dawn but before dusk.	
Dusk	The time of day during the event is sunset.	It is just before full darkness. Most vehicles will drive with headlights.
Darkness, lighted	It is dark during the event, but the roadway is sufficiently lighted. (Vehicle may be outside or inside a parking structure or tunnel.)	Lighted roadway includes street lamps as well as lighting coming from businesses provided that they illuminate the roadway also.
Darkness, not lighted	It is dark during the event, and the roadway is not lighted. (Vehicle may be outside or inside a parking structure or tunnel.)	
Unknown	Cannot determine the lighting conditions due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.4.3 Road Surface Condition

Variable Definition:

The type of roadway condition that would affect the vehicle's coefficient of friction at the initiation of the precipitating event (if categorical)

Variable Type:

Categorical or time series

Input Type:

Single choice from list or single choice over time

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Surface Condition and Surface Type

Variables sand and dirt are included in VTTI's variable 'Oily'. Gravel includes both Gravel/Dirt Road and Gravel over Asphalt.)

Potholes (not in VTTIs) were added in version v0.7.

Category	Definition	Example and Hints
Dry	There is no foreign material (rain, snow, oil, etc.) on the roadway in the	

	area of the event (nothing on the road to affect the driving task).	
Wet	Roadway is completely or partially wet in the area of the event (not snowy, icy, muddy, or oily).	
Snowy	There is some amount of unmelted snow or slush on the roadway in the area of the event (no ice on the road in the area of interest).	If other conditions are also present in the area affecting the event, choose the first category from this list that is applicable: icy, snowy, oily, or muddy, and add other conditions to narrative.
Icy	There is some amount of ice on the roadway in the area of the event.	If there is ice on the surface that affects the event, code as icy, regardless of any other coexisting conditions. Add other conditions to narrative.
Muddy	There is some amount of mud on the roadway in the area of the event, enough to affect the driving task.	If other conditions (other than simply a wet road) are also present in the area affecting the event, choose the first category from this list that is applicable: icy, snowy, or oily. Add other conditions to narrative.
Sand, Oil, Dirt	There is some amount of sand or dirt or oil, grease, or other slippery fluid on the roadway in the area of the event, enough to affect the driving task.	If the road is also icy (or icy and snowy) in the area affecting the event, categorize as icy. If the road is also snowy, categorize as snowy. Add other conditions to narrative.
Gravel	The road surface consists of gravel or dirt, not paved. Or The road surface is paved, but there is gravel over the asphalt that may create traction issues.	Use this option only if weather-related options above do not also apply.
Uneven, potholes	The road surface is in bad shape with potholes and uneven surface, often unpaved.	
Other	There is some type of foreign substance on the road, not listed in previous categories, enough to affect the driving task.	If the substance on the road can be driven over, but would affect the vehicle's coefficient of friction, code as "other" road condition. Material large or harmful enough to necessitate maneuvering around it would be categorized as an object or obstacle in the road and is not considered a Surface Condition.
Unknown	Cannot determine whether any Surface Conditions affected the event due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.4.4 Locality

Variable Definition:

The characteristics of the geographical location

Variable Type:

Categorical or time series

Input Type:

Single choice from list or single choice over time

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Locality (collapsed school, church and playground; airport not included below)

Category	Definition	Example and Hints
Open country	Other than the roadway, there is nothing but vegetation visible during the time surrounding the Precipitating Event that is described in any of the other categories. Road is not an Interstate or a bypass/divided highway with traffic signals. (Often appears as rural roads, 2 lanes undivided.)	Includes roadways not defined as Interstate or divided highway, when no landmarks mentioned in other categories are visible.
Open Residential	Rural to semi-rural areas where there may be only one or a few houses around (i.e., farmland).	
Moderate Residential	An area where multiple houses or apartment buildings are present, but is not as dense as an Urban Locality.	e.g., residential subdivisions
Business/industrial	Any type of business or industrial structure is present, but is not as dense as an Urban Locality. (If there are also houses visible, this category takes precedence over Open residential and Moderate residential).	
School/church/ playground	Vehicle passes any type of school building or school zone (including adult learning institutions)/ a church building/ a playground or children's playing field at the time of the Precipitating Event.	
Urban	Higher density area where blocks are shorter, streets are a mix of one and two way, and traffic can include buses and trams. (This category takes precedence over others when either businesses and/or residences are present.)	
Interstate/bypass/ divided highway, controlled access	Vehicle is travelling on an interstate, bypass, or divided highway with no at-grade intersections (regardless of what buildings can be seen), at the time of the Precipitating Event. All traffic to and from the roadway must utilize an interchange.	
Bypass/divided highway, access not controlled	Vehicle is travelling on a bypass or divided highway with at grade intersections present (either uncontrolled, stop signs, or traffic signals) and no other category description fits at the time of the Precipitating Event. Traffic to and from the roadway are not required to use an Interchange. (Often appears as "Open Country", but with more lanes and/or as a divided road.)	
Other	Locality at the time of the Precipitating Event is one not described in other categories.	Ex. In campground.

Unknown	Cannot determine the Locality due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.4.5 Road Type (Design based)

Variable Definition:

Type of road at the time of the precipitating event mainly based on structure like central reservation and number of lanes rather than function. For function based variable see below.

Variable Type:

Categorical or time series

Input Type:

Single choice from list

Coded for:

All

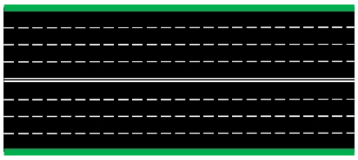
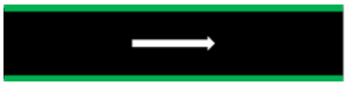
Coded by:

Central annotation

Related VTTI Variable:

No, but comparable to Locality

Category	Definition	Example and Hints
Dual Carriageway Multiple lanes	Is a class of highway with dual carriageways for traffic travelling in opposite directions separated by a central reservation with more than 2 lanes in each direction	
Dual Carriageway 2 lanes	Is a class of highway with dual carriageways for traffic travelling in opposite directions separated by a central reservation with 2 lanes in each direction	
Dual Carriageway 2+1 lanes	Is a class of highway with dual carriageways for traffic travelling in opposite directions separated by a central reservation with 2 lanes in one and 1 lane in the opposite direction	
Dual Carriageway single lanes	Is a dual carriageways for traffic travelling in opposite directions separated by a central reservation with 1 lane in each direction	

Single Carriageway Multiple lanes	Is a road with more than 2 lanes in each direction arranged within a single carriageway with no central reservation to separate opposing flows of traffic	
Single Carriageway 4 lanes	Is a road with 2 lanes in each direction arranged within a single carriageway with no central reservation to separate opposing flows of traffic	
Single Carriageway 3 lanes	Is a road with 2 lanes in one direction and 1 lane in the opposite direction arranged within a single carriageway with no central reservation to separate opposing flows of traffic	
Single Carriageway 2 lanes	Is a road with 1 lane in each direction arranged within a single carriageway with no central reservation to separate opposing flows of traffic	
Wide Lane Road	Is a road which has clearly wider lanes than other roads. There is one lane in each direction but it's wide enough for cars to overtake without entering the opposite lane.	
Single Track Road	Is a road that permits two-way travel but is not wide enough in most places to allow vehicles to pass one another (although sometimes two compact cars can pass)	
Single Track Road (one-way)	Is a road that permits one-way travel only	
Parking lot/ ramp	In parking area, park house.	
Entrance/ exit ramp	Entrance/ exit ramp	
Driveway/ alley	Driveway is a type of private road for local access to one or a small group of structures, and is owned and maintained by an individual or group. An alley or alleyway is a narrow lane, path, or passageway, often only for pedestrians, which usually runs between, behind, or within buildings in the older parts of towns and cities. It is also a rear access or service road (back lane), or a path or walk in a park or garden	
Gravel road	Is a type of unpaved road surfaced with gravel that has been brought to the site from a quarry or stream bed	
Intersection	Locality at the time of the Precipitating Event is in an intersection.	
Other	Locality at the time of the Precipitating Event is one not	Ex. In campground.

	described in other categories.	
Unknown	Cannot determine the Locality due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.4.6 Road Type (Function based)

Variable Definition:

Road classification according to the U.S. DOT's Federal Highway Administration

Each function class is based on the type of service the road provides to the motoring public, and the designation is used for data and planning purposes. Design standards are tied to function class. Each class has a range of allowable lane widths, shoulder widths, curve radii, etc.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No, but comparable to Locality

Category	Definition	Example and Hints
Interstate	Highest classification of roadways in the United States. These arterial roads provide the highest level of mobility and the highest speeds over the longest uninterrupted distance. Interstates nationwide usually have posted speeds between 55 and 75 mi/h.	
State highway	State highway	
Arterial/ Collector	Arterials include freeways, multilane highways, and other important roadways that supplement the Interstate System. They connect, as directly as practicable, the Nation's principal urbanized areas, cities, and industrial centers. Land access is limited. Posted speed limits on arterials usually range between 50 and 70 mi/h. Collectors are major and minor roads that connect local roads and streets with arterials. Collectors provide less mobility than arterials at lower speeds and for shorter distances. They balance mobility with land access.	

	The posted speed limit on collectors is usually between 35 and 55 mi/h.	
Local	Local roads provide limited mobility and are the primary access to residential areas, businesses, farms, and other local areas. Local roads, with posted speed limits usually between 20 and 45 mi/h, are the majority of roads in the U.S.	
Parking lot/ ramp	In parking area, park house.	
Entrance/ exit ramp	Entrance/ exit ramp	
Driveway/ alley	Driveway is a type of private road for local access to one or a small group of structures, and is owned and maintained by an individual or group. An alley or alleyway is a narrow lane, path, or passageway, often only for pedestrians, which usually runs between, behind, or within buildings in the older parts of towns and cities. It is also a rear access or service road (back lane), or a path or walk in a park or garden	
Off road	Not on paved roadway.	E.g. in a ditch.
Other	Locality at the time of the Precipitating Event is one not described in other categories.	Ex. In campground.
Unknown	Cannot determine the Locality due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.4.7 Divided Roads

Variable Definition:

Type of intermediate barrier in case of dual carriageway (based on European Standard EN 1317)

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

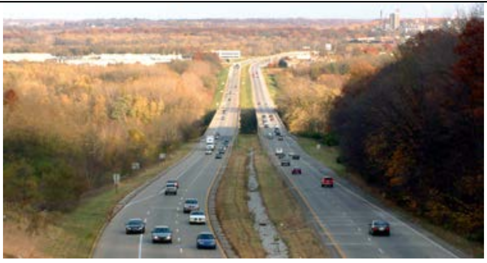
All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
No barrier, low distance	There is a soft shoulder in between, may also be grass, mud, gravel, etc., but no asphalt, no concrete.	
High distance	Typical American style, where they have some 10 meters between the carriageways, but no physical barrier. Anything more than about 3 meters should be considered high distance, below 3 meter choose 'No barrier, low distance' if not 'High green' (see below)	
High green	Minimum 1m high plants regardless of the width, without considerable interruption. 1m height due to high of the front lights of a car, during the night, even the high beam would not bother an oncoming driver.	
Wire rope barrier	Wire rope barrier	

Steel or aluminum guard rails	Regardless how many and how strong, H1 to H4b, does not matter	
Concrete barrier	Concrete barrier	
Not applicable	Single carriageway or intersections	
Unknown	Cannot determine due to limitations in video views, lighting, visual obstructions, or limited perspective.	

1.4.8 Intersection Type

Variable Definition:

This variable describes the type of intersection(s) where the event(s) occurred. Note that intersecting road sections may also involve bicycle lanes, zebras, or other VRU facilities.

Variable Type:

Categorical or time series

Input Type:

Single choice from list or single choice over time

Coded for:

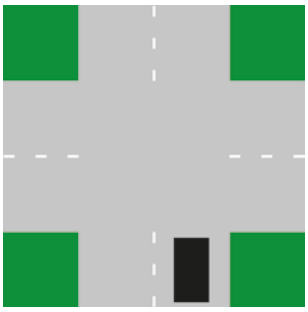
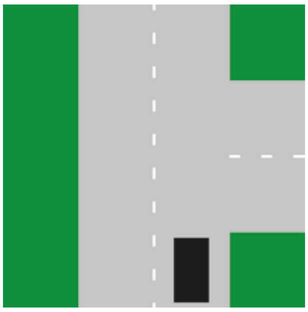
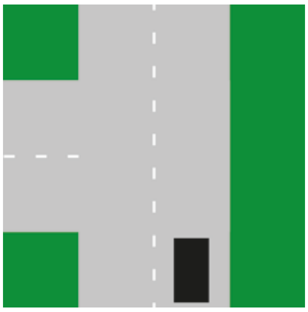
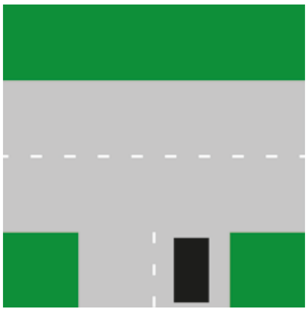
All

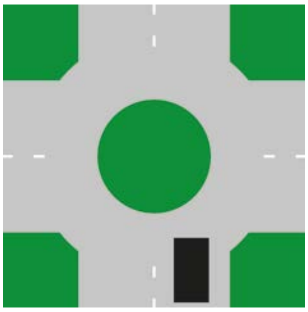
Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
Not an intersection	Not at an intersection	
X Intersection	A 4-road X intersection	
T Intersection (right)	A 3-leg T intersection with a by-road on the right side	
T Intersection (left)	A 3-leg T intersection with a by-road on the left side	
T Intersection (by-road)	A 3-leg T intersection, approached from the by-road.	

Y Intersection	A 3-leg Y intersection.	
Roundabout	A roundabout.	
5 or more legs	An intersection with 5 or more road leg.	
Merging lane	Merging onto a main road.	
Passing by merging lane	Passing by a road that merges onto the main road.	

Exit or turning lane	Passing by or taking an exit lane. Passing by or getting into dedicated turning lane. Note that this may involve crossing a bicycle lane.	
Complex intersection	This is an intersection not covered by any of the above. Use rarely.	
Unknown	The intersection type cannot be derived from the video data.	

1.4.9 Intersection Priority Situation

Variable Definition:

Type of traffic control applicable to the intersection

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Traffic Control (here split into one variable for each SV and conflict partner)

Category	**Definition**	**Example and Hints**
Regulated by law only	There is none of the traffic controls below applicable to the intersection.	
Traffic signs and road markings	A traffic sign or road markings are regulating the priority.	

Traffic lights allowing partial conflicts	A green light for the SV does NOT exclude the possibility that the SV's path crosses the path of another road user.	
Traffic lights not allowing partial conflicts	A green light for the SV excludes the possibility that the SV's path crosses the path of another road user.	
Not applicable	Not an intersection	
Unknown		

1.4.10 VRU Facilities

Variable Definition:

VRU facilities present in the whole scene.

Select facilities from the perspective of the SV. At intersections, this concerns facilities on both the current leg on which the SV is driving, as well as on all intersection legs reachable by maneuvers the SV could make (regardless of the actual maneuver). For example, if a certain leg of an intersection features a two-way separated bicycle track on one side of the road, then select the orientation (i.e., left or right) with which the SV could encounter that facility.

Multiple options are possible (e.g., pavements AND bicycle lanes).

Variable Type:

Categorical

Input Type:

Multiple choice from list

Coded for:

All

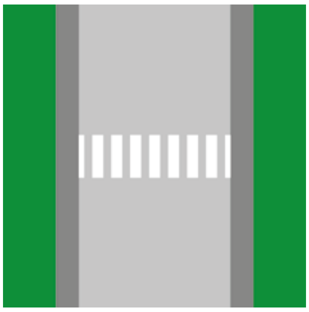
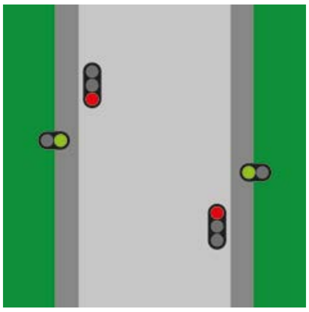
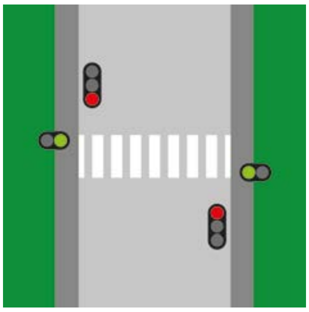
Coded by:

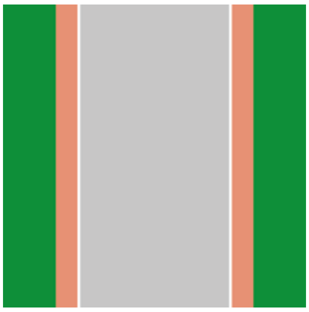
Central annotation

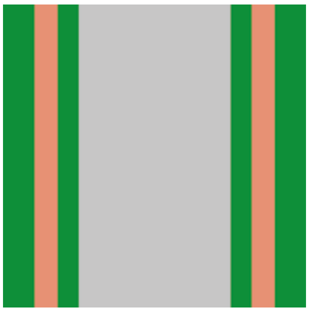
Related VTTI Variable:

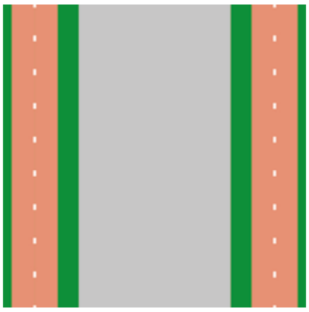
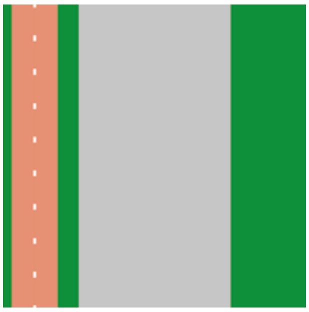
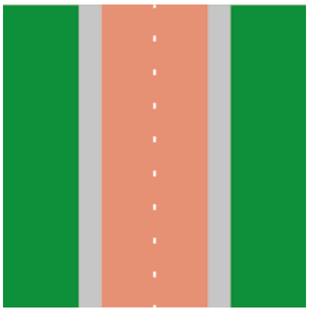
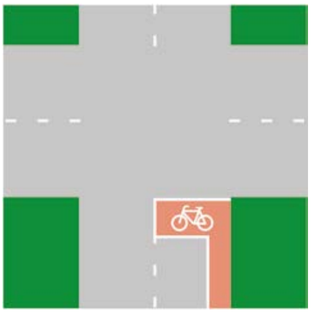
No

Category	Definition	Example and Hints
No VRU facilities	There is none of the traffic controls below applicable to the intersection or mid-block.	

Zebra crossing	A zebra crossing is present.	
Crossing pedestrian lights	A crossing with pedestrian lights is present.	
Zebra crossing pedestrian lights	A zebra crossing with pedestrian lights is present	
Pavement LR	Pavements are present on both sides.	
Pavement L	Pavement is present on the left side.	

Pavement R	Pavement is present on the right side.	
Bicycle lane adj barrier LR	Adjacent bicycle lanes are present on both sides. The bicycle lanes are marked with solid lines.	
Bicycle lane adj barrier L	An adjacent bicycle lane is present on the left side. The bicycle lane is marked with a solid line.	
Bicycle lane adj barrier R	An adjacent bicycle lane is present on the right side. The bicycle lane is marked with a solid line.	
Bicycle lane adj broken LR	Adjacent bicycle lanes are present on both sides. The bicycle lanes are marked with broken lines.	

Bicycle lane adj broken L	An adjacent bicycle lane is present on the left side. The bicycle lane is marked with a broken line.	
Bicycle lane adj broken R	An adjacent bicycle lane is present on the right side. The bicycle lane is marked with a broken line.	
Bicycle track one-way LR	Separated one-way bicycle tracks are present on both sides.	
Bicycle track one-way L	A separated one-way bicycle track is present on the left side.	
Bicycle track one-way R	A separated one-way bicycle track is present on the right side.	

Bicycle track two-way LR	Separated two-way bicycle tracks are present on both sides.	
Bicycle track two-way L	A separated two-way bicycle track is present on the left side.	
Bicycle track two-way R	A separated two-way bicycle track is present on the right side.	
Bicycle street	A road section intended for bicycles, with motorized vehicles as guest users.	
Expanded Bicycle Stacking Lane	The intersection features an expanded bicycle stacking lane (e.g., cyclists wait in front of motorized vehicles).	
Unknown	Unable to determine the presence or absence of VRU facilities.	

1.4.11 Construction Zone

Variable Definition:

An indication of whether the event occurs in or in relation to a construction zone

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Construction Zone

Category	Definition	Example and Hints
Not construction zone-related	Vehicle is not in, approaching, or otherwise affected by a construction zone (construction equipment, barrel, etc. are visible)	
Construction Zone (occurred in zone)	Vehicle is in a construction zone (construction equipment, barrel, etc. are visible)	
Construction zone-related (occurred in approach or otherwise related to zone)	Vehicle is approaching or is otherwise affected by a construction zone (construction equipment, barrel, etc. are visible)	
Unknown	Cannot determine if the event happened in or in relation to a construction zone due to limitations in video views, lighting, visual obstructions, or limited perspective.	

1.4.12 Traffic Density

Variable Definition:

The level of traffic density at the time of the start of the event

Based entirely on number of vehicles present in the subject's travel lane and other lanes in the subject's direction of travel, and the ability of the subject vehicle driver to maneuver between lanes and select the driving speed. In Variable Speed zones, consider a reduced speed limit to be an indicator of traffic density.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Traffic Density (Collapsed Level-of-service A1 [without lead traffic] and Level-of-service A2 [with lead traffic] into Level-of-service A Free Flow)

Category	Definition	Example and Hints
Free flow	Represents free flow traffic without or with a leading vehicle present in at least one lane. If there is lead traffic, individual drivers are still virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to maneuver within the traffic stream is at the highest level possible (without lead traffic) or extremely high (with lead traffic). The general level of comfort and convenience provided to the motorist, passenger, or pedestrian is excellent. Level-of-service A	 Ex. 1: If more than 1 lane is present in the direction of travel, then LOS A2 may apply if there is a lead vehicle in the subject's lane but no vehicles in the adjacent lane preventing the driver from passing the lead vehicle. If there is a lead vehicle, there should be no or very few other vehicles on the road in order to qualify for LOS A, and speed selection should be unconstrained. Ex. 2: If the subject is preparing to exit, merge, change lanes, etc., then no other vehicles should be in position to potentially interfere with this maneuver to be considered LOS A.

Flow with some restrictions	Is still in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Freedom to select desired speeds is relatively unaffected, but there is a slight decline in the freedom to maneuver within the traffic stream from LOS A. The level of comfort and convenience provided is somewhat less than at LOS A, because the presence of others in the traffic stream begins to affect individual behavior. Level-of-service B	 Driving-related decisions are made with a small need to consider the presence of other vehicles (due to a fairly low traffic density). Ex. 1: If only 1 lane is present in the direction of travel, LOS B may apply if a lead vehicle is present at a fairly constant range and the subject is moderating vehicle speed to match that of lead vehicle, but speeds are still at or near the speed limit. Ex. 2: If more than 1 lane is present in direction of travel, then LOS B may apply if there is a lead vehicle as well as an adjacent vehicle preventing the driver from easily passing OR if there are adjacent vehicles on both sides. However, this situation should be transient. The subject driver should not be _boxed_ in for a more than a few seconds. LOS B would also apply if several vehicles are present in the mid-range vicinity, even if they are not directly in front of or adjacent to the subject. Driving speeds are still at or near the speed limit and are not persistently affected by surrounding traffic. Ex. 3: If the subject is preparing to exit, merge, change lanes, etc. in a LOS B environment, there will be at least one vehicle that could pose a potential hazard and requires monitoring by the subject, but the maneuver can still be completed fairly easily.
Stable flow, maneuverability and speed are more restricted	Is still in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream. The selection of speed is now affected by the presence of others, and maneuvering within the traffic stream requires substantial vigilance on the part of the driver. The general level of comfort and convenience declines noticeably at this level. Level-of-service C	 Driving-related decisions are made with a definite need to consider the presence of other vehicles, with a good chance of mishap if such considerations are not made (due to a medium traffic density). Ex. 1: If only 1 through lane is present, LOS C may apply if

		subject has a lead vehicle AND another car is following the subject. OR, if subject is following multiple vehicles. In either case, the speed is significantly controlled by leading traffic, but the prevailing speed is not more than 10 mph below the speed limit. Ex. 2: If >1 through lane is present, LOS C may apply if the subject is "boxed in" by lead and adjacent vehicles and this condition is not transient (e.g., it persists as the vehicles travel for some time). LOS C would also apply if multiple vehicles are present in the near-range vicinity, and travel speeds are moderately affected (but are not more than 10 mph below the posted speed limit). Ex. 3: If the subject is preparing to exit, merge, change lanes, etc. in an LOS C environment, there will be multiple vehicles posing potential hazards and requiring careful monitoring by the subject. The maneuver will be more difficult, but will generally be completed without incident.
Unstable flow - temporary restrictions substantially slow driver	Represents a high-density, but stable flow. Speed and freedom to maneuver are severely restricted, and the driver or pedestrian experiences a generally poor level of comfort and convenience. Small increases in traffic flow will generally cause operational problems at this level. Level-of-service D	 Driving-related decisions are made with urgent need to consider the presence of other vehicles, with a great likelihood of mishap if such considerations are not made (due to a fairly high traffic density). Ex. 1: If only 1 through lane is present, LOS D may apply if subject is following another car AND another car is following the subject. OR, if subject is following multiple vehicles. In either case, the speed is significantly controlled by leading traffic, and prevailing speed is more than 10 mph below the speed limit. Ex. 2: If >1 through lane is present, LOS D may apply if the subject is persistently "boxed in" by lead vehicles and adjacent vehicles, AND the prevailing travel speed is determined by surrounding traffic and is more than 10 mph below the posted speed limit. Ex. 3: If the subject is preparing to exit, merge, change lanes, etc. in an LOS D environment, there will be multiple vehicles posing potential hazards and requiring careful monitoring. The maneuver will not be easy and will likely involve braking, accelerating, or excessive steering on the part of the subject or other vehicles.

Flow is unstable, vehicles are unable to pass, temporary stoppages, etc.	Represents operating conditions at or near the capacity level. All speeds are reduced to a low, but relatively uniform value. Freedom to maneuver within the traffic stream is extremely difficult, and it is generally accomplished by forcing a vehicle or pedestrian to "give way" to accommodate such maneuvers. Comfort and convenience levels are extremely poor, and driver or pedestrian frustration is generally high. Operations at this level are usually unstable, because small increases in flow or minor perturbations within the traffic stream will cause breakdowns. Level-of-service E	 Driving-related decisions are made with an urgent need to consider the presence of other vehicles, with a great likelihood of mishap if such considerations are not made/freedom to execute maneuvers is severely restricted such that drivers must be aggressive in maneuvering (due to a very high traffic density). Ex. 1: If only 1 through lane is present, LOS E may apply if subject is following multiple cars AND multiple cars are following the subject. The speed is significantly controlled by leading traffic, and the prevailing speed is reduced to less than half the posted speed limit. Ex. 2: If >1 through lane is present, then LOS E may apply if the subject is persistently "boxed in" by lead vehicles and adjacent vehicles, AND the prevailing travel speed is determined by surrounding traffic and is less than half the posted speed limit. Ex. 3: If the subject is preparing to exit, merge, change lanes, etc. in an LOS E environment, there will be multiple vehicles posing potential hazards and requiring careful monitoring by the subject. The maneuver will be "forced" and will likely involve braking, accelerating, or excessive steering on the part of both the subject and other vehicles.
Forced traffic flow condition with low speeds and traffic volumes that are below capacity	Represents forced or breakdown flow. This condition exists wherever the amount of traffic approaching a point exceeds the amount which can traverse the point. Queues form behind such locations. Operations within the queue are characterized by stop-and-go waves, and they are extremely unstable. Vehicles may progress at reasonable speeds for several hundred feet or more, then be required to stop in a cyclic fashion. LOS F is used to describe the operating conditions within the queue, as well as the point of the breakdown. It should be noted, however, that in many cases operating conditions of vehicles or pedestrians discharged from the queue may be quite good. Nevertheless, it is the point at which arrival flow exceeds discharge flow, which causes the queue to form, and level-of-service F is an appropriate designation for such points.	 Traffic flow and related driving decisions are based entirely on the presence and actions of other vehicles (due to the highest traffic density). Ex. 1: Regardless of the number of travel lanes, LOS F represents _traffic jam_ or _stop and go_ conditions.

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	Level-of-service F	Ex. 2: If the subject is preparing to exit, merge, change lanes, etc. queues will be forming or present either in the subject's desired lane and/or in the subject's destination lane. The maneuver will be _forced_ and will involve braking, accelerating, or excessive steering on the part of both the subject and other vehicles.
Unknown	Cannot determine due to limitations in video views, lighting, visual obstructions, or limited perspective.	
Not applicable	E.g. in intersections	

1.4.13 Driving context - action

Variable Definition:

The time-series of driving context.

Variable Type:

Time-series

Input Type:

Multiple choice over time

Coded for:

Each secondary task "event"

Coded by:

Initially local, possibly shifted to central annotation when definitions are clearly set.

Related VTTI Variable:

No

Category	**Definition**	**Example and Hints**
Going straight on road	Driving on a straight road. No other action. Default	
In curve		
Stopped in traffic	The vehicle is at stand-still in traffic.	
Stopped at road side or parking	The vehicle is at standstill at the road side or parking	
Lane change	Lange change ongoing. Possibly automatically extracted.	
Overtaking	Overtaking ongoing. Likely automatically	

	extracted. Only when entering oncoming traffic lane.	
Exit parking		
In intersection		
In roundabout		
Stopped at intersection		

1.4.14 Driving context - other

Variable Definition:

The time-series of driving context.

Variable Type:

Time-series

Input Type:

Multiple choice over time

Coded for:

Each secondary task "event"

Coded by:

Initially local, possibly shifted to central annotation when definitions are clearly set.

Related VTTI Variable:

No

Adjacent vehicles left	Vehicle visible the direct adjacent left lane in at least one of the three forward cameras and less than four (4) car lengths ahead.	
Adjacent vehicles right	Vehicle visible the direct adjacent left lane in at least one of the three forward cameras and less than four (4) car lengths ahead.	
Crest	The top of the crest is annotated	The crest should be visually obstructing other relevant traffic. For example, not possible to see a (potential) car on other side.

1.5 Conflict/ event related Variable

Conflict/ event related variables will be coded for SCEs and position-based events mainly. For baseline/ control events only some of them apply.

1.5.1 Number of Conflicts/ Interactions

Variable Definition:

The number of conflicts and interactions visible during the event.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
0	Only use this category if there are no conflicts AND no interactions between SV and other road users during the event. If no conflicts are visible, but there is one interaction (e.g., when the SV has to negotiate priority with a cyclist on an unregulated intersection), then use value ‘1’.	
1		
2		
3		
4+		

1.5.2 Conflict 1, 2, 3, 4 Class

Variable Definition:

Conflict class defines the nature of the conflict in terms of whether there are one or more conflict partners and whether those partners are on a collision course at any point during the conflict. At all levels of classification, conflicts must be non-intentional and non-premeditated (unplanned) by at least one conflict partner. Conflict partners may be vehicles, non-motorists, other road users, animals, or objects, including roadside barriers.

Events may comprise more than one conflict class, conflict outcome, conflict severity, or conflict type. In cases such as these, conflicts should be coded in the order in which they occur (i.e., Time 1 = Conflict 1; Time 2 = Conflict 2; and so on). The order of coding is based on the progression of time, not on the severity of the referenced conflict.

It is useful to think of this classification system as paralleling other classification schemes, such as is used to classify species in biological sciences. Once the conflict class is assigned, lower orders of classification may be applied, including Conflict Outcome (only for events classified here as classical and/or run-off-road), Conflict Severity (only when conflict outcome is Crash), and Conflict Nature and Conflict Type (for all Crash Class categories except Control). As such three examples are provided: 1) a typical two vehicle collision may be classified as a ”Classical Crash, Level 2, Conflict with lead vehicle, Rear-end striking”, 2) a typical road departure may be classified as ”Run-off-Road Crash, Level 1, Road Departure Left”, and 3) a typical near crash between two vehicles may be classified as ”Classical Near Crash, Conflict with oncoming vehicle, Opposite direction head-on”.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	**Definition**	**Example and Hints**
Classical Conflict	A classical conflict involves at least two conflict partners that are on a collision course on or off the roadway such that a collision is kinematically imminent or resulting and an evasive maneuver is required by at least one conflict partner to avoid a collision. Conflict partners may be vehicles, non-motorists, other road users, animals, or objects (including roadside barriers that exceed the ground clearance of the vehicle).	
Run-Off-Road Conflict	A run-off-road conflict involves only a single conflict partner on a path toward the road edge such that a road departure is imminent or resulting and an evasive maneuver is required by that conflict partner to avoid a road departure. The road edge is defined as the edge of the shoulder (if present) or a physical raised median on the left or right side of the roadway, including low roadside barriers such as curbs and curb-style medians that are within the ground clearance of the vehicle.	

Proximity Conflict	Proximity conflicts involve at least two conflict partners that are not on a collision course and require no evasive maneuver to avoid a collision (assuming kinematics remain unchanged), but nevertheless result in a small spatial and temporal kinematic proximity to one another that is inappropriate for the driving circumstance (including considerations such as conflict partners' speed, sight distance, weather, etc.). Conflict partners may be vehicles, non-motorists, other road users, animals, or objects (including roadside barriers other than curbs or similar) but not curbs, curb-style medians, or the road edge (see Run-Off-Road Conflict).	
Non-Conflict/ interaction	Any specific incident or maneuver that is within the bounds of "normal" driving behaviors and scenarios. The driver may react to situational conditions and events, but the reaction is not evasive and the situation does not place the subject or other conflict partners at higher-than-normal risk. Non-conflicts are not further classified at the Conflict Outcome or Conflict Severity levels, but may be classified as to Conflict Type and Conflict Partner Type.	
Unknown	Unknown conflict class	

1.5.3 Conflict 1, 2, 3, 4 Outcome

Variable Definition:

Conflict outcome defines the result of the conflict (crash vs. non-crash), and can be applied to both the Classical Conflict and Run-Off-Road conflict classes. Conflict outcome does not apply to proximity conflicts, non-conflicts, or controls, as by definition these do not involve a collision course and thus cannot result in a crash.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Event severity

Category	Definition	Example and Hints
Crash	A crash is any contact that the subject vehicle has with another conflict partner, either moving or fixed, at any speed that is observable or in which kinetic energy is measurably transferred or dissipated. This excludes roadway features meant to be driven over such as speed bumps. For classical conflicts, this includes any contact between two or more conflict partners. For run-off-road conflicts, this includes cases where at least one tire leaves the roadway,	

	beyond the shoulder or onto a physical (raised) median on the left or right side of the roadway. Includes tire-only contact with roadside barriers and curbs. Does not include contact between the vehicle body and taller roadside objects such as guardrails. Crashes must meet the following two criteria: 1. Impact. The vehicle must make contact with another conflict partner and/or the maneuver must result in some degree of road departure. 2. Not premeditated (i.e., not planned). The maneuver(s) performed by at least one conflict partner must not be premeditated (planned). This criterion does not rule out crashes caused by unexpected events experienced during a premeditated maneuver (e.g., a premeditated aggressive lane change resulting in a crash with an unseen or faster-than-expected vehicle in the adjacent lane).	
Near-Crash	A near-crash is any circumstance that requires a rapid evasive maneuver by at least one conflict partner to avoid a crash. Near-crashes must meet the following four criteria: 1. No impact. The subject vehicle must not make contact with any other conflict partner, and the maneuver must not result in a road departure. 2. Not premeditated (i.e., not planned). The maneuver(s) performed by at least one conflict partner must not be premeditated (planned). This criterion does not rule out near-crashes caused by unexpected events experienced during a premeditated maneuver (e.g., a premeditated aggressive lane change resulting in a conflict with an unseen vehicle in the adjacent lane that requires a rapid evasive maneuver by one of the vehicles). 3. Evasive maneuver is required. An evasive maneuver to avoid a crash was required by at least one conflict partner. An evasive maneuver is any action performed to avoid a potential collision by changing the trajectory or speed, such as steering, braking, accelerating, running, or stopping. 4. Urgent response required. The required evasive maneuver must also require an urgent response given the amount of time from the beginning of the subject's reaction and the potential time of impact.	
Crash-Relevant	A crash-relevant conflict is any circumstance that requires an evasive maneuver on the part of the subject vehicle or any other conflict partner that is less urgent than a rapid evasive maneuver (as defined above in Near-Crash) but greater in urgency than a "normal maneuver" to avoid a crash. Crash-relevant conflicts must meet the following four criteria: 1. No impact. The subject vehicle must not make contact with any other conflict partner, and the maneuver must not result in a road departure. 2. Not premeditated (i.e., not planned). The maneuver(s) performed by at least one conflict partner must not be premeditated (planned). This criterion does not rule out crash-relevant conflicts caused by unexpected events experienced during a premeditated maneuver (e.g., a premeditated aggressive lane change resulting in a conflict with an unseen vehicle in the adjacent lane that requires an evasive maneuver by one of the vehicles). 3. Evasive maneuver is required. An evasive maneuver to avoid a crash was required by at least one conflict partner. An evasive maneuver is any action performed to avoid a potential collision by changing the trajectory or speed, such as steering, braking, accelerating, running, or stopping.	

	4. Urgent response NOT required. The required evasive maneuver(s) does not require an urgent response given the amount of time from the beginning of the subject's reaction and the potential time of impact.	
Non-Participant Conflict	A non-participant conflict is any conflict that gets captured on video that does not involve the subject driver. Non-participant conflicts are often analyzed as part of a larger conflict that does involve the subject driver. For example, the subject driver's lead vehicle brakes hard and nearly rear-ends another lead vehicle (Non-participant Conflict coded as Conflict Outcome 1), causing the subject to rear-end the lead vehicle (Crash coded as Conflict Outcome 2).	
Not applicable	For conflict classes proximity conflict, non-conflict and baseline/ control.	
Unknown	Unknown conflict outcome	

1.5.4 Conflict 1, 2, 3, 4 Severity (Crash only for now)

Variable Definition:

A conflict severity rating is assigned only to events in the Classical Conflict and Run-Off-Road conflict classes with a "Crash" conflict outcome.

There are four levels of crash severity, ranging from Level 1 (most severe), to Level 4 (least severe).

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

SCE with outcome crash only

Coded by:

Central annotation

Related VTTI Variable:

Crash severity

Category	Definition	Example and Hints
Level 1, Most Severe	Level 1 is any crash that results in at least one of the following outcomes: 1. Airbag deployment 2. Vehicle rollover 3. Towing of either vehicle involved in the conflict	

	4. Likely or observed injury of any driver or passenger (from any conflict partner), non-motorist, or other road user. The injury must be serious enough to require a doctor's visit, which includes self-reported injuries and those apparent from video. 5. A large change in the speed of any conflict partner (a high delta-V). A high delta-V is defined as a change in speed of the subject vehicle in any direction during impact greater than 20 mph or 32 km/h (excluding curb strikes and any pre- or post-impact braking) or acceleration on any axis greater than ±2g (excluding curb strikes). 6. For run-off-road conflicts, any road departure that results in a vehicle rollover	
Level 2, Moderate Severity	Level 2 is any crash that does not meet the requirements for a Level I crash but that includes at least one of the following outcomes: 1. A moderate level of property damage where all vehicles can be driven from the scene 2. A modest change in speed of any conflict partner that reaches an acceleration on any axis greater than ±1.3g (excluding curb strikes) 3. Most large animal strikes, traffic sign strikes, and fixed roadside barrier strikes, unless at very low speed (Level 3), or unless criteria for Level 1 are met 4. For run-off-road conflicts, any road departure that results in a 90+ degree uncontrolled horizontal vehicle rotation or where all four wheels leave the roadway	
Level 3, Minor Severity	Level 3 is any crash that does not meet the requirements of Level 1 or Level 2 but that includes at least one of the following outcomes: 1. Physical contact with another object (other than curb strikes) but with no or minimal resulting property damage 2. Most small animal strikes, light objects (e.g., empty box in road), and light/non-fixed roadside barriers (e.g., construction cones) 3. For run-off-road conflicts: a. Any road departures and curb, median, or similar tire strikes that occur while underway (speed ≥ 20 mph or 32 km/h, AND not turning or parking) with at least two tires departing the road or being struck b. Any road departures that result from an evasive maneuver performed in response to a previous incident (e.g., steering off the road to avoid a stopped lead vehicle), unless the maneuver meets the outcome criteria for Level I or Level 2	
Level 4, Minor	Level 4 applies only to run-off-road conflicts with a crash outcome. Level 4 crashes do not meet the requirements of Level 1, 2, or 3 but do include at least one of the following outcomes: 1. At least one tire departed the roadway or struck a curb, median, or similar low barrier during a reduced-speed maneuver (e.g., turning, parking). 2. At least one tired departed the roadway or struck a curb, median, or similar low barrier at a speed of < 20 mph (32 km/h). Note that Run-Off-Road is the only conflict class that that may receive a Level 4 Crash severity rating. Crashes between two conflict partners are always given a Level 1, Level 2, or Level 3 rating.	

Not applicable	If not a crash.	
Unknown	Not known if impact or not.	

1.5.5 Conflict/Interaction 1, 2, 3, 4 Type

Variable Definition:

The type of conflict that the SV has with the conflict partner.

NOTE: The conflict partner can even be a bicycle or pedestrian and the categories apply. E.g. A subject vehicle is striking a bicycle from behind.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

SCE, position-based annotation

Coded by:

Central annotation

Related VTTI Variable:

Incident Type 1, 2 (Note: Variable “Violation of stop sign or signal at intersection” deleted as part of SV Traffic Rule Violation)

Category	Definition	Example and Hints
Rear-end, striking	Subject vehicle makes contact or nearly makes contact with any portion of the back of a conflict partner in front. Point of impact is or would have been e.g. the back plane of the lead vehicle.	
Rear-end, struck	Conflict partner behind makes contact or nearly makes contact with any portion of the back of the subject vehicle. Point of impact is or would have been the back plane of the subject vehicle.	
Road departure (left or right)	Any tire on the subject vehicle leaves the roadway, beyond the shoulder or onto median, on the left or right side of the roadway. Includes interaction with roadside barriers and curbs.	
Road departure (end)	Any tire on the subject vehicle leaves the end of the roadway.	

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Sideswipe, same direction (left or right)	Subject vehicle is struck or nearly struck by a conflict partner or strikes or nearly strikes a conflict partner on either the left or right side when traveling in the same direction. Point of impact is or would have been e.g. the side plane of either vehicle.	
Opposite direction (head-on or sideswipe)	Subject vehicle and conflict partner make contact or nearly make contact in the front when traveling in opposite directions. Point of impact is or would have been e.g. front plane of both vehicles.	
Straight crossing path	Subject vehicle or conflict partner crosses another path perpendicularly. Both intending to proceed straight across each other's paths.	
Turn across path	Subject vehicle or conflict partner crosses in front of the path of the other. Conflicting partners were initially on the same roadway, either in the same or opposite directions. Partner turning across path intends to turn right or left onto another trafficway and drove in front of the other.	Should be reserved only for crashes/near-crashes that occur in intersections (not, for example, in parking lots)—Incident Type "Other" should be used otherwise.
Turn into path (same direction)	Subject vehicle or conflict partner turns into the path of the other. Conflicting partners were initially on different trafficways traveling perpendicular to each other. One partner turns into the path of the other, intending to be on the same roadway and traveling in the same direction.	Should be reserved only for crashes/near-crashes that occur in intersections (not, for example, in parking lots, which would be "Other".
Turn into path (opposite direction)	Subject vehicle or conflict partner turns into the path of the other. Conflicting partners were initially on different trafficways, traveling perpendicular to each other. One partner turns into the path of the other vehicle, intending to be in the same lane or trafficway as the other vehicle but traveling in the opposite direction.	Should be reserved only for crashes/near-crashes that occur in intersections (not, for example, in parking lots)—Incident Type "Other" should be used otherwise.
Backing, fixed object	SV backs into a non-moving, fixed object	
Backing into traffic	SV backs into traffic flow	
Ground impact, under way	A two-wheeled vehicle's upright orientation is lost and the vehicle goes to the ground while moving, initially near roadway speeds. The scenario is not typical of a low-speed maneuvering situation and is caused by an issue not defined in other categories.	Only applicable to Powered Two-Wheelers (PTWs)
Ground impact, low speed	A two-wheeled vehicle falls coincident with low or no speed (even if in gear) caused by an issue not defined in other categories. The rider allows the bike to lean while it is being stopped, just beginning to move from a stop, or making a turn at low speed. Vehicle upright stability is lost because of lack of input by the rider to counteract the effect of gravity.	Only applicable to Powered Two-Wheelers (PTWs)
Other	Any other interaction not listed above.	
Unknown	Cannot determine full Incident Type due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.5.6 Conflict/Interaction 1, 2, 3, 4 Partner Type

Variable Definition:

Specification of the conflict partner involved in the event or that restricts the subject vehicle's ability to maneuver at the initiation of the precipitating event

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

SCE, position-based annotation

Coded by:

Central annotation

Related VTTI Variable:

Motorist/ Non-Motorist/ Animal/ Object 2, 3 Type (has more and partly different variables)

Category	Definition	Example and Hints
Automobile	Light vehicle designed primarily to transport passengers in an enclosed (or convertible) space (includes automobile derivatives such as auto-based pickups).	Ex. convertible; 2-door sedan, hardtop, coupe; 2 to 5-door hatchback; 3-door coupe; 4-door sedan; station wagon (excluding van- and truck-based); cargo station wagon, El Camino, auto-based ambulance/hearse; large limousine; 3-wheeled automobile
Utility Vehicle	Utility vehicle designed to have off-road capabilities.	

		 Ex. multi-purpose vehicle; compact utility vehicle; large utility vehicle; utility station wagon
Van based light truck	Vehicle designed to maximize cargo/passenger area versus overall length, has an enclosed cargo/passenger area and relatively short (or non-existent) hood.	 Ex. minivan; large van; step van or walk-in van; van based motorhome; van based school bus; other van derivatives
Light Truck/ Bus		 

Medium/heavy Truck/ Bus		 
Medium/heavy Truck with Trailer		
Train/Tram		
VRU	Including motored cycle, bicycles and pedestrian.	To be further coded for type etc. please see VRU – related variables!
Natural object	E.g. trees	
Man-made object	Excluding safety equipment	
Vehicle Restraint System	Barriers, crash cushions	
Animal	Any type of live animal.	
Other	Any non-motorist conveyance, non-motorist, or motorist not included in the other categories.	Non-motorist conveyance includes baby carriage, coaster wagon, ice skates, roller skates, push cart, scooter, skate board, skis, sled, wheel chair, rickshaw, etc. Non-motorist includes persons riding on an animal or

		animal-powered conveyance and any person outside a sidewalk or path contiguous with a trafficway. This category also includes dead animals.
Unknown	Cannot determine the conflict partner type due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.5.7 Conflict Partner 1, 2, 3, 4 Crash (not with SV)

Variable Definition:

A crash of the conflict partner induced by but not with the SV

*NOTE: **Please provide more details in the narrative!** These secondary crashes might be further analyzed in a second step by making the conflict partner to the subject and using the standard coding schema given that enough information is available to do so.*

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

SCE, position-based annotation

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
Yes	The conflict partner having any contact with other than the SV. That is an object or other road user, either moving or fixed, at any speed that is observable or in which kinetic energy is measurably transferred or dissipated. This excludes roadway features meant to be driven over such as speed bumps. Crashes must meet the following two criteria: 1. Impact. The conflict partner must make contact with another conflict partner or object and/or the maneuver must result in some degree of road departure. 2. Not premeditated (i.e., not planned). The maneuver(s) performed by at least one conflict partner must not be premeditated (planned). This criterion does not rule out crashes	E.g. The SV and a bicycle on either collision course (classical conflict) or in a proximity conflict missing each other (no impact) but the bicycle falls or crashes into an object or another road user. Includes falling events. That is a bicyclist or pedestrian falling (=impacting ground).

	caused by unexpected events experienced during a premeditated maneuver (e.g., a premeditated aggressive lane change resulting in a crash with an unseen or faster-than-expected vehicle in the adjacent lane).	
No	No crash of conflict partner as defined above.	
N/a	No conflict partner.	
Unknown	Unknown if conflict partner having a crash due to poor or no video information.	

1.5.8 Visual Obstructions 1, 2, 3, 4

Variable Definition:

The visual factors that are likely to have contributed to the event

Variable Type:

Categorical or time-series

Input Type:

Single choice from list

Coded for:

SCE, position-based annotation

Coded by:

Central annotation

Related VTTI Variable:

Visual Obstructions (definition changed)

Category	Definition	Example and Hints
No obstruction	No visual obstructions for the subject vehicle driver were obvious.	
Rain, snow, fog, smoke, sand, dust	Surrounding atmosphere included rain, snow, fog, smoke, and/or dust, which decreased visibility.	If it is not actively raining or snowing, but rain or snow is on the windshield obstructing the view, use the category "Broken or improperly cleaned windshield." If window is foggy (no fog in the air), use category "Inadequate defrost or defog system" or "Broken or improperly cleaned windshield" as appropriate.
Reflected glare	Glare reflected off of the vehicle or other exterior objects decreased visibility.	Reflections from the sun create more visual problems than the direct sunlight.
Sunlight	Direct bright sunlight decreased visibility.	Direct sunlight (i.e., the sun shining into the driver's eyes) creates more visual problems than reflections

		from the sun.
Headlights	Headlights of other vehicle(s) decreased visibility.	
Curve or hill	The presence of a curve or hill in the field of view decreased visibility.	
Building, billboard, or other roadway infrastructure design features	The presence of a man-made structure in the field of view decreased visibility.	Includes sign, embankment, building.
Trees, crops, vegetation	The presence of trees, crops, or vegetation in the field of view decreased visibility.	
Moving or stopped vehicle (with or without load)	The presence of a vehicle in motion or stopped (standstill) on the trafficway (with or without a load) in the field of view decreased visibility.	
Parked vehicle	The presence of a parked vehicle in the field of view decreased visibility.	
Splash or spray of passing vehicle	A splash or spray of water, snow, sand, etc. from a passing vehicle in the field of view decreased visibility.	
Inadequate defrost or defog system	The presences of frost or fog on the subject vehicle's windshield due to an inadequate defrost/defog system decreased visibility. (Defrost/defog system must be in use for this category to apply).	If the defrost/defog system was not being used, use category "Broken or improperly cleaned windshield".
Inadequate roadway lighting system	Inadequate lighting of the roadway (other than lighting provided by vehicles) decreased visibility.	
Inadequate vehicle headlamps	An inadequate exterior lighting system of the subject vehicle (malfunctioning or turned off) decreased visibility.	Includes headlights, fog lights, but not lighting systems of other vehicles.
Obstruction interior to vehicle	An interior feature (other than head restraints) of the subject vehicle decreased visibility.	Includes interior mirrors, objects hanging from rear view mirror, objects piled on the rear or passenger seat blocking windows.
Mirrors	Exterior mirrors on the subject vehicle in the field of view decreased visibility.	
Broken or improperly cleaned windshield	The windshield of the subject vehicle was broken or otherwise disfigured, or was at least partially covered by some material such as dirt, rain, or snow, which decreased visibility (no attempt to clean the windshield had been made).	Includes not utilizing the defrost/defog system or wipers.
Other obstruction	A known visual obstruction not listed in previous categories decreased visibility.	Can be external or internal to the vehicle (e.g., driver drinking from a water bottle that obscures the vision).

Vision obscured - no details	The vision of the subject vehicle driver was obviously obscured, but the source of the impediment cannot be determined.	
Unknown whether vision was obstructed	Cannot determine whether any Visual Obstructions are present due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.5.9 Precipitating Event

Variable Definition:

The state of environment or action that began the event sequence under analysis

What environmental state or what action by the subject vehicle, another vehicle, person, animal, or non-fixed object was critical to this vehicle becoming involved in the crash or near-crash? This is a vehicle kinematic measure (based on what the vehicle does--an action, not a driver behavior). It does not include factors such as driver distraction, fatigue, or disciplining a child. This is the critical event which made the crash or near-crash possible. It may help to use the "but for" test; "but for this action, would the crash or near-crash have occurred?" This is independent of fault. For example, Vehicle A is speeding when Vehicle B crosses Vehicle A's path causing a crash, the Precipitating Event would be Vehicle B crossing Vehicle A's path. If two possible Precipitating Events occur simultaneously, choose the event that imparted the greatest effect on the crash or near-crash. If more than one sequential event contributed to the crash or near-crash, determination of which is the Precipitating Event depends upon whether the driver had enough time or vehicular control to avoid the latter event. If the driver avoids one event and immediately encounters another potentially harmful event (with no time or ability to avoid the latter), then the Precipitating Event is the first obstacle or event that was successfully avoided (this is where the critical envelope begins, and is the reference point for the other variables). If the driver had ample time or vehicular control to avoid the latter event, then that latter event would be coded as the Precipitating Event (the critical envelope would begin here, and all other variables would be coded based on this event). Note that a parking lot is considered a roadway--thus a barrier or light pole in the parking lot would be considered an object in the roadway.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

SCE, SCEs in position-based annotation

Coded by:

Central annotation

Related VTTI Variable:

Precipitating Event, deleted "and in the same direction" from category definition "Other vehicle ahead - stopped on roadway more than 2 seconds".

Category	Definition	Example and Hints
SV Loss of control related categories		
This vehicle lost control - blow-out or flat tire	Driver of subject vehicle loses some amount of vehicular control due to tire "air out".	
This vehicle lost control - stalled engine	Driver of subject vehicle loses some amount of vehicular control due to loss of engine power.	Stalled engine must precipitate the event, rather than have been ongoing for some time before the event, such as a vehicle stopped in the road due to a stalled engine.
This vehicle lost control - disabling vehicle failure	Driver of subject vehicle loses some amount of vehicular control due to a mechanical malfunction of a component (other than stalled engine), which prevents the vehicle from being drivable.	Ex. wheel fell off, steering or suspension system failure
This vehicle lost control - minor vehicle failure	Driver of subject vehicle loses some amount of vehicular control due to a mechanical abnormality (other than stalled engine), but vehicle is still drivable.	Ex. car hood flew up, car overheated
This vehicle lost control - poor road conditions	Driver of subject vehicle loses some amount of vehicular control due to poor environmental or structural conditions of the roadway surface. The poor road conditions must have caused a loss of control, and does not qualify as a Precipitating Event on its own.	Condition must precipitate the event, rather than have been ongoing for some time before the event. Example: puddle, pothole, an isolated patch of ice. Not an ice-covered or wet roadway, which may be categorized as excessive speed for conditions below).
This vehicle lost control - excessive speed	Driver of subject vehicle loses some amount of vehicular control due to traveling too fast for the driving conditions (including traffic and roadway design). This excessive speed must have caused a loss of control, and does not qualify as a Precipitating Event on its own.	Excessive speed is considered more than 10 mph above the posted speed limit or too fast for driving conditions if they warrant a lower speed.
This vehicle lost control - other cause	Driver of subject vehicle loses some amount of vehicular control, and the loss of control was due to some recognized reason not described in previous categories.	Ex. Driver takes foot off brake at a red light and doesn't realize it.
This vehicle lost control - unknown cause	Driver of subject vehicle loses some amount of vehicular control, but the cause (ex. vehicular or environmental cause) cannot be determined due to limitations in video views, lighting, visual obstructions, or limited perspective.	
Subject vehicle action related categories		
Subject over left lane line	Subject vehicle departs its lane to the left and is entering or has entered an adjoining lane or	Crash or near-crash occurs before vehicle leaves the roadway (not past the shoulder area or onto

	shoulder (first harmful or potentially harmful event occurs out of trafficway). (Note: Use this category only if other categories do not apply, including Subject lane change - left behind vehicle/left in front of vehicle/left, sideswipe threat/left, other.)	median.) Code only if lane departure is a direct factor in the event. For example, if vehicle crosses lane line, then an animal runs in its path, the factor would be "animal in roadway".
Subject over right lane line	Subject vehicle departs its lane to the right and is entering or has entered an adjoining lane or shoulder (first harmful or potentially harmful event occurs out of trafficway). (Note: Use this category only if other categories do not apply, including Subject lane change - right behind vehicle/right in front of vehicle/right, sideswipe threat/right, other.)	Crash or near-crash occurs before vehicle leaves the roadway (not past the shoulder area or onto median). Code only if lane departure is a direct factor in the event. For example, if vehicle crosses lane line, then an animal runs in its path, the factor would be "animal in roadway".
Subject over left edge of road	Subject vehicle departs the roadway beyond the left side shoulder area or onto a median (first harmful or potentially harmful event occurs OFF of roadway).	Crash or near-crash occurs after vehicle has left the shoulder area or entered median to the left. Code only if road departure is a direct factor in the event. For example, if vehicle departs the road to the left in order to avoid hitting an animal, the factor would be "animal in roadway".
Subject over right edge of road	Subject vehicle departs the roadway beyond the right side shoulder area or onto a median (first harmful or potentially harmful event occurs OFF of roadway).	Crash or near-crash occurs after vehicle has left the shoulder area or entered median to the right. Code only if road departure is a direct factor in the event. For example, if vehicle departs the road to the right in order to avoid hitting an animal, the factor would be "animal in roadway".
Subject vehicle - end departure	Subject vehicle departs the end of a roadway.	Ex. vehicle runs off of road at a "T" intersection
Subject in intersection - turning left	Subject vehicle (V1) attempts a left turn from its roadway to another roadway, driveway, or ramp, and the act of performing this turn precipitates the crash or near crash.	
Subject in intersection - turning right	Subject vehicle (V1) attempts a right turn from its roadway to another roadway, driveway, or ramp, and the act of performing this turn precipitates the crash or near crash.	
Subject in intersection - passing through	Subject vehicle (V1) is proceeding through an intersection without planning to make a turn, and the act of crossing through the intersection precipitates the crash or near crash.	
Subject ahead, but decelerating	Subject vehicle (V1) is the lead vehicle and is decelerating, traveling in the same lane ahead of (and in same direction as) other vehicle (V2). The deceleration of the subject vehicle precipitates the crash or near crash.	
Subject ahead, but at a slower constant speed	Subject vehicle (V1) is the lead vehicle and is traveling at a lower constant speed in front of and in the same lane as the other vehicle (V2). The lower constant speed precipitates the event.	

Subject ahead, stopped on roadway more than 2 seconds	Subject vehicle (V1) is the lead vehicle and has been stopped on the roadway for more than 2 seconds when crash or near-crash occurs.	Subject vehicle (V1) is stopped, parked, or disabled.
Subject ahead, slowed and stopped 2 seconds or less	Subject vehicle (V1) is the lead vehicle and is decelerating to a stop or has just stopped (has been stopped for 2 seconds or less) when crash or near-crash occurs.	Subject vehicle (V1) is nearly or completely stopped, rather than in a longer process of decelerating (in that case, code as "Subject ahead, but decelerating").
Subject lane change - left behind vehicle	Subject vehicle (V1) departs its lane to the left and is entering or has entered adjacent lane behind a leading vehicle (V2) in that lane, contacting or nearly contacting the rear portion of that lead vehicle. Both vehicles are traveling in the same direction.	Usually seen with passing vehicles or lane change.
Subject lane change - right behind vehicle	Subject vehicle (V1) departs its lane to the right and is entering or has entered adjacent lane behind a leading vehicle (V2) in that lane, contacting or nearly contacting the rear portion of that lead vehicle. Both vehicles are traveling in the same direction.	Usually seen with passing vehicles or lane change.
Subject lane change - left in front of vehicle	Subject vehicle (V1) departs its lane to the left and is entering or has entered adjacent lane in front of another vehicle (V2) in that lane, contacting or nearly contacting the front portion of that following vehicle. Both vehicles are traveling in the same direction.	Usually seen with passing vehicles or lane change.
Subject lane change - right in front of vehicle	Subject vehicle (V1) departs its lane to the right and is entering or has entered adjacent lane in front of another vehicle (V2) in that lane, contacting or nearly contacting the front portion of that following vehicle. Both vehicles are traveling in the same direction.	Usually seen with passing vehicles or lane change.
Subject lane change - left, sideswipe threat	Subject vehicle is traveling in the adjacent right lane, beside and in the same direction as other vehicle. Subject vehicle (V1) crosses left lane line (i.e., other vehicle's right lane line), resulting in contact or near-contact between the left side of subject vehicle (V1) and the right side of the other vehicle (V2). Both vehicles are traveling in the same direction.	
Subject lane change - right, sideswipe threat	Subject vehicle is traveling in the adjacent left lane, beside and in the same direction as other vehicle. Subject vehicle (V1) crosses right lane line (i.e., other vehicle's left lane line), resulting in contact or near-contact between the right side of subject vehicle (V1) and the left side of the other vehicle (V2). Both vehicles are traveling in the same direction.	
Subject lane change - left, other	Subject vehicle (V1) is traveling in the adjacent right lane, in the same direction as other vehicle (V2), and crosses left lane line (i.e., other	

	vehicle's right lane line) in a manner not described in other categories. Both vehicles are traveling in the same direction.	
Subject lane change - right, other	Subject vehicle (V1) is traveling in the adjacent left lane, in the same direction as other vehicle (V2), and crosses right lane line (i.e., other vehicle's left lane line) in a manner not described in other categories. Both vehicles are traveling in the same direction.	
Subject vehicle making a U-turn	Subject vehicle makes a U-turn, intending to proceed in the opposing lane of travel. Performing this U-turn precipitates the crash or near crash.	
Subject vehicle backing	Subject vehicle (V1) is in the process of backing up while in or into another vehicle's (V2) travel lane or path of travel.	This includes a backing out of a parking space into another vehicle's path. If the vehicle movement also fits the description of another category, code as such, rather than using this category.
Subject vehicle, other	State or action by subject vehicle (V1) was critical to the vehicle becoming involved in the crash or near-crash in a manner not described in other categories.	
Other vehicle action related categories		
Other vehicle ahead - stopped on roadway more than 2 seconds	Another vehicle (V2) is ahead of subject vehicle (V1) in the same lane and has been stopped for more than 2 seconds when the crash or near-crash occurs.	Other vehicle (V2) is stopped, parked, or disabled.
Other vehicle ahead - slowed and stopped 2 seconds or less	Another vehicle (V2) is ahead of subject vehicle (V1) in the same lane traveling in the same direction as subject vehicle. V2 is decelerating to a stop or has just stopped ahead in subject vehicle's lane (has been stopped for 2 seconds or less) when crash or near-crash occurs.	Other vehicle (V2) is nearly or completely stopped, rather than in a longer process of decelerating (in that case, code as "Other vehicle ahead, but decelerating").
Other vehicle ahead, but at a slower constant speed	Other vehicle (V2) is the lead vehicle and is traveling at a lower constant speed as the subject vehicle (V1) in the same lanes ahead of (and traveling in the same direction as) subject vehicle. The lower constant speed precipitates the event.	
Other vehicle ahead, but decelerating	Other vehicle (V2) is the lead vehicle and is decelerating, traveling in the same lane ahead of (and traveling in same direction) as subject vehicle. The deceleration of the lead vehicle precipitates the event.	If both the lead vehicle and subject vehicle are initially decelerating at the same rate, the Precipitating Event would begin when the lead vehicle begins decelerating at a higher rate (thus decreasing the headway between lead and subject vehicle). If lead vehicle is still decelerating but still in motion at the point where subject vehicle acted to avoid the rear-end striking, use this code (even if lead ends up eventually stopping). If lead is stopped at the point of subject acting to avoid the rear-end, code _Other

		vehicle ahead _ slowed and stopped 2 seconds or less_ or "Other vehicle ahead - stopped on roadway more than 2 seconds._
Other vehicle ahead, and accelerating	Other vehicle (V2) is the lead vehicle and is accelerating or traveling at a higher speed, ahead of (and in same lane and direction) as subject vehicle. The acceleration precipitates the event.	
Other vehicle - traveling in opposite direction	Other vehicle (V2) is in subject vehicle's (V1) travel lane and traveling head-on in the opposite direction of subject vehicle. Other vehicle may have just crossed or be in the process of crossing the double yellow line or otherwise maneuvered into the oncoming path of subject vehicle.	
Other vehicle - in crossover	Other vehicle (V2) enters a crossover already occupied by subject vehicle (V1). A crossover is a designated opening in a median used primarily for U-turns.	
Other vehicle making U-turn	Other vehicle (V2) makes a U-turn, intending to proceed in the opposite direction. V2 may initially be a lead vehicle in front of subject vehicle (V1) or may initially be traveling in the opposite or perpendicular direction of V1 when the U-Turn causes V2 to be in the path of V1.	
Other vehicle - backing	Other vehicle (V2) is in the process of backing up while in subject vehicle's (V1) travel lane or path of travel.	This includes a vehicle backing out of a parking space into the subject vehicle's path. If the vehicle movement also fits the description of another category (such as "Other vehicle from driveway - straight across path"), code as such, rather than using this category.
Other vehicle lane change - left in front of subject	Other vehicle (V2) is traveling in the adjacent lane on the left side of the subject vehicle (V1), in the same direction and ahead. V2 crosses subject vehicle's left lane line (i.e., other vehicle crosses its right lane line), resulting in contact or near-contact between the front of subject vehicle and rear of the other vehicle.	Lane lines are from subject vehicle's point of view (left or right).
Other vehicle lane change - right in front of subject	Other vehicle (V2) is traveling in the adjacent lane on the right side of the subject vehicle (V1), in the same direction and ahead. V2 crosses subject vehicle's right lane line (i.e., other vehicle crosses its left lane line), resulting in contact or near-contact between the front of subject vehicle and rear of the other vehicle.	Lane lines are from subject vehicle's point of view (left or right).
Other vehicle lane change - left behind subject	Other vehicle (V2) is traveling in the adjacent lane on the left side of the subject vehicle (V1), in the same direction and behind. V2 crosses subject vehicle's left lane line (i.e., other vehicle crosses its right lane line), resulting in contact or near-contact between the front of subject vehicle and rear of the other vehicle.	Lane lines are from subject vehicle's point of view (left or right).

Other vehicle lane change - right behind subject	Other vehicle (V2) is traveling in the adjacent lane on the right side of the subject vehicle (V1), in the same direction and behind. V2 crosses subject vehicle's right lane line (i.e., other vehicle crosses its left lane line), resulting in contact or near-contact between the front of subject vehicle and rear of the other vehicle.	Lane lines are from subject vehicle's point of view (left or right).
Other vehicle lane change - left, sideswipe threat	Other vehicle (V2) is traveling in the adjacent lane on the left side of the subject vehicle (V1), in the same direction and beside the subject vehicle. V2 crosses subject vehicle's left lane line (i.e., other vehicle crosses its right lane line), resulting in contact or near-contact between the left side of subject vehicle and right side of the other vehicle.	Lane lines are from subject vehicle's point of view (left or right).
Other vehicle lane change - right, sideswipe threat	Other vehicle (V2) is traveling in the adjacent lane on the right side of the subject vehicle (V1), in the same direction and beside the subject vehicle. V2 crosses subject vehicle's right lane line (i.e., other vehicle crosses its left lane line), resulting in contact or near-contact between the right side of subject vehicle and left side of the other vehicle.	Lane lines are from subject vehicle's point of view (left or right).
Other vehicle lane change - left other	Other vehicle (V2) is traveling in the adjacent lane on the left side of the subject vehicle (V1), in the same direction as subject vehicle, and crosses subject vehicle's left lane line in a manner not described in other categories.	Lane lines are from subject vehicle's point of view (left or right).
Other vehicle lane change - right other	Other vehicle (V2) is traveling in the adjacent lane on the right side of the subject vehicle (V1), in the same direction as subject vehicle, and crosses subject vehicle's right lane line in a manner not described in other categories.	Lane lines are from subject vehicle's point of view (left or right).
Other vehicle oncoming - over left line	Other vehicle (V2) crosses subject vehicle's (V1) left lane line while traveling in the opposite direction from subject vehicle.	Lane lines are from subject vehicle's point of view (left or right).
Other vehicle oncoming - over right line	Other vehicle (V2) crosses subject vehicle's (V1) right lane line while traveling in the opposite direction from subject vehicle.	Lane lines are from subject vehicle's point of view (left or right).
Other vehicle from parallel/diagonal parking lane	Other vehicle (V2) enters or crosses subject vehicle's (V1) lane line while departing some type of parking lane.	
Other vehicle entering intersection - turning same direction	Other vehicle (V2) is turning from another roadway (left or right) onto subject vehicle_s (V1) roadway with the intention of traveling in the same direction as subject vehicle, crossing or entering subject vehicle's lane line.	
Other vehicle entering intersection	Other vehicle (V2) is continuing straight through an intersection moving in a perpendicular	

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- straight across path	direction to the subject vehicle's (V1) travel lane and attempts to cross over subject vehicle_s roadway, crossing subject vehicle's travel lane.	
Other vehicle entering intersection - turning onto opposite direction	Other vehicle (V2) is entering an intersection from another roadway and is turning or attempting to turn onto subject vehicle_s (V1) roadway, intending to travel in the opposite travel direction of subject vehicle. V2 crosses subject vehicle's travel lane.	
Other vehicle entering intersection - left turn across path	Other vehicle (V2) is on the same roadway as subject vehicle (V1) and is entering an intersection to make a left turn across the path of the subject vehicle. V2 could have originally been traveling in either the same direction (in an adjacent lane) or opposite direction (in an oncoming lane) as the subject vehicle.	
Other vehicle entering intersection - right turn across path	Other vehicle (V2) is on the same roadway as subject vehicle (V1) and is entering an intersection to make a right turn across the path of the subject vehicle. V2 was originally traveling in the same direction (in left adjacent lane) as the subject vehicle.	
Other vehicle entering intersection - intended path unknown	Other vehicle (V2) enters an intersection, crossing subject vehicle's (V1) travel lane, but the other vehicle_s travel direction (intended path) could not be determined.	
Other vehicle from driveway - turning into same direction	Other vehicle (V2) is turning from a driveway (a roadway providing access from some property adjacent to the trafficway) onto subject vehicle_s (V1) roadway, intending to travel in the same direction as subject vehicle. V2 crossed or enters subject vehicle's travel lane.	
Other vehicle from driveway - straight across path	Other vehicle (V2) is entering subject vehicle_s (V1) roadway from a driveway (a roadway providing access from some property adjacent to the trafficway) and intends to continue straight across to another driveway or roadway. V2 crosses subject vehicle's travel lane.	
Other vehicle from driveway - turning into opposite direction	Other vehicle (V2) is entering subject vehicle_s (V1) roadway from a driveway (a roadway providing access from some property adjacent to the trafficway) and intends to turn into the opposite travel direction of subject vehicle. V2 crosses subject vehicle's travel path.	
Other vehicle from driveway - intended path unknown	Other vehicle (V2) is entering subject vehicle_s (V1) roadway from a driveway (a roadway providing access from some property adjacent to the trafficway), crossing subject vehicle's lane line, but details about its intended path are unknown.	

Other vehicle from entrance to limited access highway	Other vehicle (V2) is attempting to enter (merge) onto a limited access highway (via an entrance ramp) which is being traveled by subject vehicle. V2 crosses or enters subject vehicle's travel path.	
Pedestrian related categories		
Pedestrian in roadway	A pedestrian is present somewhere on the roadway (not necessarily walking). A pedestrian is any person who is on a trafficway or a sidewalk/path contiguous with a trafficway, and who is not in or on either a motorized or non-motorized conveyance. Also includes persons who are in contact with the ground, roadway, etc., but who are holding onto a vehicle.	Person can be sitting, standing, walking, running, etc. A non-motorist conveyance is a human-powered device by which a non-motorist may move or may move another non-motorist (includes baby carriage, coaster wagon, ice skates, roller skates, push cart, scooter, skate board, skis, sled, wheel chair, rickshaw, but does NOT include pedal cyclists). Any of these examples should be coded as "Pedal cyclist/other non-motorist".
Pedestrian approaching roadway	A pedestrian is within or adjacent to the trafficway and moving toward the roadway or attempting to enter the roadway, but is not yet on the roadway. A pedestrian is any person who is on a trafficway or a sidewalk/path contiguous with a trafficway, and who is not in or on either a motorized or non-motorized conveyance. Also includes persons who are in contact with the ground, roadway, etc., but who are holding onto a vehicle.	A non-motorist conveyance is a human-powered device by which a non-motorist may move or may move another non-motorist (includes baby carriage, coaster wagon, ice skates, roller skates, push cart, scooter, skate board, skis, sled, wheel chair, rickshaw, but does NOT include pedal cyclists). Any of these examples should be coded as "Pedal cyclist/other non-motorist".
Pedestrian in unknown location	The presence or action of a pedestrian is a critical factor in the crash or near-crash, but the location and/or action of the pedestrian is unknown. A pedestrian is any person who is on a trafficway or a sidewalk/path contiguous with a trafficway, and who is not in or on either a motorized or non-motorized conveyance. Also includes persons who are in contact with the ground, roadway, etc., but who are holding onto a vehicle.	A non-motorist conveyance is a human-powered device by which a non-motorist may move or may move another non-motorist (includes baby carriage, coaster wagon, ice skates, roller skates, push cart, scooter, skate board, skis, sled, wheel chair, rickshaw, but does NOT include pedal cyclists). Any of these examples should be coded as "Pedal cyclist/other non-motorist".
Pedal cyclist related categories		
Pedal cyclist/other non-motorist in roadway	A pedal cyclist (person riding a pedal-powered conveyance such as a bicycle or tricycle) or other non-motorist (person riding on or in a conveyance not pedal-powered or motorized such as a baby carriage, skateboard, roller blades, etc.) is present somewhere on the roadway.	Relative motion of the pedal cyclist or non-motorist is not a factor. Non-motorist conveyance includes baby carriage, coaster wagon, ice skates, roller skates, push cart, scooter, skate board, skis, sled, wheel chair, rickshaw, etc. Non-motorist includes persons riding on an animal or animal-powered conveyance and any person outside a sidewalk or path contiguous with a trafficway.
Pedal cyclist/other non-motorist approaching roadway	A pedal cyclist (person riding a pedal-powered conveyance such as a bicycle or tricycle) or other non-motorist (person riding on or in a conveyance not pedal-powered or motorized such as a baby carriage, skateboard, roller blades, etc.) is within the trafficway or a	Non-motorist conveyance includes baby carriage, coaster wagon, ice skates, roller skates, push cart, scooter, skate board, skis, sled, wheel chair, rickshaw, etc. Non-motorist includes persons riding on an animal or animal-powered conveyance and any person outside a sidewalk or

	sidewalk/path contiguous with a trafficway and moving toward the roadway or attempting to enter the roadway, but is not yet on the roadway.	path contiguous with a trafficway.
Pedal cyclist/other non-motorist in unknown location	The presence or action of a pedal cyclist (person riding a pedal-powered conveyance such as a bicycle or tricycle) or other non-motorist (person riding on or in a conveyance not pedal-powered or motorized such as a baby carriage, skateboard, roller blades, etc.) is a critical factor in the crash or near-crash, but the location and/or action of the pedal cyclist/non-motorist is unknown.	Non-motorist conveyance includes baby carriage, coaster wagon, ice skates, roller skates, push cart, scooter, skate board, skis, sled, wheel chair, rickshaw, etc. Non-motorist includes persons riding on an animal or animal-powered conveyance and any person outside a sidewalk or path contiguous with a trafficway.
Animal related categories		
Animal in roadway	A live animal (stationary or moving) is present somewhere on the roadway.	
Animal approaching roadway	A live animal is within the trafficway and moving toward the roadway or attempting to enter the roadway, but is not yet on the roadway.	
Animal in unknown location	The presence or action of a live animal is a critical factor in the crash or near-crash, but the location and/or action of the animal is unknown.	
Object related categories		
Object in roadway	An inanimate object (either fixed or non-fixed) is present somewhere on the roadway. Does not include barriers or curbs along the side of the roadway.	Object can be a dead animal. Also includes objects falling off the back of a truck in front of the subject.
Object approaching roadway	An inanimate object is within the trafficway and moving toward the roadway or attempting to enter the roadway, but is not on the roadway.	Object can be a dead animal (for example, if it has been hit into driver's roadway). Also includes objects being blown or thrown onto roadway from sidewalk.
Object in unknown location	The presence or movement of an inanimate object (either fixed or non-fixed) is a critical factor in the crash or near-crash, but the location and/or specific movement of the object is unknown.	Object can be a dead animal.
Other categories		
Other event not attributed to subject vehicle	Precipitating event is not described in any other category, and is not attributed to the subject vehicle.	
Unknown	Cannot determine the Precipitating Event due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.5.10 Precipitating Event Start

Description:

The onset of the precipitating event.

It is important to underline that the conflict partners need to be on a collision course, in order to define the start of the precipitating event.

Variable Type:

Integer

Input Type:

Insert time

Coded for:

SCE, SCEs in position-based annotation

Coded by:

Central annotation

Related VTTI Variable:

No

1.5.11 Surprise Reaction

Variable Definition:

Driver's reaction to an unexpected event. This can be a change in facial expression or movement of a body part in a way that indicates awareness and/or the start of an evasive maneuver. For motorcycles, this relies more heavily on body movement and evasive maneuver begin than on facial expressions due to obstruction of the face by the helmet.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

SCE, SCEs in position-based annotation

Coded by:

Central annotation

Related VTTI Variable:

Subject Reaction Start

Category	Definition	Example and Hints
Yes	Clear surprise reaction visible.	
No	Cleary no surprise reaction visible.	
Unknown	Unknown surprise reaction.	

1.5.12 Surprise Reaction Time

Description:

The time when the driver is seen to recognize an unexpected event and begins to react. This can be a change in facial expression or movement of a body part in a way that indicates awareness and/or the start of an evasive maneuver. For motorcycles, this relies more heavily on body movement and evasive maneuver begin than on facial expressions due to obstruction of the face by the helmet.

Variable Type:

Integer

Input Type:

Insert time

Coded for:

SCE, SCEs in position-based annotation

Coded by:

Central annotation

Related VTTI Variable:

Subject Reaction Start

1.5.13 Evasive Maneuver

Variable Definition:

The subject driver's reaction or avoidance maneuver (if any) in response to the event/incident(s)

This is independent of maneuvers associated with or caused by the resulting crash or near-crash. This is a vehicle kinematic measure--based on what the vehicle does.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

SCE, SCEs in position-based annotation

Coded by:

Central annotation

Related VTTI Variable:

V1 Evasive Maneuver 1,2: including MC categories and additional combinations with releasing brakes and throttle – listed as a more detailed alternative as a second part of the table below

Category	**Definition**	**Example and Hints**
No driver present	No driver was present in the subject vehicle (V1) at the time of the event.	
No reaction	No change in the driving behavior of the subject vehicle (V1) driver due to the Precipitating Event was evident.	
Braked	Subject driver activated brake pedal. Did not include evasive steering.	
Released brakes	Subject driver released brake pedal.	
Steered to left	Subject driver steered to left of initial travel direction.	Generally, lateral acceleration greater than +/- 0.25 g would be noted.
Steered to right	Subject driver steered to right of initial travel direction.	Generally, lateral acceleration greater than +/- 0.25 g would be noted.
Braked and steered left	Subject driver activated brake pedal and steered to left of initial travel direction.	Generally, lateral acceleration greater than +/- 0.25 g would be noted.
Braked and steered right	Subject driver activated brake pedal and steered to right of initial travel direction.	Generally, lateral acceleration greater than +/- 0.25 g would be noted.
Accelerated	Subject driver activated or increased pressure on gas pedal to accelerate. (May or may not have released brake first.)	Generally, longitudinal acceleration greater than + 0.25 g would be noted.
Accelerated and steered left	Subject driver activated or increased pressure on gas pedal to accelerate and steered to left of initial travel direction. (May or may not have released brake first.)	Generally, lateral/longitudinal acceleration greater than +/- 0.25 g (lateral) or + 0.25 (longitudinal) would be noted.
Accelerated and steered right	Subject driver activated or increased pressure on gas pedal to accelerate and steered to right initial travel direction. (May or may not have released brake first.)	Generally, lateral/longitudinal acceleration greater than +/- 0.25 g (lateral) or + 0.25 (longitudinal) would be noted.

Other actions	Subject driver performed other corrective action not included in previous categories.	
Unknown if action was attempted	Cannot determine if the subject driver attempted an evasive maneuver or the nature of the evasive maneuver due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video or other data to make a determination.
Not Applicable	Code Evasive Maneuver 2 as Not Applicable when only one Event Nature and Incident Type are coded. (Evasive Maneuver 2 only)	

1.5.14 Evasive Maneuver Time

Description:

The time when the subject driver's avoidance maneuver (if any) in response to the event starts

Variable Type:

Integer

Input Type:

Insert time

Coded for:

SCE, SCEs in position-based annotation

Coded by:

Central annotation

Related VTTI Variable:

No

1.5.15 Driver Foot Position

Variable Definition:

Position of driver's right foot.

Variable Type:

Time series

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
On brake pedal	Right foot over/on brake pedal	
On accelerator pedal	Right foot over/on accelerator pedal	
Not on pedal	Right foot neither over/on brake nor accelerator pedal	
Unknown	Unable to determine foot position.	

1.6 Intersection related Variable

Intersection related variables will be coded for all events in an intersection regardless if SCEs, baselines/ controls or position-based events.

1.6.1 Intersection SV Maneuver

Variable Definition:

This variable describes what is the SV driver action or intention towards the intersection.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
Going Straight	SV intends to go straight.	
Turning Left	SV intends to turn left.	
Turning Right	SV intends to turn right.	
Unknown	Unknown intention.	

1.6.2 Intersection Conflict/Interaction Partner 1, 2, 3, 4 Initial Direction

Variable Definition:

Specifies the direction from which the Conflict Partner initially approaches the intersection, at the moment that the SV approaches the intersection.

Variable Type:

Categorical

Input Type:

UDRIVE
European Naturalistic Driving Study

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
Straight	Approaches intersection from the same direction.	
Opposite	Approaches intersection from the opposite direction.	
Left	Approaches intersection from a left intersection leg.	
Right	Approaches intersection from a right intersection leg.	
Unknown	Unknown from which direction.	

1.6.3 Intersection Conflict/Interaction Partner 1, 2, 3, 4 Maneuver

Variable Definition:

This variable describes what is the conflict partner action or intention towards the intersection.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
Going Straight	POV intends to go straight.	
Turning Left	POV intends to turn left.	
Turning Right	POV intends to turn right.	
Unknown	Unknown intention.	

1.6.4 Intersection Conflict/Interaction Partner 1,2,3,4 Priority Negotiation

Variable Definition:

Describes who - SV or conflict/ interaction partner (CIP) - has the right of way according to the Priority Situation, and who eventually takes right of way.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
SV_has_SV_takes	SV has right of way, SV gets right of way.	
SV_has_CIP_takes	SV has right of way, but CP claims right of way.	
IP_has_CIP_takes	IP has right of way, CP gets right of way.	
CIP_has_SV_takes	IP has right of way, but SV claims right of way.	
Prio_unclear_SV_takes	Unclear who has right of way, SV claims right of way.	
Prio_unclear_CIP_takes	Unclear who has right of way, CP claims right of way.	

Prio_unclear_Action_unclear	Unclear who has right of way, unclear who claims right of way.	E.g., if both SV and CIP (continue) to claim right of way.

1.6.5 Intersection Primary/ Secondary Road

Variable Definition:

This variable describes if the subject vehicle is driving on a primary or secondary road when entering the intersection.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

Each secondary task "event"

Coded by:

Central annotation

Related VTTI Variable:

No

Category	**Definition**	**Example and Hints**
On secondary road	Driving on secondary (minor) road when entering intersection	
On primary road	Driving on the primary (main) road when entering intersection	
Equal size roads	The intersection roads are of equal size.	
Unknown		

1.7 Driver State/ Distraction - related Variables

Driver State/ Distraction - related variables will be coded for all events regardless if SCEs, baselines/ controls or position-based events.

1.7.1 Secondary Task 1, 2, 3, 4, 5

Variable Definition:

Observable driver engagement in any of the listed secondary tasks, beginning at any point during the event. Visual distractions include non-driving related glances away from the direction of vehicle movement. Does not include tasks that are critical to the driving task, such as speedometer checks, mirror/blind spot checks, activating wipers/headlights, or shifting gears. Other non-critical tasks are included, including radio adjustments, seatbelt adjustments, window adjustments, and visor and mirror adjustments. Note that there is no lower limit for task duration. If there are more than 3 secondary tasks present, select the most critical or those that most directly impact the event, as defined by event outcome or proximity in time to the event occurrence. Populate this variable in numerical order. (If there is only one distraction, name it Secondary Task 1; if there are two, name them Secondary Task 1 and 2. Enter "No Additional Secondary Tasks" for remaining Secondary Task variables.)

NOTE:

***Priority column** in the table below is:*

***1** - high interest (code category and code start and stop even if outside pre-selected time window)*
***0** - moderate interest (code category and code start and stop inside pre-selected time window only)*
***-1** - no interest (code type only, don't code start and stop)*

*Many different categories have been given the same or similar start points and end points for coding purposes. The intention is to capture the full task with further breakdown into sub-tasks being conducted at the local level dependent on RQ. As a result, an additional column has been added to show broader secondary task categories [**Task Group**]. This is for illustrative purposes and does not need to be coded.*

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Secondary Task 1, 2, 3

Priority	Task Group	Category	Definition	Example and Hints	Start	End
-1	None	No Secondary Tasks (or No Additional Secondary Tasks)	The subject vehicle driver is not engaged in any observable secondary tasks and is attentive to the driving task.			
1	Cell phone[1]	Cell phone, Holding	Subject is holding a cell phone but not manipulating it. Could be holding it in hand, lap, or some other way.		First glance towards or hand movement towards the phone. Code whichever occurred first.	Phone is put down
1	Cell phone[1]	Cell phone, Talking/listening, hand-held	Subject vehicle driver is talking on a handheld phone or has phone up to ear as if listening to a phone conversation or waiting for person they are calling to pick up the phone. If driver has an earpiece or headset, the driver must be observed talking repeatedly.		First glance towards or hand movement towards the phone. Code whichever occurred first.	Phone is put down
1	Cell phone[1]	Cell phone, Talking/listening, hands-free[2]	Subject vehicle driver is talking or listening on a phone using a hands-free device such as a headset, in-vehicle integrated system, or hands-free speaker phone. This category is only used in studies where sufficient information exists and is not used in the current study. Instead, refer to "Talking/Singing, audience unknown" category.	This category cannot be reliably and consistently determined in many naturalistic studies due to insufficient information. Cell phone records, audio recordings, and/or extensive review of extended video footage are required to code this category, none of which were available at the time of the current coding effort.	First glance towards or hand movement towards the phone to initiate the call. Code whichever occurred first.	Hand movement to end the call, or if this does not occur, first sign that conversation has ended
1	Cell phone[1]	Cell Phone,	Subject vehicle driver is pressing		First glance towards or	Phone is put

		Texting[3]	buttons or a touch screen on the cell phone to create and/or send a text message.		hand movement towards the phone. Code whichever occurred first.	down
1	Cell phone[1]	Cell Phone, Browsing[4]	Subject vehicle driver is pressing buttons or a touch screen on the cell phone to browse the internet or phone applications. May also include voice commands (e.g., Siri).		First glance towards or hand movement towards the phone. Code whichever occurred first.	Phone is put down
1	Cell phone[1]	Cell Phone, Dialing hand-held	Subject vehicle driver is pushing number buttons on a cell phone or touch screen to dial a number or browse/check something else on their cell phone (this would also include reading the phone number from a sheet of paper).	If unsure whether driver is texting or dialing/browsing, code as dialing.	First glance towards or hand movement towards the phone. Code whichever occurred first.	Phone is put down
1	Cell phone[1]	Cell Phone, Dialing hand-held using quick keys	Subject vehicle driver is pushing quick key buttons (e.g., speed dial) on a cell phone to dial a number or check something else on their cell phone (this would also include reading the phone number from a sheet of paper). Maximum number of buttons is 6, else code as "dialing hand-held phone".		First glance towards or hand movement towards the phone. Code whichever occurred first.	Phone is put down
1	Cell phone[1]	Cell Phone, Dialing hands-free using voice-activated software[5]	Driver speaks into open or activated cell phone, headset, or in-vehicle integrated device for the purpose of dialing with long, prior delay of no speaking into device (i.e., most likely not		First glance towards or hand movement towards the phone if this is required to initiate the voice-activated	Hand movement to end the call, or if this does not occur, first sign that conversation has ended

			in prior conversation) and no more than one or two button presses (e.g., push to begin) on phone, earpiece, headset, or in-vehicle integrated system are made first.		software. Code whichever occurred first.	
1	Cell phone[1]	Cell Phone, Locating/reaching/ answering	Subject vehicle driver is glancing to find cell phone, reaching towards his/her cell phone, and/or flipping phone open or pressing a button to answer a call.	If more than one distraction happens (e.g., driver looks for phone, reaches for it and then answers it), the last frame number would be the last step in this sequence (e.g., answering cell phone). Once phone is at driver's ear or conversation has clearly begun, code as the appropriate "talking" category.	First glance towards or hand movement towards the phone. Code whichever occurred first.	Phone is put down
1	Cell phone[1]	Cell phone, other	Subject vehicle driver is interacting with a cell phone in some manner (e.g., looking at a cell phone or just holding it, but not necessarily manipulating the cell phone in any way), or action does not fit in any other category.	Includes plugging phone into charger, cleaning screen, putting on headset, etc.	First glance towards or hand movement towards the phone. Code whichever occurred first.	Phone is put down
1	Electronic device	Tablet device, Locating/reaching	Subject vehicle driver reaches or starts to glance around for an electronic tablet device (e.g., iPad).		First glance towards or hand movement towards the tablet. Code whichever occurred first.	Tablet is put down
1	Electronic device	Tablet device, Operating	Subject vehicle driver is pressing buttons on or using the touch screen on		First glance towards or hand movement	Tablet is put down

			the electronic tablet device.		towards the tablet. Code whichever occurred first.	
1	Electronic device	Tablet device, Viewing	Subject vehicle driver is holding and looking at an electronic tablet device, but not pressing any buttons.		First glance towards or hand movement towards the tablet. Code whichever occurred first.	Tablet is put down
1	Electronic device	Tablet device, Other	Subject vehicle driver is interacting with an electronic tablet device in some manner not described in other categories.	Includes plugging tablet into charger, cleaning screen, headset, holding without manipulating, etc.	First glance towards or hand movement towards the tablet. Code whichever occurred first.	Tablet is put down
1	Electronic device	CB Radio, Interact (Car/Truck Only)	Subject vehicle driver is reaching for, manipulating, talking into, or listening to a CB Radio.		First glance towards or hand movement towards the CB radio. Code whichever occurred first.	CB radio is put down
-1	Electronic device	Intercom, Interact	Subject vehicle driver is reaching for, manipulating, talking into, or listening to an intercom system (e.g., announcement/PA system on a bus).			
-1	Electronic device	Electronic dispatching device, Interact with(Truck Only)	Subject vehicle driver is interacting in some way with an electronic dispatching device.		Driver first interacts with dispatching device in some way, either looking, reaching, etc., whichever is first.	Driver last interacts with dispatching device.
-1	Electronic device	DAS, Interact	Subject vehicle driver is reaching for, manipulating, or otherwise interaction with the Data Acquisition		Driver first interacts with the DAS in some way, either looking, reaching, etc., whichever is	Driver last interacts with DAS.

			System.		first.	
1	Electronic device	Other electronic device, Interact with	Subject vehicle driver is interacting in some way with an electronic device that is not included in other categories and is not integral to the vehicle (e.g., calculator, camera, nomadic GPS).		First glance towards or hand movement towards the device. Code whichever occurred first.	Device is put down
1	Food and drink[6]	Reaching for food-related or drink-related item	Subject vehicle driver is looking for or reaching for any item related to eating or drinking. If the driver is already in the process of eating, and is just picking up food repeatedly to put in mouth, code as the appropriate eating category. This reaching task is for the initial locating, reaching, and preparing food or drink to be eaten.	Ex. reaching for cup, utensils, plate, food. Once the item is in hand and being moved with the intent to use, code as appropriate usage category (e.g., eating).	First glance to or physical motion towards the food/drink-related item, whichever occurred first.	Driver's hand releases item for the last time e.g. consumption complete
1	Food and drink[6]	Eating with utensils	Subject vehicle driver has food that will be put in his/her mouth via a utensil like a fork, spoon, knife, chopsticks, etc.		First glance to or physical motion towards the food/drink-related item, whichever occurred first.	Driver's hand releases item for the last time e.g. consumption complete
1	Food and drink[6]	Eating without utensils	Subject vehicle driver has food that will be put in his/her mouth and a utensil is not used to place the food in the driver's mouth.		First glance to or physical motion towards the food/drink-related item, whichever occurred first.	Driver's hand releases item for the last time e.g. consumption complete
1	Food and drink[6]	Drinking with lid and straw	Subject vehicle driver uses a straw to drink from a container that has a cover on it and cannot easily spill if it tips over.	Ex. Fountain drink with lid and straw, sippy water bottle	First glance to or physical motion towards the food/drink-related item, whichever occurred first.	Driver's hand releases item for the last time e.g. consumption complete

1	Food and drink[6]	Drinking with lid, no straw	Subject vehicle driver drinks from a container that has a cover on it and cannot easily spill if it tips over (not using a straw).	Ex. coffee mug with lid that closes	First glance to or physical motion towards the food/drink-related item, whichever occurred first.	Driver's hand releases item for the last time e.g. consumption complete
1	Food and drink[6]	Drinking with straw, no lid	Subject vehicle driver uses a straw to drink from a container that does not have a lid.	Ex. uncovered fountain drink with a straw	First glance to or physical motion towards the food/drink-related item, whichever occurred first.	Driver's hand releases item for the last time e.g. consumption complete
1	Food and drink[6]	Drinking from open container	Subject vehicle driver drinks from a container that does not have a lid (not using a straw).	Ex. uncovered cup, coffee cup, water bottle with lid off, soda can	First glance to or physical motion towards the food/drink-related item, whichever occurred first.	Driver's hand releases item for the last time e.g. consumption complete
1	Smoking[7]	Reaching for cigar/cigarette	Subject vehicle driver reaches or starts to glance around for cigar/cigarette or related items.	Once the item is in hand and being moved with the intent to use, code as appropriate usage category (e.g., lighting).	First glance to or physical motion towards the cigar/cigarette , whichever occurred first.	Discards the cigar/cigarette
1	Smoking[7]	Lighting cigar/cigarette	Subject vehicle driver is in some stage of the process of lighting cigar/cigarette.		First glance to or physical motion towards the cigar/cigarette , whichever occurred first.	Discards the cigar/cigarette
1	Smoking[7]	Smoking cigar/cigarette	Subject vehicle driver has a lit cigar/cigarette either in their mouth or hand.		First glance to or physical motion towards the cigar/cigarette , whichever occurred first.	Discards the cigar/cigarette
1	Smoking[7]	Extinguishing cigar/cigarette	Subject vehicle driver puts out his/her cigar/cigarette, hands it to someone else, or tosses it out the window.		First glance to or physical motion towards the cigar/cigarette , whichever occurred first.	Discards the cigar/cigarette

-1	Smoking[7]	Tobacco, other	Subject vehicle driver is using some other form of tobacco not included in other categories such as chewing tobacco (putting it in mouth, spitting).	If chewing tobacco and tobacco is simply in mouth at during the analysis window (not reaching, spitting, etc.), do not code as a secondary task.	First glance to or physical motion towards the cigar/cigarette , whichever occurred first.	Discards the cigar/cigarette
1	Personal grooming[8]	Reaching for personal body-related item	Subject vehicle driver is reaching for any item related to personal hygiene, health, or adornment.	Ex. reaching for comb, brush, makeup, razor, dental floss, contact lenses, glasses (not currently being worn), hat (not currently being worn). Once the item is in hand and being moved with the intent to use, code as appropriate usage category.	First glance to or physical motion towards the object, whichever occurred first.	Puts the object down
1	Personal grooming[8]	Combing/brushing/ fixing hair	Subject vehicle driver is adjusting, or combing/brushing hair, except for quickly swiping hair out of eyes or idle twirling of hair.		First glance to or physical motion towards the object, whichever occurred first.	Puts the object down
1	Personal grooming[8]	Applying make-up	Subject vehicle driver is in some stage of applying any body product to body.	Ex., lotion, make-up, lip balm, perfume	First glance to or physical motion towards the object, whichever occurred first.	Puts the object down
1	Personal grooming[8]	Shaving	Subject vehicle driver is using any appliance with a blade to remove hair from body.	Ex., razor (electric or manual)	First glance to or physical motion towards the object, whichever occurred first.	Puts the object down
1	Personal grooming[8]	Brushing/flossing teeth	Subject vehicle driver is using any appliance to brush, floss or otherwise clean teeth or mouth.	Ex., includes toothbrush, floss, toothpick, etc.	First glance to or physical motion towards the object, whichever occurred first.	Puts the object down

1	Personal grooming[8]	Removing/adjusting clothing	Subject vehicle driver is removing, adjusting, or putting on clothing, including jackets, shirt, pants, shoes, socks, hats, gloves, neckties, and scarves.		First glance to or physical motion towards the object, whichever occurred first.	Puts the object down/releases the object
1	Personal grooming[8]	Removing/adjusting jewelry	Subject vehicle driver is removing or adjusting jewelry, including watches.	Ex., rings, necklaces, bracelets, watches, earrings or other piercings.	First glance to or physical motion towards the object, whichever occurred first.	Puts the object down/releases the object
1	Personal grooming[8]	Removing/inserting/ adjusting contact lenses or glasses	Subject vehicle driver is removing or inserting contact lens(es) from eye(s) or putting on/taking off/adjusting glasses or sunglasses.		First glance to or physical motion towards the object, whichever occurred first.	Puts the object down/releases the object
-1	Personal grooming[8]	Other personal hygiene	Subject vehicle driver is engaged in some other personal hygiene activity(ies) not described in previous categories.	Ex., checking oneself in mirror without the preceding tasks, trying to get something out of one's eye.	Driver has first interaction.	Driver has last interaction.
1	Reading and writing	Reading[9]	Subject vehicle driver is reading material that is in the vehicle, but not a part of the vehicle (i.e., not reading external signs, or center stack display).	This could be reading directions, paper material, and packaging. If reading a phone number, record as dialing cell phone.	First eye glance towards the reading material or first physical motion towards the reading material. Code whichever occurs first.	Puts down the reading material or no glances towards the reading material for 30s. Code whichever occurs first.
1	Reading and writing	Writing	Subject vehicle driver is writing with a pen/pencil or using a stylus on a tablet.	Driver could be writing on a piece of paper, making notes on a tablet, etc.	First eye glance towards the writing material or first physical motion towards the writing material. Code whichever	Puts down the writing material or no glances towards the writing material for 30s. Code whichever occurs first.

					occurs first.	
0	Controls	Adjusting/monitoring climate control[10]	Subject vehicle driver interacts with in-vehicle climate control system either by touching the climate control buttons, glancing at the climate control on dashboard, or adjusting climate control vents.		Driver's hand first moves towards the control OR driver first glances at climate control, with or without subsequent reaching (whichever occurs first).	Driver's hand has last interaction adjusting knobs or any controls for that device OR driver glances at device for the last time (whichever occurs last).
0	Controls	Adjusting/monitoring radio	Subject vehicle driver interacts with in-vehicle radio/audio system either by touching the radio buttons on dashboard or steering wheel, or glancing at the radio on dashboard.		Driver's hand first touches the control OR driver first glances at the radio, with or without subsequent reaching (whichever occurs first).	Driver's hand has last interaction adjusting knobs or any controls for that device OR driver glances at device for the last time (whichever occurs last).
0	Controls	Inserting/retrieving CD (or similar)	Subject vehicle driver picks up CD, cassette, or other music storage device (other than MP3 player) in vehicle and/or inserts it into radio, presses any subsequent buttons to get device to play/rewind/fast forward and then play, or driver presses button to eject device and then places it somewhere in vehicle.		Driver's hand moves in the direction of the CD, cassette, or other music storage device (other than MP3 player) to insert it into player OR driver's hand first touches the player to extract a CD OR driver first glances at case or direction of the CD player to insert or retrieve a CD (whichever comes first).	Driver's hand has last interaction with player (e.g., pushing play) OR driver puts CD that has been retrieved either in a case or puts it down OR driver last glances at device or CD.
-1	Controls	Adjusting/monitoring other/unknown Instrument Panel device	Subject vehicle driver interacts with a manufacturer-installed Instrument Panel device other than those listed in	Includes integrated Navigation systems.		

			other categories (or an unknown device), either by touching or glancing at the device. Does not include driving-critical tasks, such as turn signal, wipers, headlights, gear shift, speedometer. Instrument Panel can include any integral device or control on or around the steering wheel, on the dashboard, or on the center stack.			
-1	Controls	Adjusting/monitoring other devices integral to vehicle	Subject vehicle driver interacts with a manufacturer-installed device other than those listed in other categories, either by touching or glancing at the device. Does not include driving-critical tasks, such as turn signal, wipers, headlights, gear shift, speedometer.	Includes interaction with seat belt, door locks, window controls, Navigation system, sun visors, rear view mirror, etc.	Driver's hand first touches the device OR driver first glances at that device, with or without subsequent reaching (whichever occurs first).	Driver's hand has last interaction touching that device OR driver glances at that device for the last time.
0	Interaction - object	Moving object in vehicle, interact (or on motorcycle)	Any interaction with an object inside the vehicle (or on the motorcycle) which is not being held by the driver or passenger(s) (if present) but is in motion, either due to the motion of the vehicle or due to another passenger throwing the object.	Ex. Driver looks at and/or reaches for an object that fell off the seat when driver stopped hard at a traffic light; or CB cord is dangling and driver reaches up to steady it.	Object is first set in motion (e.g., by hard braking, or throwing).	Object comes to a rest.
-1	Interaction - object	Insect in vehicle, interact (or around motorcycle)[11]	Interaction with any insect in the vehicle (or around the motorcycle) (e.g., swatting at insect, moving body to avoid insect, looking around trying to locate insect).		Driver first responds to insect (i.e., looks away from driving scene, or moves body away from or towards it).	Driver goes back to normal driving behavior (e.g., looking at driving scene) and stops looking at and interacting with the insect (whichever occurs last).

-1	Interaction - object	Pet in vehicle, interact (or on motorcycle) [11]	Any interaction with a pet in the vehicle (or on the motorcycle), including holding, petting, talking to, or moving pet or interacting with pet carrier.	Only code if animal/pet is visible at some point in the trip file or if there is history/context with the driver and the driver is exhibiting behaviors that are appropriate to having a pet in the vehicle.	Driver first interacts with pet. This could be first glance away from driving scene when looking for or at pet or the first body movement towards or away from pet. If driver first speaks and then looks at pet, then the beginning frame number would be when first word is formed.	Driver stops interacting with pet. This would be when driver has last glance at pet OR takes hand off of pet (if not looking at pet), OR stops talking to pet (whichever occurs last).
0	Interaction - object	Object dropped by driver	Subject vehicle driver is initially holding something and drops it and the driver then immediately picks it back up, taking the driver's attention away from the driving task.	This category supersedes other "reaching" categories in the situation of an object being dropped and immediately retrieved.	Driver last touches the object before it drops.	Driver touches the object and it is first lifted up and glance returns to the driving task.
0	Interaction - object	Reaching for object, other[12]	Subject vehicle driver reaches for an object not described in any other category.	Once the driver has finished reaching for the object and has it in hand (if not being moved for intended usage), then it becomes "object in vehicle, other," as long as it doesn't fit into any of the other categories (e.g., eating, drinking, etc.)	Driver first starts to move hand to reach for object OR glances toward the object and immediately reaches for it (whichever occurs first).	Driver first touches the object.
0	Interaction - object	Object in vehicle, other (or on motorcycle)	Subject vehicle driver clearly is looking at, handling, holding, or manipulating an object (visible or not) or thing located in the vehicle, other than those listed in		Driver first looks at OR handles the object (whichever occurs first).	Driver places object and it no longer is in his/her hands, OR is no longer looking at the object (whichever

			other categories.			occurs last).
0	Interaction - passenger	Passenger in adjacent seat – interaction[13]	A front seat passenger is visible or not visible, but the subject vehicle driver is clearly interacting with a passenger (other than a child) in the adjacent/front seat. This could be talking, listening, reacting to (i.e., laughing), gesturing towards, moving toward or away from the passenger, or reaching to take something from or give something to the passenger. If age of passenger is unable to estimate, use this category.	Use this distraction if you can see the front seat passenger (other than a child) in the camera or the driver is talking and looking in the direction of the front passenger seat. Entire trip file or segment may be used to look for evidence of passenger. Consider this distraction as long as the driver and passenger both remain in the vehicle (even if the car stops or is idling).	The first frame number when driver interacts with a passenger in the adjacent front seat. This could be talking, reacting to (e.g., laughing), moving toward or away from the passenger (e.g., reaching for the passenger, or avoiding a pat from the person) or looking/glancing at the passenger or something the passenger is showing him/her.	The last frame number when driver interacts with a passenger in the adjacent seat in any of the ways listed under Start Point, or Event End, whichever is first.
0	Interaction - passenger	Passenger in rear seat - interaction[13]	A rear seat passenger (other than a child, or age unable to estimate) is visible or not visible, but the driver is clearly interacting with a passenger (other than a child) in the rear seat. This could be talking, listening, reacting to (i.e., laughing), moving toward or away from the passenger, or reaching for the rear seat passenger. If age of passenger is unable to estimate, use this category.	Use this distraction if you can see the rear seat passenger (other than a child) in the camera or the driver is talking and looking in the direction of the rear seat. May also use the rear view to view the rear seat passenger. Entire trip file or segment may be used to look for evidence of passenger. Consider this distraction as long as the driver and passenger remain in the vehicle (even if the car stops or is idling).	When the passenger gets in the vehicle or the first frame number when driver interacts with a passenger in the rear seat(s). This could be talking, reacting to (e.g., laughing), moving toward or away from the passenger (e.g., reaching for the passenger, or avoiding a pat from the person) or glancing at the passenger or	The last frame number when driver interacts with a passenger in the rear seat(s) in any of the ways listed under Start Point, or Event End, whichever is first.

					something the passenger is showing him/her.	
0	Interaction - passenger	Child in adjacent seat - interaction[13]	Child is visible or not visible, but the driver is clearly interacting with a child in the front adjacent seat. This could be talking, listening, reacting to (i.e., laughing), or moving toward or away from the child (i.e., reaching for a child, not object, or avoiding a pat from the child).	Use this distraction if you can see the child in the front adjacent seat in the camera or the driver is talking and looking in the direction of the adjacent seat, handing bottles/toys, etc. Entire trip file or segment may be used to look for evidence of passenger. Consider this distraction as long as the driver and passenger remain in the vehicle (even if the car stops or is idling).	The first frame number when driver interacts with a child in the adjacent front seat. This could be talking, reacting to (e.g., laughing), moving toward or away from the child (e.g., reaching for the child, or avoiding a pat from the person) or looking/glancing at the child or something the child is showing him/her.	The last frame number when driver interacts with a child in the adjacent front seat in any of the ways listed under Start Point, or Event End, whichever is first.
0	Interaction - passenger	Child in rear seat - interaction[13]	A child is visible or not visible in the rear seat, and the driver is clearly interacting with a child in the rear seat. This could be talking, listening, reacting to (i.e., laughing), or moving toward or away from the child (i.e., reaching for a child, not object, or avoiding a pat from the child).	Use this distraction if you can see the child in the rear seat in the camera or the driver is talking and looking in the direction of the rear seat, handing bottles/toys, etc. If the driver is looking at the rear passenger using the rearview mirror, then that would be coded as passenger in rear seat AND center rear-view mirror. Entire trip file or segment may be used to look for evidence of passenger. Consider this distraction as long	The first frame number when driver interacts with a child in the rear seat(s). This could be talking, reacting to (e.g., laughing), moving toward or away from the child (e.g., reaching for the child, or avoiding a pat from the person) or looking/glancing at the child or something the child is showing him/her.	The last frame number when driver interacts with a child in the rear seat(s) in any of the ways listed under Start Point, or Event End, whichever is first.

				as the driver and passenger remain in the vehicle (even if the car stops or is idling).		
0	Interaction - passenger	Look back into sleeper berth (truck only)	The driver is looking back into the sleeper berth (e.g., to interact with a passenger or look for an item).		The first frame number when driver starts to look at, reach towards, or move towards the sleeper berth area, whichever comes first.	Driver has last interaction with the sleeper berth and returns hands and attention back to the driving task. May be when eyes return forward, hands return to wheel, etc., whichever is last.
-1	External	Looking at previous crash or incident	Subject vehicle driver is looking outside of the vehicle in the direction of what is obviously an accident or similar incident.	Only mark if it is clear that the driver is tracking a specific external distraction as they drive by. Quick glances are not categorized in this category; code these according to where the driver is glancing (ex., mirror or window).	Driver's glance is first directly on the accident or something related to the accident (e.g., police officer standing on the side of the road).	Driver has taken his/her last glance at the accident.
-1	External	Looking at pedestrian	Subject vehicle driver is looking outside of the vehicle in the direction of a pedestrian (not in a construction zone) either on the side of the road or in front of them (i.e., using a cross walk or riding a bike at a red light).		Driver first glances at pedestrian.	Driver has taken his/her last glance at the pedestrian.
-1	External	Looking at animal	Subject vehicle driver is looking outside of the vehicle in the direction of an animal either on the side of the road (this would not be used for an animal		Driver first glances at the animal.	Driver has taken his/her last glance at the animal.

			crossing the road).			
-1	External	Looking at an object external to the vehicle	Subject vehicle driver is looking outside of the vehicle in the direction of an object (not in a construction zone) on the side of the road (e.g., a box).		Driver first glances at the object.	Driver has taken his/her last glance at the object.
-1	External	Distracted by construction	Subject vehicle driver is looking outside of the vehicle in the direction of a construction zone. A construction zone would be defined as the presence of a barrel, person in a hard hat, construction equipment or vehicles.		Driver first glances at an object or person in the construction zone.	Driver has taken his/her last glance at an object or person in the construction zone.
-1	External	Other external distraction	Subject vehicle driver is looking outside of the vehicle for purposes not described in previous categories, or for an unknown reason when glance is not considered to be part of the driving task.	Includes looking at vehicle ahead in adjacent lane.	Driver first glances outside of the vehicle for purposes not described in previous categories (and not driving-related).	Driver's eyes first fixate on a location fitting into another category or the driving task.
0	Other	Talking/singing, audience unknown[14]	Subject vehicle driver is moving lips as if talking or singing, the interaction is not believed to be with a passenger. This category includes whistling, and also includes possible or suspected cases of hands-free cell phone use. (See "Cell phone, Talking/listening, hands free" category for further information.) This category does not include the driver	Driver may or may not also be interacting with a passenger, but this Secondary Task involves singing with radio, talking to self, using a cell phone through a hands-free medium, etc.	Driver first starts to open mouth, forming first word.	Driver stops moving mouth for last time.

			talking to a pedestrian or other known party outside the vehicle, which should be coded as the appropriate external distraction.			
-1	Other	Dancing[15]	Subject vehicle driver is moving his/her arms, head, or other body part seemingly in time with the beat of music.	e.g., tapping hands/fingers on steering wheel, bobbing head, "air drums" or "air guitar".	Body first starts moving in a rhythmic motion.	Body stops moving in a rhythmic motion for the last time.
-1	Other	Biting nails/cuticles[16]	Subject vehicle driver is biting nails or cuticles.		Driver's hand first moves towards mouth before biting nails.	Driver's hand last touches mouth or bitten off cuticle OR finger nail is removed from driver's mouth (whichever occurs last).
-1	Other	Removing/adjusting helmet (MC only)	Subject rider is removing, putting on, or adjusting helmet (including visor).	Includes adjusting visor up or down, adjusting chinstrap, converting three-quarter helmet, wiping visor, applying or removing tape from visor, interacting with helmet-mounted camera. If adjustment is related to operation of other peripherals (such as cell phone or radio), code as appropriate (e.g., answering cell phone) rather than this category.	Rider's hand first moves towards or rider first glances at helmet or related item	Rider's hand last touches helmet/item or last glances at helmet/item, whichever step occurs last.
-1	Other	Other non-specific internal eye glance	Subject vehicle driver glances away from the direction of travel at something inside the subject vehicle, but cannot determine a specific		Driver's eyes first fixate on something in the vehicle (not listed in another category).	Driver's eyes first fixate on the next glance location or direction of travel.

			glance location.			
-1	Other	Other known secondary task	Subject vehicle driver is engaged in a recognizable secondary task that is not listed in other categories.	Includes cases where the vehicle is traveling in reverse and the driver is looking out the forward or side windows (other than side mirrors), rather than the roadway behind the car, which is now the direction of travel.		
-1	Unknown	Unknown type (secondary task present)	Subject vehicle driver is clearly distracted from the driving task, but the specific distraction is unknown.		Driver is first clearly distracted from the driving task (specific distraction is unknown or not listed).	Driver behavior fits into another category or there is no longer any evidence of distraction.
-1	Unknown	Unknown	Cannot determine whether the subject vehicle driver is engaged in a secondary task due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.		

1. Same start and end point for phone-related tasks. Each cell phone subtask is tagged using the same start and end points. Later analysis will decide on how break down subtasks. Note the different start/end points for hands-free.
2. Starting call is easier. Ending call is a challenge if no manual action. End of conversation could be difficult to identify if followed by immediate conversation with passenger.
3. Same start and end point for phone related tasks. Each cell phone subtask is tagged using the same start and end points. Later analysis will decide on how break down subtasks. Note the different start/end points for hands-free.
4. Can this be reliably distinguished from texting? Cases will be reviewed.
5. Same start and end point for phone related tasks. Each cell phone subtask is tagged using the same start and end points. Later analysis will decide on how break down subtasks. Note the different start/end points for hands-free.
6. Eating and drinking-related tasks have common start points and end points. Chewing only does not count as a secondary task e.g. chewing gum
7. Smoking-related tasks have common start points and end points.
8. Personal grooming actions share a common definition
9. Definition of start and end will be reviewed based on the number and type of cases we see i.e. to drivers typically pick up the reading material
10. Low expectation that this interaction will produce effects on driver performance. Possible availability of start-end points of interaction via CAN signal if approved (except Clio 3)

11. Limited interest due to difficulties to provide recommendations
12. Ask annotator to note what the object was. An additional part of the analysis could consider object type and location of the reaching action
13. Medium priority. Difficult to code, but considerable academic interest
14. Low priority because driver mouth opening and closing is not specific to singing
15. Low priority because hard to contribution to recommendations to EC
16. Not considered personal grooming, low interest

1.7.2 Secondary Task 1, 2, 3, 4, 5 Start

Description:

The time at which the driver began to engage in the secondary task (see secondary task table above)

This is a specific integer value for the video timestamp in milliseconds from the start of the file.

Variable Type:

Integer

Input Type:

Insert time

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Secondary Task 1 Start Time

1.7.3 Secondary Task 1, 2, 3, 4, 5 End

Description:

The time at which the driver disengaged from the secondary task or the driver's attention returned to the driving task or another activity (see secondary task table above)

This is a specific integer value for the video timestamp in milliseconds from the start of the file.

Variable Type:

Integer

Input Type:

Insert time

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Secondary Task 1 Start End

1.7.4 Visual behavior of the SV - vehicle oriented

Variable Definition:

Areas of interest towards which gaze is directed, coded over time

The assigned area of interest should include video frames that capture transitions towards that area of interest. The variable also covers eye closures.

Variable Type:

Categorical/ Time series

Input Type:

Single choice over time

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

VTTI Eye glance location (MASK Validation Static/ Dynamic Eye Glance)

Category	Definition	Example and Hints
Transition	This category should be coded if it is visible a transition between two other categories (e.g. passing from “Forward” to “Right”).	
Forward	Any glance out the straight forward windshield. Note that when the vehicle is turning, these glances may not be	

	directed straight forward but towards the vehicle's heading. Note also that 'forward' glances may be directed to vehicles ahead in the adjacent lane or other external distractions slightly ahead of the subject.	
Left Forward	Any glance out the left forward windshield.	
Right Forward	Any glance out the right forward windshield.	
Instrument Cluster	Any glance to the instrument cluster underneath the dashboard. This includes glances to the speedometer, control stalks, and steering wheel.	
Rear View Mirror	Any glance to the rear view mirror or equipment located around it.	
Up		
Forward Up		
Right Forward Up		
Left Forward Up		
Ceiling		
Left		
Left Window		
Left Mirror		
Right		
Right Window	Any glance to the right side window.	
Right Mirror	Any glance to the right side mirror.	
Down		
Center Stack	Any glance to the vehicle's center stack.	
Steering Wheel		
Nomadic device	Any glance at a nomadic device, no matter where it is located.	
Interior Object	Any glance to an identifiable object in the vehicle other than a nomadic device. These objects include personal items brought in by the participant (e.g., purse, food, papers), any part of their body that may look at (e.g., hand, ends of hair), and	

	also OEM installed devices that don't fall into other categories (e.g., door lock, window and seat controls). Glances to the center console (cup-holder area between passenger seat and driver seat) will also be included in this category.	
Passenger or Passenger Seat		
Checking blind spots	Any glance over the shoulder checking blind spots.	
Rear Seat		
Eyes Closed	Driver's eyes closed.	
Eyes Covered	If eyes are covered by e.g. hand so that the driver's vision is obstructed, does not refer to whether eyes are visible in camera or not.	
Unknown		
Not applicable		

1.7.5 Turn Direction Blind Spot Checked

Variable Definition:

Indication whether the driver checks his/her blind spot when making a right turn on an urban intersection (UK: left turn).

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No, but sleepiness part of Driver Behavior and Driver Impairment

Category	Definition	Example and Hints

Yes	Driver checks his/her blind spot when making a right turn on an urban intersection (UK: left turn).	
No	Driver does not check his/her blind spot when making a right turn on an urban intersection (UK: left turn).	
Unknown	Cannot determine	

1.7.6 Driver Drowsiness

Variable Definition:

Observer's rating of drowsiness state of the drive

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No, but sleepiness part of Driver Behavior and Driver Impairment

Category	Definition	Example and Hints
Alert	Driver is alert.	No signs of drowsiness (see below).
Possibly drowsy	Driver might be drowsy.	Occasional long blinks, some yawning, posture changes.
Clearly drowsy	Driver clearly drowsy.	Micro sleep, half-closed eyes, yawns, frequent posture changes, head nods.
Unknown	Cannot determine driver drowsiness.	

1.7.7 Driver Impairment

Variable Definition:

Observer's rating of driver’s impairment

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Driver Impairment (Multiple choice: possible reasons for the observed driver behavior(s), judgment, or driving ability as e.g. drowsiness, drugs, medication, and alcohol, emotional state but even wheelchair)

Category	Definition	Example and Hints
Obviously impaired	Obviously impaired, please provide an explanation under 'Narrative'	Can be obviously drunk, stoned, exceptional angry or sad (crying). But even if obvious physically handicapped.
No obvious impairment	No obvious impairment	
Unknown	Cannot determine the driver impairment	

1.7.8 Hands on Wheel

Variable Definition:

A description of how many and/or which hands the driver had on the steering wheel at the start of the evasive maneuver some part of the hand must be touching the wheel).

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

SCE, baseline

Coded by:

Central annotation

Related VTTI Variable:

Hands on the Wheel (VTTI phrase definition: '... on the steering wheel (or handlebars for motorcycles)'

Category	Definition	Example and Hints
None	Subject vehicle driver was not touching the steering wheel with any part of the body at the start of the Precipitating Event.	
None - Knees	Subject vehicle driver was not touching the steering wheel with either hand/arm at the start of the Precipitating Event, but was attempting to maintain steering control with knees or other body part other than hands or arms.	
Left hand off at least	Subject vehicle driver was not touching the steering wheel with the left hand/arm at the start of the Precipitating Event, and the location of the right hand/arm is unknown.	
Left hand only	Subject vehicle driver was touching the steering wheel with the left hand/arm only at the start of the Precipitating Event.	
Left hand at least	Subject vehicle driver was touching the steering wheel with the left hand/arm at the start of the Precipitating Event, and the location of the right hand/arm is not known (may or may not be on wheel).	
Both hands	Subject vehicle driver was touching the steering wheel with both the right and left hands/arms at the start of the Precipitating Event.	
Right hand at least	Subject vehicle driver was touching the steering wheel with the right hand/arm at the start of the Precipitating Event, and the location of the left hand/arm is not known (may or may not be on wheel).	
Right hand only	Subject vehicle driver was touching the steering wheel with the right hand/arm only at the start of the Precipitating Event.	
Right hand off at least	Subject vehicle driver was not touching the steering wheel with the right hand/arm at the start of the Precipitating Event, and the location of the left hand/arm is unknown.	
Unknown	Cannot determine the location of any hands or arms due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.7.9 Driver's Seatbelt

Variable Definition:

Driver's use of seatbelt

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

Driver Seatbelt Use, expanded by 3 categories (lap only, shoulder only, other)

Category	Definition	Example and Hints
Lap/shoulder belt properly worn	The subject vehicle driver is properly restrained by a lap/shoulder belt combination at the time of the Precipitating Event.	
Lap/shoulder belt NOT properly worn	The subject vehicle driver is improperly restrained by a lap/shoulder belt combination at the time of the Precipitating Event. Driver may have lap belt on and shoulder belt behind back or looped under arm.	
Other	The subject vehicle driver uses a racing seatbelt or other types of seatbelts.	
None used	The subject vehicle driver does not appear to be using any form of seatbelt at the time of the Precipitating Event.	
Unknown if used	Cannot determine the driver's seatbelt use at the time of the Precipitating Event due to limitations in video views, lighting, visual obstructions, or limited perspective.2	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.
Not Applicable	There is no driver.	

1.8 Passenger-related Variables

Passenger - related variables will be coded for all events regardless if SCEs, baselines/ controls or position-based events.

1.8.1 Number of passengers

Variable Definition:

The number of passengers (human occupants) in the vehicle at the time of the event

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

2 variables: Front seat passengers and Rear seat passenger

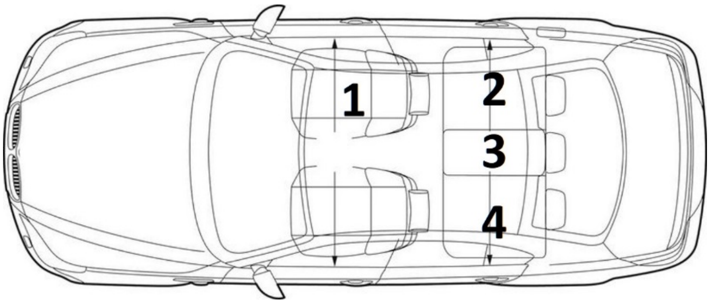
Category	Definition	Example and Hints
0		
1		
2		
3		
4		
5+		
Unknown		

1.8.2 Passenger 1,2,3,4 Age

Variable Definition:

Observer's estimation of the age of passengers

Please number the passenger according to the figure below (mirrored numbering for vehicles with right-hand drive):



Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

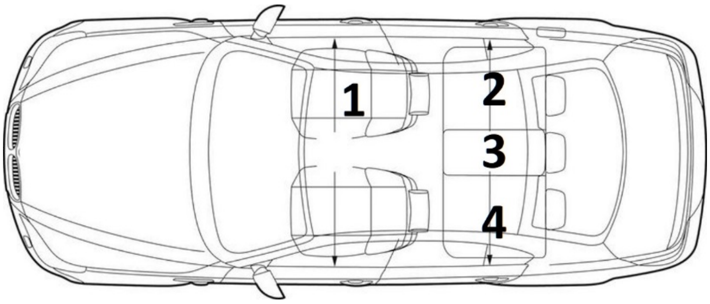
Category	Definition	Example and Hints
Infant	0-1 year old	
Child	1-12 years old	
Teenager	13 – 19 years old	
Young adult	20 - 29 years old	
Adult	30 – 64 years old	
Elderly	65+ years old	
Unknown	Cannot determine passenger’s age	
Not applicable	No passenger	

1.8.3 Passenger 1,2,3,4 Gender

Variable Definition:

Observer's assessment of the gender of passengers

Please number the passenger according to the figure below (mirrored numbering for vehicles with right-hand drive):



Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	**Definition**	**Example and Hints**
Female	Obviously female	
Male	Obviously male	
Unknown	Unsure of gender	

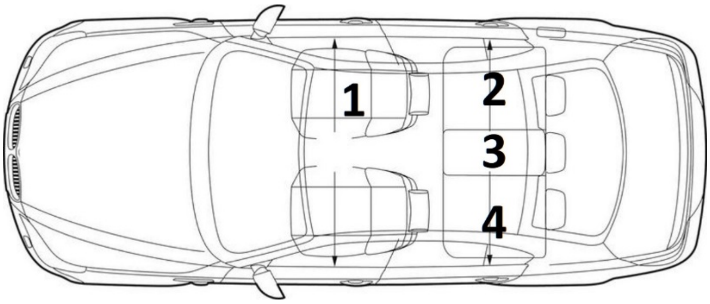
1.8.4 Seatbelt Passenger 1,2,3,4

Variable Definition:

Passenger’s use of seatbelt at the time of the start of the precipitating event

If video is available, information from events not at the time of the precipitating event may clarify whether seatbelt is in use.

Please number the passenger according to the figure below (mirrored numbering for vehicles with right-hand drive):



Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No, but compare to driver's seatbelt

Category	Definition	Example and Hints
Lap/shoulder belt properly worn	The passenger is properly restrained by a lap/shoulder belt combination at the time of the Precipitating Event.	
Lap/shoulder belt NOT properly worn	The passenger is improperly restrained by a lap/shoulder belt combination at the time of the Precipitating Event. Passenger may have lap belt on and shoulder belt behind back or looped under arm.	
Lap only		
Shoulder only		
Other	The passenger uses a racing seatbelt or other types of seatbelts.	
None used	The passenger does not appear to be using any form of seatbelt at the time of the Precipitating Event.	
Unknown if used	Cannot determine the passenger's seatbelt use at the time of the Precipitating Event due to limitations in video views, lighting, visual obstructions, or limited perspective.2	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

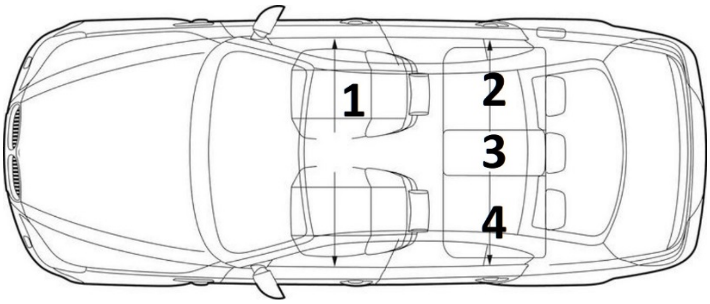
Not Applicable	There is no passenger.	

1.8.5 Child Seat 1,2,3,4

Variable Definition:

Use of child seats in case one or more passenger are children.

Please number the position of child seats according to the figure below (mirrored numbering for vehicles with right-hand drive):



Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
Rear Facing Child Seat	Child safety seats (sometimes referred to as an infant safety seat, a child restraint system, a restraining car seat, or ambiguously as car seats) are seats designed specifically to protect children from injury or death during collisions. Child is sitting rear facing in the car.	
Front Facing Child Seat	Child safety seats (sometimes referred to as an infant safety seat, a child restraint system, a restraining car seat, or ambiguously as car seats) are seats designed specifically to protect children from injury or death during collisions. Child is sitting front facing in the car.	

Booster Seat	A booster seat is a seat cushion that is used to elevate children in cars so that the seat belt fits better. In general most booster seats are used for children who are between four and twelve years of age and between 100 and 150 cm tall.	 or 
None	Child is not using any of the above.	
On lap	Child is sitting on a passengers lap either belted or unbelted.	
Unknown	Cannot determine the use of child seats due to limitations in video views, lighting, visual obstructions, or limited perspective.	Ex. Part of the video is missing or there is insufficient information in the video to make a determination.

1.9 VRU – related Variables

VRU - related variables will be coded for all events where conflict/interaction partner is a VRUs.

1.9.1 VRU 1,2,3,4 Type

Variable Definition:

Specifies whether the identified (groups of) VRUs are (combinations of) pedestrians, cyclists, or powered two-wheelers. Note that people moving with skateboard/longboards, segways, inline skates, wheelchairs and mobility scooters count as pedestrians.

In case of VRU groups: if the VRU type cannot be established for some of the group members, then select the category that captures at least half of the identified VRU types. If the VRU type cannot be established for less than half of the group members, then select 'unknown'.

If 5 or more (groups of) VRUs are present, then only describe the four (groups of) VRUs with the closest temporal proximity to the SV.

Note that pets/animals do not count as VRUs. Therefore, a pedestrian who is walking his/her dog is counted as one pedestrian (i.e., no group).

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

all

Coded by:

Central annotation

Related VTTI Variable:

No

Category	**Definition**	**Example and Hints**
Pedestrian	One pedestrian.	
Cyclist	One cyclist.	
PTW	One powered two-wheeler.	
Group pedestrians	A group of 2 or more pedestrians.	
Group cyclists	A group of 2 or more cyclists.	

Group PTW	A group of 2 or more powered two-wheelers.	
Mix ped cyc	A group of 2 or more VRUs with a mixture of pedestrians and cyclists.	
Mix ped PTW	A group of 2 or more VRUs with a mixture of pedestrians and powered two-wheelers.	
Mix cyc PTW	A group of 2 or more VRUs with a mixture of cyclists and powered two-wheelers.	
Mix ped cyc PTW	A group of 3 or more VRUs with a mixture of pedestrians, cyclists, and powered two-wheelers (i.e., consisting of all VRU types).	
Two-wheeler unknown	It is not possible to identify whether the VRU is a cyclist or a powered two-wheeler.	
Unknown	It is not possible to establish the nature of the VRU.	

1.9.2 VRU 1,2,3,4 Age

Variable Definition:

Observer's estimation of the age of VRUs.

In case of VRU groups: if the VRU age cannot be established for some of the group members, then select the category that captures at least half of the identified VRU ages. If the VRU age cannot be established for less than half of the group members, then select 'unknown'.

If 5 or more (groups of) VRUs are present, then only describe the four (groups of) VRUs with the closest temporal proximity to the SV.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
Child	0-12 years old.	

Teenager	13-18 years old.	
Adult	19-69 years old.	
Elderly	70+ years old.	
Group children	All group members are children.	
Group teenagers	All group members are teenagers.	
Group adults	All group members are adults.	
Group elderly	All group members are elderly.	
Mix children teenagers	A mixture of children and teenagers.	
Mix children adults	A mixture of children and adults.	
Mix children elderly	A mixture of children and elderly.	
Mix teenagers adults	A mixture of teenagers and adults.	
Mix teenagers elderly	A mixture of teenagers and elderly.	
Mix adults elderly	A mixture of adults and elderly.	
Mix children teenagers adults	A mixture of children, teenagers, and adults.	
Mix children teenagers elderly	A mixture of children, teenagers, and elderly.	
Mix teenagers adults elderly	A mix of teenagers, adults, and elderly.	
Mix all ages	A mixture of children, teenagers, adults, and elderly.	
Unknown	Cannot determine VRUs age	

1.9.3 VRU 1,2,3,4 Gender

Variable Definition:

Observer's assessment of the gender of VRUs.

If 5 or more (groups of) VRUs are present, then only describe the four (groups of) VRUs with the closest temporal proximity to the SV.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
Female	Obviously female(s)	
Male	Obviously male(s)	
Mixed group	The group of VRUs obviously contains one or more females and one or more males.	
Unknown	Unsure of gender(s)	

1.9.4 VRU 1,2,3,4 Secondary task

Variable Definition:

Observable VRU engagement in any of the listed secondary tasks, beginning at any point during the event. Note that there is no lower limit for task duration. Multiple options are possible (e.g., listening music AND texting). In case of VRU groups, select any secondary task that applies.

Variable Type:

Categorical

Input Type:

Multiple choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	Definition	Example and Hints
No secondary tasks	The VRU is not engaged in any observable secondary tasks and is attentive to the traffic situation.	

Manual interaction	The VRU is operating mobile phone or other electronic device with his/her hand(s).	Texting, browsing, dialing
Calling	The VRU is engaged in a mobile phone conversation.	The mobile phone is held to the ear of the VRU.
Talking	The VRU is engaged in a conversation with another road user (phone calls excluded).	
Listening	The VRU is listening to music.	The VRU is wearing headphones.
Smoking	The VRU is smoking a cigarette.	
Other	The VRU is engaged in secondary task behavior not listed here.	
Unknown	The VRU is engaged in secondary task behavior, but it is not possible to establish the nature of such behavior.	

1.9.5 VRU 1,2,3,4 Impairment

Variable Definition:

Observer's rating of VRU’s impairment. In case of a group of VRUs, select ‘obviously impaired’ if this is true for at least one VRU.

Variable Type:

Categorical

Input Type:

Single choice from list

Coded for:

All

Coded by:

Central annotation

Related VTTI Variable:

No

Category	**Definition**	**Example and Hints**
Obviously impaired	Obviously impaired, please provide an explanation under ‘Narrative’	Can be obviously drunk, stoned, exceptional angry or sad (crying). Can be carrying goods, which means not all hands can be used to control the bicycle or PTW. Can also be physically handicapped.
No obvious impairment	No obvious impairment	

Unknown	Cannot determine the VRU's impairment	

1.10 Additional Information

1.10.1 Narrative

Variable Definition:

A short, open-ended description of the event

This variable provides context and descriptions in sufficient detail so as to fill any gaps in reconstructing the event if video were not available. It should always be clear in the written narrative which vehicle is the subject vehicle (SV, Vehicle 1, V1, or "subject vehicle") and which are the other vehicle(s) (POV or Vehicle 2/3).

The narrative includes the following:

1. A description of the most relevant aspects of the environment and traffic dynamics prior to the crash,

2. A description of the sequence of events, focusing in particular on discrepancies between the subject vehicle driver's activity/state (e.g., driver expectations, eyes off road, impairment) and the environmental context (e.g., the driver looks away while the lead vehicle brakes), and

3. Any other relevant aspects that are not covered by other variables.

For Baselines, this variable is "Additional Notes", only completed when additional information is needed that was not captured in the previous variables.

Could include items such as:

- Comment on adaptive behavior: information (comments) specific to observed adaptive behavior by the driver. No specific format. Optional
- Comments on the secondary task: information (comments) specific to observed secondary task behavior by the driver. No specific format. Optional

Variable Type:

Text

Input Type:

Text

Coded for:

SCE, baseline

Coded by:

Central annotation

Related VTTI Variable:

Final Narrative/Additional Comment

1.10.2 Exclusion

Variable Definition:

If there are something that warrant the exclusion of this secondary task (or a whole trip) from analysis, this variable is annotated, with the reason why stated in the "Exclusion reason".

Variable Type:

Categorical

Input Type:

Single choice

Coded for:

Secondary task "events" that are to be excluded from analysis.

Coded by:

Central and/or local annotation

Related VTTI Variable:

-

Category	Definition	Example and Hints
Include		
Camera issues		
Other		

1.10.3 Comment on exclusion

Variable Definition:

This is a text input where an annotator should add information about exclusion reasons (for trip or secondary tasks). Mandatory if the "exclusion" variable is set to other

Variable Type:

Text

Input Type:

Text

Coded for:

Secondary task "events". Optional

Coded by:

Central and/or loca annotation

Related VTTI Variable:

No

1.11 Automated extraction of context

The following descibe the variables that we (likely) will be able to extract automatically from the video, for use as contectual variables in the analysis of secondary tasks.

1.11.1 In curve with radii

Variable Definition:

Extraction of curves of different radii using time-series CAN (and other sensor data).

Variable Type:

Categorical as time-series

Input Type:

Automatically extracted with initial manual verification

Coded for:

All trips, all data

Coded by:

Automatically through algorithms implemented by WP43 partners

Related VTTI Variable:

No

WP43 specifics:

This is a WP43 unique variable

Algorithms:

TBD (using speed, yaw rate and lateral acceleration)

From Emme T paper

"The *driving* variable was used to categorize both the local road environment and the drivers' movements in relation to it. Road segments away from intersections were divided into three groups depending on curve radius (R < 500 m, R = 500–1000 m, R > 1000 m). A curve radius larger than 1,000 m was considered a straight road segment. To quantify each curve's radius, analysts used a combination of forward video, GPS, maps[1] and curve radius estimation based on yaw rate, according to Eq. (1).

$R_{CURVE}=V_{CAR}/(\omega * \pi/180)$RCURVE=VCAR/ω* π/180

In Eq. (1), R_{CURVE} is the estimated curve radius (m), V_{CAR} is the car velocity (m/s), and ω is the yaw rate (deg/s)."

1.11.2 Overtaking

Variable Definition:

Extraction of overtaking events using time-series CAN (and other sensor data).

Variable Type:

Single choice as time-series (from start till stop of overtaking)

Input Type:

Automatically extracted with initial manual verification

Coded for:

All trips, all data

Coded by:

Automatically through algorithms implemented by WP43 partners

Related VTTI Variable:

No

WP43 specifics:

Synergies with WP4.2.4 (normal driving)

Algorithms:

TBD (using speed, yaw rate, lateral and longitudinal acceleration)

1.11.3 In intersection

Variable Definition:

Extraction of passing of intersections through the use of position (GPS) and MAP data.

Variable Type:

Categorical as time-series

Input Type:

Automatically extracted with initial manual verification

Coded for:

All trips, all data

Coded by:

Automatically through algorithms implemented by WP43 partners

Related VTTI Variable:

No

WP43 specifics:

Get from WP4.5?

Algorithms:

TBD (using GPS and MAP data)

1.11.4 Turning

Variable Definition:

Extraction of turning in intersections (right/left) though the application of algorithms on time-series data from CAN and other data sources.

Variable Type:

Categorical as time-series (left/right)

Input Type:

Automatically extracted with initial manual verification

Coded for:

All trips, all data

Coded by:

Automatically through algorithms implemented by WP43 partners

Related VTTI Variable:

No

WP43 specifics:

Get from SWOV/WP4.5?

Algorithms:

TBD: using A) yaw rate, heading and speed, and B) GPS and MAP data.

1.11.5 Lead vehicle present

Variable Definition:

Extraction of car following (and the opposite: free driving) through the application of algorithms on time-series data from CAN and other data sources.

Variable Type:

Categorical as time-series (free flow (no-lead vehicle) and different categories of THW)

Input Type:

Automatically extracted with initial manual verification

Coded for:

All trips, all data

Coded by:

Automatically through algorithms implemented by WP43 partners

Related VTTI Variable:

No

WP43 specifics:

This is a WP43 unique variable. Note that MobilEye is best at short distances. This may produce bias in wrongly classifying lead-vehicle presence as free-flow. This is particularly problematic at higher speeds (where THW means larger ranges).

Algorithms:

TBD: using MobilEye data. Proposal of categories:

- Below 1.0 s
- Below 1.5s
- Between 1.5 and 2.0s
- Between 2.0 and 3.0s
- Between 3.0 and 4.0s
- Greater than 4s as free flow (preferably we should also have 4-5 s, but this is likely not possible given MobilEye performance. Even 3-4 seconds is likely difficult (especially at higher speeds)

  “The variable lead vehicle present was categorized as a binary variable (i.e., yes, no). A lead vehicle was considered present if it was traveling in the same lane and within 150 m of the subject vehicle. Car-following was coded using the forward camera view, and the forward radar measured the distance to the vehicle ahead.” (From Emma T paper)

1.11.6 Oncoming vehicle present

Variable Definition:

Extraction of information on if oncoming vehicles are present. Through the application of algorithms on time-series data from CAN and other data sources.

Variable Type:

Categorical as time-series (free flow (no-lead vehicle) and different categories of THW)

Input Type:

Automatically extracted with initial manual verification

Coded for:

All trips, all data

Coded by:

Automatically through algorithms implemented by WP43 partners

Related VTTI Variable:

No

WP43 specifics:

This is a WP43 unique variable. Note that MobilEye is best at short distances. This may produce bias in wrongly classifying oncoming vehicle as free-flow. This is particularly problematic at higher speeds (where THW means larger ranges).

Algorithms:

TBD: using MobilEye data.

“The variable oncoming vehicle present was categorized as a binary variable (i.e., yes, no), and coded to identify situations when one or more vehicles were approaching the subject car from the opposite direction. An oncoming vehicle was only considered present if all of the following conditions were met: (a) it was visible in the front view camera, (b) it was less than 3 s away from passing the subject car, and (c) the road did not have a median barrier “ (From Emma T paper)

1.11.7 Lane width

Variable Definition:

Extraction of different lane widths though the application of algorithms on MobilEye data.

Variable Type:

Categorical as time-series

Input Type:

Automatically extracted with initial manual verification

Coded for:

All trips, all data

Coded by:

Automatically through algorithms implemented by WP43 partners

Related VTTI Variable:

No

WP43 specifics:

This is a WP43 unique variable, possibly synergies with WP4.2.4

Algorithms:

TBD: using MobilEye lane position information.

1.11.8 Traffic density

Variable Definition:

Extraction of different levels of traffic density through the application of algorithms on time-series data from MobilEye

Variable Type:

Categorical as time-series

Input Type:

Automatically extracted with initial manual verification

Coded for:

All trips, all data

Coded by:

Automatically through algorithms implemented by WP43 partners

Related VTTI Variable:

No

WP43 specifics:

Synergies with several other task, but specifically WP4.2.4

Algorithms:

TBD: transforming number of objects of MobilEye data into categories of traffic density.

Appendix C Review report template; checklist for reviewers

C.1 Overall judgment: readability, structure and format

		Yes	No	N/A
	Does the deliverable reflect the content described in the Description of Work?			
Comments				
	Is the deliverable sufficiently understandable: did you fully understand it (even if slightly off topic for you)?			
Comments				
	Does the deliverable include learning from mistakes/challenges encountered and does it stimulate to further research?			
Comments				
	Is the document template applied properly?			
Comments				
	Is the structure of the deliverable easy to follow? Do you suggest any changes to the structure to make the deliverable more accessible?			
Comments				
	Is the English in the deliverable good? Is it clear and accessible?			
Comments				
	Are the figures and tables understandable and refered to in the text?			
Comments				

C.2 Scientific judgment

		Yes	No	N/A
	Is the issue which is being researched clearly and simply stated?			
Comments				
	Are the objectives as described in the deliverable in line with the Description of Work (description of the Task)?			
Comments				
	Is the quality of the study design sufficient, are the methods/procedures as well as their actual application appropriate/correct?			
Comments				
	Do the results match the objectives as described in the Description of Work?			
Comments				
	How are the findings and results of the work described in the deliverable? Does the conclusion chapter reflect all described main important issues in the report and are the conclusion well based? Are the conclusions clearly stated? Are the conclusions relevant and applicable?			
Comments				
	Does the report include the relevant and necessary references? If relevant, is the			

	necessary wider view on the field of work properly given?			
Comments				
	Other comments			