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Bringing intelligent vehicles to the road

Deliverable D6.8

FOT Data

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Executive summary

There are three main steps (i.e., preparation, data collection, analysis) in the implementation of an FOT project. This document provides an overview of the results of the data collection step of the euroFOT project together with information regarding data access for third parties.

The document summarizes the information about the data gathered from three data sources, namely, vehicles sensors, video streams and questionnaires. The collected data has been processed, enriched, stored and analysed. The results of the comprehensive data analysis are described in other euroFOT deliverables.

The handling and use of FOT-data have to take into account ethical and legal constraints as well as IPR rights. The personal data includes both video, GPS and questionnaires. The vehicle data can be used to unveil and violate intellectual property rights. For example it may allow benchmarking since signals from comparable ADAS functions in different vehicle brands are collected. Therefore, general considerations on the use of data are discussed.

For further investigations e.g. as additional source of information inside a research project, part of the data can be accessed by third parties. The access procedure for third parties, as agreed upon by all project partners, is detailed. The third party submits a request for data access. The research proposal is reviewed by the data owners, access is granted after successful review. The researcher queries the database at the Vehicle Management Center (VMC) and extracts information. The information will be checked against the research proposal.

1 Introduction

The euroFOT project is a large-scale Field Operational Test (FOT) of in-vehicle Advanced Driver Assistance Systems (ADAS) performed on the roads of several European countries. Equipped vehicles have been used by ordinary drivers over more than one year in real world traffic conditions, and large amounts of data have been gathered by sensors, capturing driver and vehicle behaviour, as well as the driving context. These data enables us to analyse the impacts of ADAS on safety, efficiency and the environment, as well as the usability and acceptance of the systems by the users.

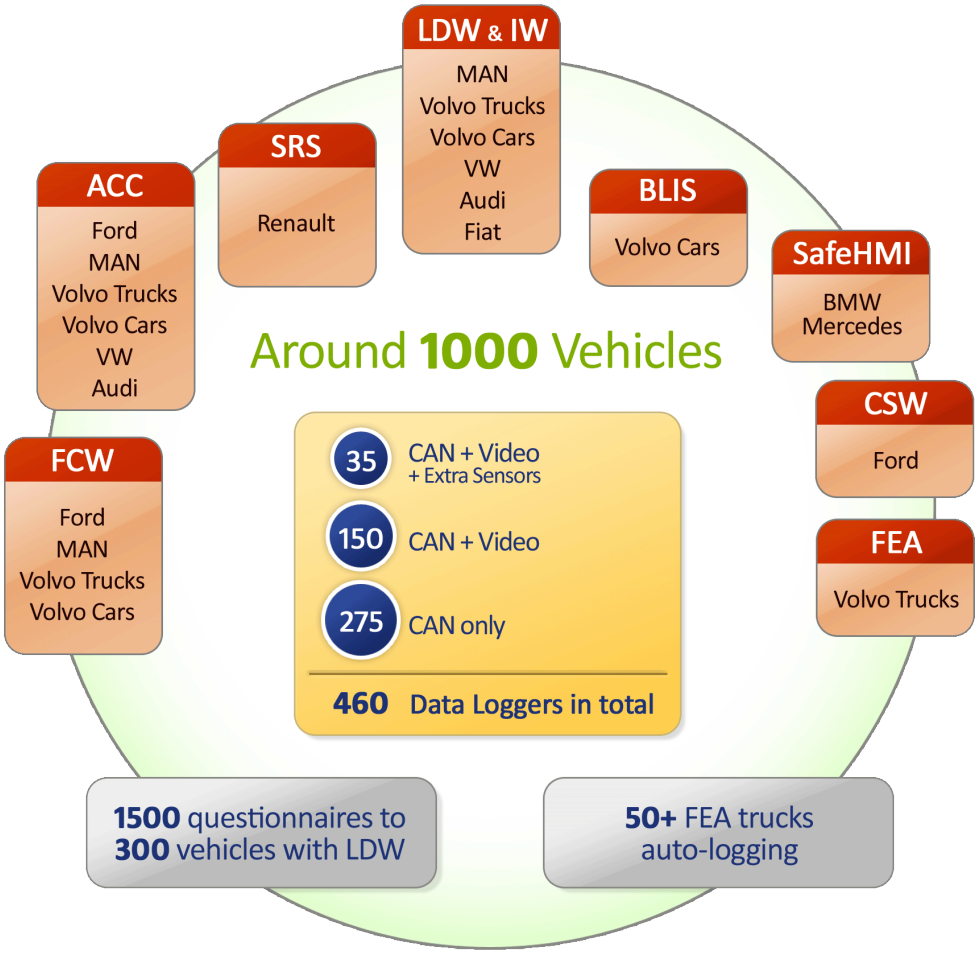


Figure 1: Functions selected for FOT and partners providing the function in their products.

The ADAS addressed by the evaluation are either commercial functions already available on the market, or sufficiently mature applications to allow the application of fully standard test procedures. For this purpose, series vehicles, produced by 8 European manufacturers, were instrumented with Data Acquisition Systems, able to continuously collect many aspects of vehicle performance and individual driving behaviour (e.g. by using CAN-data, video, GPS). In addition, questionnaires were handed out to gain a deeper insight into the driver's perception of ADAS.

Functions which are tested in euroFOT have been categorised into three groups (Figure 1):

- **Longitudinal:** Adaptive Cruise Control (ACC), Forward Collision Warning (FCW), Speed Regulation System (SRS)
- **Lateral:** Lane Departure Warning (LDW), Impairment Warning (IW), Blind Spot Information System (BLIS)

- **Others:** Safe Human-Machine-Interaction (SafeHMI; navigation system), Curve Speed Warning (CSW), Fuel Efficiency Advisor (FEA)

This deliverable provides an overview on the data that has been collected during the euroFOT project. The overall objective is to provide the readers with a starting point on how to get access to the data. Moreover, general considerations are presented regarding the usage of data. The document does not describe details on the content of individual collections of files, nor does it explain the different procedures applied for data analysis.

The general considerations regard the two categories of data acquired in the FOT. These are

- Subjective data from questionnaires and
- Objective data from sensors

A more detailed view on the collections of data, sensors and design parameters is given in the public deliverables from Subproject SP5 (Vehicle and Test Management) [3, 4, 5, 6].
A matrix listing all the measures planned in the euroFOT experimental design is reported in Deliverable D4.1 (as Annex 7) [8]; these measures are derived from a number of performance indicators needed for the planned analysis, and are linked to specific traffic events and situational variables. However, this list was regarded as a set of minimum measurements, and often additional variables have been acquired during the tests, for possible future studies.
The analysis of data is addressed in Subproject SP6 (Evaluation) and is described in several public final deliverables [7 and references therein].

The following chapter gives an overview of the collected data, chapter 3 discusses issues with the data. In chapter 4 the solution is given, which has been adopted in euroFOT to solve these issues.

2 FOT Data

This chapter gives information regarding the collected FOT-data. A closer look at the different types of data is appropriate to explain the many facets of data gathered during our Field Operational Test. One basic distinction is between raw data and data at different phases of processing.

Raw data

Raw data are both in-vehicles signals and signals from extra sensors and video cameras, collected from the vehicle during operation (objective data) and the questionnaires answered by the driver during the FOT (subjective data). Data are transferred from the vehicles to the storage system at dedicated servers wirelessly (e.g. through GPRS- or UMTS-services) or through direct upload, performed by operators who access or even exchange the physical storage media in the vehicles. The following categories of raw data are considered:

- CAN-signals derived from the vehicle internal bus, describing the state of in-vehicle systems; The time base and signal content (e.g. vehicle speed with a time stamp at a resolution of 100 milliseconds), is in the data format of the data logging device.
- Video recordings showing the driver, the foot of driver, the front and rear of the vehicle.
- GPS-signal, often in the form of NMEA-format denoting the geo-position of the vehicle.
- Additional sensor-signals, added for the FOT, e.g. eye tracker, external radar, navigation device-status messages, e.g. vehicle is driving, all systems are working.
- Questionnaires. Answers received on paper, web-based or telephone interviews.

Processed data

Raw data need to be converted into other formats to be used for further analysis by specific software routines. Extensive computation is also needed for data synchronisation, video encoding, creating derived measures (combining two or more signals) and data reduction (creating events for specific interest). During the pre-processing, the data is enriched with additional information such as road classification, weather, traffic load, etc. For subjective data, the paper based questionnaires are converted to digital form. For video data, a complex process is needed to extract and annotate situation data without looking at the full content in real-time.

2.1 Data logging

In euroFOT, the tests have been organised by four Vehicle Management Centres (VMCs). Table 1 indicates the number of vehicles logging the different types of objective data for each VMC.

Table 1: Overview of the number of vehicles collecting objective data at each VMC

VMC		Operation site	CAN	Video	Extra sensors	Eye tracker	GPS
French VMC		CEESAR	30+5	●	●(5)	●	●
German VMC	Operation Centre 1	FORD	98+2	-	● (2)	-	●
		MAN	56	-	-	-	●
		VW/AUDI	32	-	-	-	●
	Operation Centre 2	BMW	15	●	●	-	●
		DAG	15	●	●	-	●
Italian VMC		CRF	-	-	-	-	-
Swedish VMC		VOLVO	30+50	●	●	●	●
		VCC	100	●	●	●	●

During the project, extended piloting phases were needed for a good preparation and setting-up of the experiments, Moreover, the recruitment of drivers required a slow ramp-up for several practical reasons. Overall, the period covered by data collection is from 2009 (first piloting) till early 2012(last FOT vehicles decommissioned). The data which entered into the full analysis covers a shorter period, namely from February 2010 until August 2011. The data outside of this period is kept for subsequent analysis.

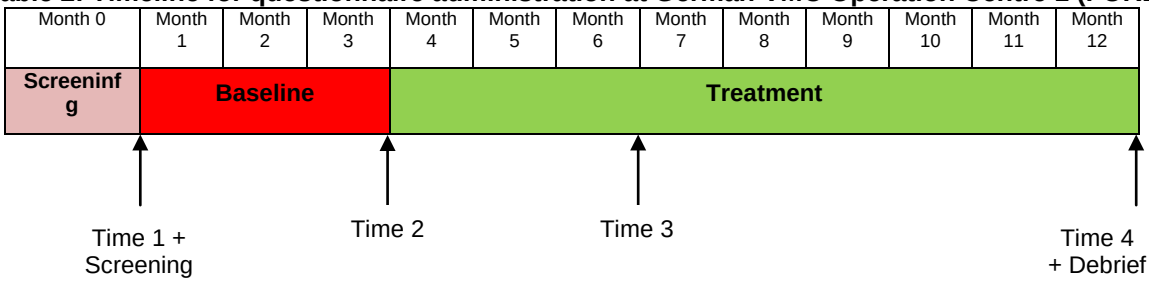
2.2 Questionnaires

Questionnaires have been designed in Subproject SP4 (Experimental procedures) and have been adapted for the functions to be tested. The administering of questionnaires has been handled by each VMC according to their design of experiment. An example of the delivery of questionnaires is given in Table 2:

- The screening questionnaire was sent together with the first questionnaire (at Time 1 or T1) to complete information already gathered through telephone.
- The second questionnaire (T2) was sent out when the baseline was finished (after three months in the FOT).
- The third questionnaire (T3) had to be filled in after three months in the treatment period.
- The fourth and last questionnaire (T4) was sent out after the participant had finished the FOT (after one year).

The questionnaires were filled-out either on paper forms, web based forms and telephone interviews. Questionnaire data has been transferred to collective lists and is included in the database.

Table 2: Timeline for questionnaire administration at German VMC Operation Centre 1 (FORD)



2.3 Storage and Maintenance of Data

The output of the pre-processing phase is uploaded into a database. The database consists of

- a collection of files, with variable dimensions from small to very large, since each file generally represents a single trip
- a structure to store the data, and
- software, which allows information retrieval with a standardized query language.

Any calculation and computation on the data uploaded into the database is considered as post-processing.

The use of a database greatly enhances the accessibility of data. Each VMC maintains its own database. Generating and operating a large database that contains as many aspects, e.g. drivers, trips, situations, hypotheses, performance indicators, and still maintains acceptable access-time, has been one of the distinct achievements inside the project. The size of the largest database is in the Terabyte range. Hence, to operate the database with acceptable response-time (minutes or hours instead of days), a network of servers and connected hard disk storage is necessary, as well as suitable maintenance of the system by operators.

The locations of the five databases are given in Table 3.

Table 3: Location of database for each VMC

	Partner	Full Name	City
France VMC	CEES	Centre Européen d'Etudes de Sécurité et d'Analyse des Risques	Nanterre/Paris
German VMC OC 1	IKA	RWTH Aachen Institut für Kraftfahr-wesen Aachen	Aachen
German VMC OC 2	IZVW	IZVW, Julius-Maximilians Universität Würzburg	Würzburg
Italian VMC	POLI	Politecnico di Torino	Torino
Swedish VMC	CHAL	Chalmers tekniska hogskola AB	Gothenburg

The data will be kept for one year after the end of the project maintaining a status, which allows access to part of the data. Access to the data, or publishing, will be detailed in the chapter 4.

Table 4: Storage size of information, kilometre and time driven, number of collected trips.

Vehicle Management Center	Total Mileage [km]	Mileage used for statistical data analysis [km]	Total hours of driving [h]	Type of Collected data
CEESAR (French VMC)	600.000	545.340	14.000	CAN and Video, CAN only
Ford (German 1 VMC)	2.030.000	1.490.000	61.844	CAN only
MAN (German 1 VMC)	7.500.000 (expected 10.000.000)	180.000	182.467	CAN only
VW (German 1 VMC)	300.000	130.000	6.315	CAN only
BMW (German 2 VMC)	383.392	330.049	6.021	CAN and video
Daimler (German 2 VMC)	629.870	610.858	9.108	CAN and video
Fiat (Italian VMC)	>8.000.000	8.000.000	194.632	Questionnaires only
VCC (Swedish VMC)	1.069.460	1.069.460	26.019	CAN and video
Volvo (Swedish VMC)	14.356.000	4.000.000	97.316	CAN and video
Total	**34.868.722**	**16.355.707**	**597.722**	

3 Considerations on the use of data

The euroFOT data has been and will continue to be a valuable source of information for several research topics, also for studies not foreseen when the project were outlined. Therefore, already at the beginning of the project, the interest of other researchers for using the euroFOT data has been high. This chapter details the use of the data for further analysis by third parties, i.e. parties which have not been a member of the project consortium, including the issues around the publication of data. Third parties are not bound by the limitations of use which have been stipulated in the Consortium Agreement and its amendments during the project. Three topics are the keys to understanding the sensitive nature of collected data, namely privacy, reengineering and benchmarking. We will explain the issues concerned and list the provisions stipulated in euroFOT to address these considerations.

Concerning privacy, video, geolocation and questionnaires data, as collected in an FOT with real drivers, represent personal data, and "personal data" is subject to European Directives (e.g. D95/46/EC [2]) as well as national laws. Data collection in FOTs, however, is not a frequent topic (there are very few instances of co-funded FOTs in Europe with publication of data), and without litigation there are no easy precedents which could serve as guiding rules. In the contract with the driver, though, each FOT-centre has stipulated that personal data will not be disclosed without permission of the driver.

Vehicle data indicating the speed of a vehicle, combined with geolocation and the digital map, can reveal actionable offences such as speeding or hit and run offences. With the knowledge of parking locations it is known with some detail where the driver has been and the time spent there. Even if the identity of a driver was removed the overnight location and working place could be used to identify a person by name.

Video data (showing the face and actions of the driver) are highly personal, especially as subjects forget after some days that they are under constant monitoring. The video data could be used to identify a person’s face through image processing on the internet. An example of unlawful behaviour would be to give access to an undisclosed number of persons to collected personal data on a publicly accessible website, when there is no agreement from the individual from whom this data is collected.

Methods to remove personal information from FOT-data exist, e.g. removing beginning and end of a trip (and decreasing the information content) or blurring faces in video-data (this is a very costly process when thousands of hours are involved). This option has not been considered, since it was not practical.

Reengineering is another issue. Messages from ADAS-functions form a basis for the analysis of the tests performed in euroFOT. The functions represent the result of expensive development and testing activities from suppliers and OEMs – activities that are their core competency. Through skilful analysis of many thousands of trips, the underlying algorithms (e.g. how to perform ACC) and the even more important fine-tuning and parameterization (how does it feel) can be measured and thus reengineered. Reengineering is a violation of Intellectual Property Rights.

Benchmarking is the comparison of properties of a function implemented by different brands (e.g. ACC, which many of the VMC are studying). Benchmarking is a favourite task of automotive journals and not a violation of IPR. However, the massive amount of data collected here would allow a more detailed and objective analysis than the comparison which is performed by a journal. Therefore, benchmarking has already been excluded in the Description of Work (DoW) of euroFOT.

The above considerations make it necessary to control access and the use of data. However, the singularity of the huge amount and complexity of data collected is a treasure for many studies to come in the next years. Access to the data for experts is necessary, especially where so many important indications could not be fully exploited.

4 Access to data

The considerations on the use of data have already been manifested in the DoW by limiting the public access to data, i.e. allowing access to "aggregated data" for one year after the end of the project euroFOT. Aggregation in the context of the DoW means that data is treated in a way that allows fundamental research without violating privacy and IPR and, which does not allow benchmarking. The process of aggregation, however, requires the development of new algorithms to remove personal information and brand related information while still retaining a sound content of information. In short, it implies a significant effort with a decrease in value.

A task force with project stakeholders (OEMs, suppliers, researchers, and legal counsel) has studied the feasibility and efforts needed to find a suitable process for data aggregation. The conclusion of the task force has been to altogether stop any efforts on data aggregation. A breakdown of efforts to balance four goals (ensure privacy, respect IPR, avoid benchmarking, maintain reasonable information content) showed, that the funds needed would not be justifiable to, at the foremost, artificially reduce the information content and to create a second body of minimal interest. The task force adopted a different procedure and included this in a 3rd amendment to the Consortium Agreement that has been signed by all project partners.

Instead of providing aggregated data on a public website for download for one year (i.e. publishing the data) the granting of access is now based on a research proposal that will be reviewed by owners of the data. Research proposal are addressed to the Management of euroFOT (see contact at www.eurofot-ip.eu). The accessible content, after successful review of the proposal, represents the large body of data that has been analysed to derive the results obtained in euroFOT. An exception has been made not to provide personal data, such as video and GPS position, as this would require the acceptance of all FOT participants. The site of access is at the site of the owner of the database and stored results can be extracted after their content has been reviewed and checked against the research proposal. All costs for the access - like training session, operator, and consumables - will be agreed upon before the analysis is started. The access to the data ends one year after end of project that is June 31, 2013.

Acknowledgements

We would like to thank the taskforce on "Data sharing" and the taskforce on "Data publication" which met during a busy year and half to clarify many issues regarding data inside euroFOT. In both working parties, lawyers and engineers explained, discussed and fine-tuned over many months the meaning of access rights, ownership and legal definitions. Their work resulted in two amendments to the Consortium Agreement.

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Annex 1 Glossary

ACC	Adaptive Cruise Control
ADAS	Advanced Driver Assistance System
BLIS	Blind Spot Information System
CAN	Controller Area Network
CSW	Curve Speed Warning
DAS	Data Acquisition System
Electronic Horizon	The summary of information available for the stretch of road the vehicle is driving on (now until seconds to minutes ahead)
DoW	Description of Work
FCW	Forward Collision Warning
FEA	Fuel Efficiency Advisor
FOT	Field Operational Test
GPRS	General Packet Radio Service
GPS	Global Positioning System
HMI	Human-Machine Interface
IPR	Intellectual Property Right
IW	Impairment Warning
LDW	Lane Departure Warning
NMEA	National Marine Electronics Association
OC	Operational Centre
OEM	Original Equipment Manufacturer
SRS	Speed regulation System
UMTS	Universal Mobile Telecommunications System
VMC	Vehicle Management Centre