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Assessing the impact of automated driving: needs, challenges and future directions

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Abstract

Automated driving in all its different forms is now underway and large European projects have been launched to investigate the effects in real life. Field Operational Tests are typically used to gather evidence to assess the impacts. The FESTA methodology was developed to design and conduct FOTs and analyse the outcomes. Currently the methodology is being updated to address the challenges of the upcoming pilots on road automation. The ultimate goal of performing automated driving studies is to gain insight into the impacts automation will have on transport and on society in general. In this paper we will explain how the series of FOT-Net (2008-2016) and the CARTRE (2016-2018) coordination and support actions address the development of a common methodology. Questions around the formulation of research questions, data analysis, user acceptance and impact assessment are addressed. One of the most important ways forward is the sharing of data, knowledge and experiences. Only by combining the knowledge sources will we be able to get a clearer picture of what the future impacts of road automation will be. FOT-Net has developed a data sharing framework and recommendations from this framework will be described.

Keywords: Automated driving, Field Operational Test, Impact assessment, user acceptance, evaluation methodology

Nomenclature

AD	Automated Driving
ADAS	Advanced Driver Support Systems
FOT	Field Operational Test
ITS	Intelligent Transport Systems

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1. Introduction

Automated driving (AD) in all its different forms is now underway and large European projects have been launched to investigate the effects in real life. Field Operational Tests (FOTs) are typically used to gather evidence to assess the impacts. However, it is not just the vehicle that is changing, transport itself is changing as a result of automation in many different areas. Automated vehicles will become part of transport as a service, where the service will provide door-to-door transport, not necessarily with one transport mode but where only part of the journey will be made by an automated vehicle and the rest by some other means, such as public transport or walking and cycling. This may mean that travel patterns will change. Also the ownership of cars may no longer be as important as it is today as car sharing may become far more popular. In freight transport new forms will also arise, such as freight sharing and new forms of last mile transport. All this will lead to new mobility needs and novel behaviours of people.

In order to investigate the potential consequences of large scale automation in transport, trials in real life conditions are necessary. Over the last decade large-scale Field Operational Tests have been conducted in order to study the effects of Intelligent Transport Systems (ITS) such as Nomadic Devices and Advanced Driver Assistance Systems (ADAS) and cooperative systems where there is communication between vehicles themselves and with the infrastructure. These FOTs, including also Naturalist Driving studies, have been developed in Europe often supported by the European Union (EU) Framework Programme for Research and Innovation as well as by national programmes. An extensive list of these activities is available on the FOT-NET wiki: more than one hundred European projects are reported there and an overview of several international initiatives (e.g. in USA and Japan) is also offered. These numbers highlight the relevance of FOTs to assess new ITS technology and to pave the way to its deployment.

Now we see the start of large scale FOTs and pilots on real roads. National programmes have been supported in several European countries. Relevant examples are the DAVI, Dutch Automated Vehicle Initiative, in the Netherlands, aiming at developing highly automated vehicles for research and demonstrations on public roads and the Nouvelle France Industrielle, in France, to support the testing of new autonomous vehicles.

In addition, several innovation projects have recently been launched targeting large scale automated driving trials: the Drive Me project, a collaborative research project involving public, private and academic interests, with more than 100 self-driving cars in the city of Gothenburg; the EU-funded L3PILOT (Piloting Automated Driving on European Roads) project focuses on large-scale piloting of SAE Level 3 functions, with additional assessment of some Level 4 functions, involving more than 1,000 test drivers and 100 vehicles in 11 European countries. Finally several projects will kick-off in the coming months in the framework of the H2020 2016-2017 ART (Automated Road Transport) targeting a wide range of research topics, including automated shuttles and truck platooning.

2. Impacts of automated driving

The ultimate goal of performing Automated Driving studies is to gain insight into the impacts automation will have on transport and on society in general. The impacts of (higher level) automated driving are manifold, complex and far-reaching. In addition to the intended impacts, automated driving will have some unintended (positive or negative), typically indirect impacts. Therefore, understanding the big picture and underlying relationships is important (Figure 1).

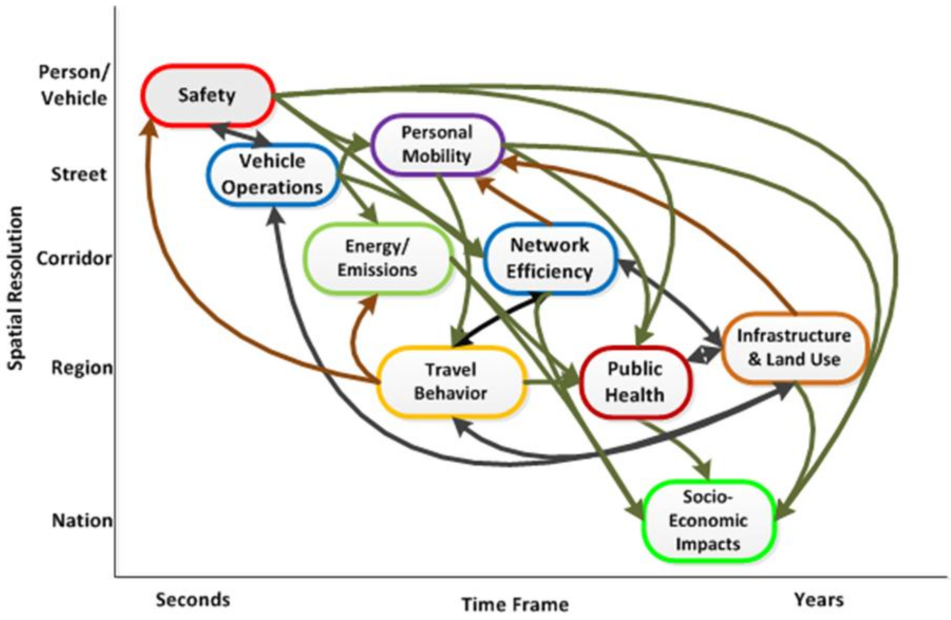

Fig. 1 Impact Areas (Innamaa et al., 2017)

The automated vehicles are introduced into a complex transport system, and the technology is changing very rapidly. There will be other factors affecting the system in addition to automation. These other factors include e.g. electrification and new mobility service models. Also, it will not be one single vehicle type that will be automatized. All kinds of vehicles will be involved: passenger cars, trucks, busses, etc. It will depend on policy goals and on the actions of several players in the transport field what the future of the transport system will look like. Studying the overall societal impacts for long periods ahead is therefore really challenging.

When studying systems like ADAS, the impact areas addressed were usually road safety, mobility, environment and efficiency. However, with automated driving, questions about new societal impacts become relevant, like land use, public health, socio-economic questions, accessibility, and equity. The socio-economic impact assessment can only be performed if the FOT follows a structured and scientifically based approach. However, it must be acknowledged that it will be impossible to study many indirect impacts in a short-term field test. New complementary research methods are therefore needed. Thus, there are many open questions on what effects should be studied, and how they can be investigated.

3. The main questions: policy, evidence and methodology

There are several questions we need to address in order to be able to study the impact of automation.

First there is the question of why we want to know, in other words, the **policy question**. Knowledge about impact is needed for a variety of stakeholders in order to be able to make decisions. Industry has to develop business plans and determine how these new technologies and services can best be deployed. Political decisions need to be taken: where do we invest, what do we subsidize, what do we allow, and what should be prohibited. And as we may expect large changes in transport, we need insight in how best to plan the future of our cities, roads, services, etc.

The next question is: when are we convinced about the likelihood of positive and negative aspects of automation? In order words: the **evidence question**. There are several answers to this. We could look at the user and societal acceptance. Is automation answering user needs and preferences, is the general public willing to adopt these new ways of transport and change their mobility? This is usually investigated by means of large-scale questionnaires. Also the press and user organisations like the automobile clubs play an important role in informing the public and sounding out the climate for this transition.

Another way of answering the question is by looking at the business side. Do industry business models predict profit, and are governments subsidizing technological development and implementation? As we see large investments these days, by industry, both car manufacturers and information technology companies, and several governments claiming they want to become world leaders in road automation, we may assume that there is quite some consensus concerning the economic benefits of road automation.

We could also ask for scientific evidence: can we find proof that the promises about, for example, improved safety and mobility can be realised? The FOTs and pilots that are now starting are meant to provide some of the answers by looking at the claims from a scientific and objective point of view, investigating in detail what is really happening. The European Commission in the H2020 program is investing in large-scale trials to obtain these answers.

The ultimate goal of performing AD studies is to gain insight into the impacts automation will have on transport and on society in general. This socio-economic impact assessment can only be performed if the study follows a structured and scientifically based approach. However, there are many open questions on what effects should be studied, and how they can be investigated while the technology is changing very rapidly, and the impacts are manifold and complex.

This brings us to the next question: how do we investigate the effects, in other words: the **methodology question**. There is a variety of methods available ranging from testing in laboratory conditions, with simulators, and trials on test-tracks, to virtual simulation and developing micro and macro simulation models. User questionnaires, surveys, and expert consultations are methods to capture more subjective data. In this paper we look specifically at trials in real-life conditions on the road by means of Field Operational Tests and pilots, and at the way in which these FOTs can be realised in the best way possible to answer impact questions.

4. Methodology for FOTs

In order to set-up and conduct FOTs, and to analyse the results and perform impact assessment, the FESTA methodology was developed, see Figure 2. In the European Commission funded FESTA project a common FOT methodology was developed (FESTA 2016, Barnard & Carsten, 2010), which is now widely used as the basis for the planning and execution of FOTs. Since the original FESTA project, the methodology has been maintained and updated by FOT-Net support actions (FOT-Net, FOT-Net 2 and FOT-Net Data) from 2008-2016. At the end of 2016 version 6 of the revised handbook was released. The scientific evidence based approach we discussed in the previous section forms the key principle of the FESTA methodology. It provides and advocates a systematic research-oriented approach to define and conduct FOTs, and analyse the results in order to assess the potential impacts of a wide introduction of Intelligent Transport Systems.

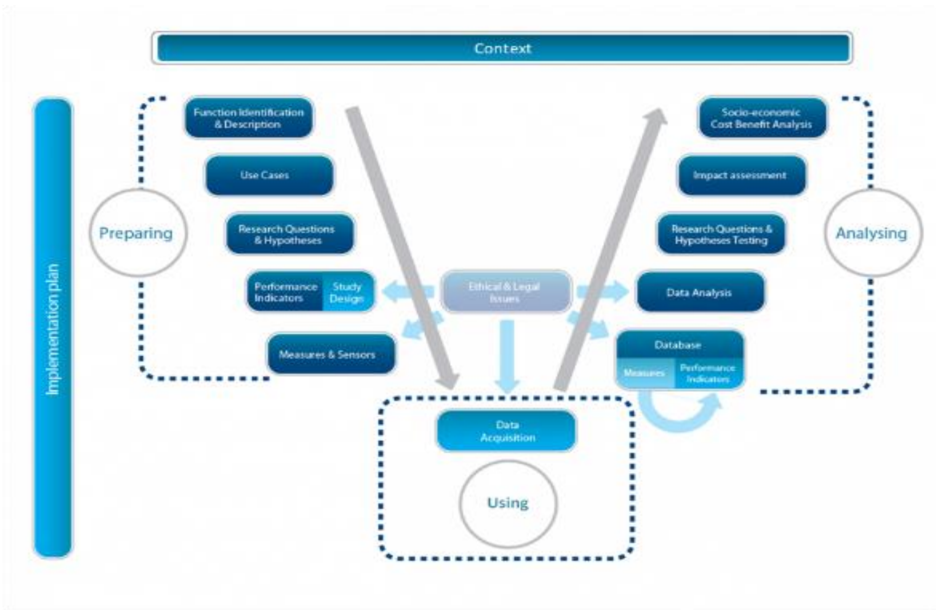

Fig. 2 The FESTA methodology

Currently work is under way to adapt the methodology to support FOTs on road automation. The CARTRE (2016-2018) coordination and support action continues to develop the methodology, and supports the transfer of knowledge and experience between projects.

A common methodology adopted by projects has major advantages, allowing for comparison of results between FOTs, and providing a common vocabulary, enhancing communication between a wide variety of people involved in FOTs. The methodology is not a rigid one, it is adaptable and kept alive by workshops in which experiences are exchanged. For automation studies a common methodology is even more important, as we are not only interested in the findings of individual projects, but in gaining knowledge about the wider impacts automation may have.

The FESTA methodology puts a strong emphasis on defining research questions and hypotheses, inspired by the traditional impact areas of safety, mobility, environment and efficiency. With the new developments, not only in technology but also in transport services, impact areas will be wider and sometimes new (e.g. land use), thereby multiplying the number of research questions that are of interest. Also, new research questions may arise during the study.

5. Areas for adaptation of the methodology and new directions

We will discuss four main areas in which the methodology will need to be adapted and in which new methods for evaluation are needed:

- Research questions
- Data acquisition and analysis
- User acceptance
- Impact assessment

5.1. Research questions

A lot of the research questions valid for the evaluation of ADAS systems are still valid for automated vehicles, such as how do the drivers behave, what are the incidents, when is the system activated (correctly or incorrectly), what are the effects on speed, emissions, etc.

New types of research question are now also being formulated, examples being:

- Can automated vehicles successfully become objects in the Internet of Things?
- What can we connect to automated vehicles?
- With Artificial Intelligence techniques, will we still be able to understand what the vehicle is doing?
- Questions around cybersecurity
- Questions around ethics
- What will people do when they do not have to take care of the driving?

In the FESTA methodology, the definition of research questions is an important step. Experience in projects has taught us that establishing the final research questions to be answered by the FOT is not an easy step. Time for discussion and iteration is needed to reach consensus. There usually are very many questions that stakeholders would like to have answered, but there are also limitations of time, resources, and technical possibilities of sensors and systems usually pose restrictions, so choices have to be made. As research questions are strongly related to impact areas, it is clear that limiting research questions may also mean that it will sometimes not be possible to address all impact areas. This will happen even more frequently as we augment the number of impact areas. For automation studies, FOTs will often be done with prototypes that are not fully developed. This could mean that research questions may also have to take into account what the consequences of future developments will be. For example, research questions about the environmental impacts of car emissions may not be very useful if it is foreseen that in the future the automated car will be electric. As the number of possible research questions may easily explode, it is necessary to think about issues that will play a role in the future, and that can be generalised for different types of automated vehicle. Questions, for example, about the interaction with other road users will be pertinent for many automated vehicles.

In Table 1, examples of research questions are given that were generated in a series of workshops in CARTRE. They are not related to a specific project, and concern several use cases, varying from lower levels of automation (where the driver is still supposed to be able to take over control) to automated trucks.

Table 1. Example research questions from CARTRE workshops

Impact area	Vehicle	Research questions
Safety	Automated passenger car, with driver involvement	Do people enable or disable automated driving, under what circumstances and why?
		Is the Automated Vehicle out of sync with what people consider “normal” behaviour and with their expectations? For example, is a shorter time-headway acceptable?
		How are the transitions, hand-over and take-over, handled? How much time does a transition take, including preparation?
		What do people do as their primary task in cars?
	Automated truck	Will the truck driver leave the driver’s seat? Is he allowed to do this?
	Automated passenger car	What are the effects of telling the user in advance what to expect (e.g. sharp curves that might cause motion sickness)?
Comfort	Automated passenger car	How much (and what kind of) information do people want in order to feel comfortable?
	Automated truck	What operation times are possible (driver needs to take a break from driving sooner or later)?
	Automated passenger car	Will the number and the length of journeys increase?
Mobility	Automated passenger car	Will the car be favoured over other transport modes? Short vs. long journeys?
		What is the effect at certain times of the day, e.g. peak hours, night time?
Economy	Automated truck	What is the price limit for additional technology for automation?
		Which kind of infrastructure (service provider) is necessary?
		Can the truck driver use freed-up time to do different work-related tasks?
Environment	Automated truck	What is the fuel consumption in real traffic (including surrounding traffic and changing infrastructure elements such as bridges, tunnels, construction sites)?

In order to answer research questions, we usually compare the old situation (without a system) – the baseline – with the new situation (with the system). However, for many automated scenarios it is difficult to understand what the baseline should be. Vehicles and scenarios that form a complete break with the old situation are hard to compare. Do we compare a fully automated car with a fully manually driven one, or with a car where the driver has to be vigilant and has to take over the driving in certain situations? What do we compare automated parking with? Manual parking? And if so, on what aspects?

5.2 Data acquisition and analysis

As new challenges arise to assess the impact of automated driving, the CARTRE project is working on gathering expertise on novel evaluation methods, such as visioning methods, scenario development, data mining, machine learning analysis techniques, automated video analysis, and anonymization to enable wide sharing of data, automated scenario detection, new ways of measuring user acceptance and behaviour, and performing stakeholder analyses.

The main challenge in data acquisition, data processing and data analysis is the establishment of automated processes. Automated driving requires a precise environmental detection and understanding, which is provided by different perception systems, communication and self localisation. This is realised by means of many different sensors. Depending on the sensor technology and the level of data processing within the sensor, the amount of data collected can be quite large. Additionally, driver monitoring and other services may be part of the automated driving experience. This causes constrains on data handling, management and processing. Data loggers are able to capture the different sensor signals (also different video streams) and store them in the vehicle. Data transfer from the vehicle to a dedicated database is to be established, and the data should be stored in the database in a structured way.

Due to the large amount of data manual analysis is not possible. Automated processes have to be implemented, which will provide analysis results without constant interaction with data analysts.

Data from FOTs may also be personally sensitive, specifically when video data are collected, but also GPS data on the position of the vehicle may reveal all kinds of personal details, like where participants live and work. Anonymization techniques are essential, and automated procedures are again needed to lighten the burden of having to look through large video files. Not only strict regulations on personal data are now in place in order to protect privacy, but anonymized data are also easier to share by more analysists at different locations and from different organisations. New and promising techniques are emerging but not all problems related to anonymization have been solved. The anonymization of driver faces is rather advanced, but the driving environment is more difficult, and anonymizing location and trajectories is still problematic (Barnard et al., 2016c).

The analysis of data from automated driving pilots or test drives is dependent on the research question and the evaluation methodology. Research questions range from human factors (take-over situations, change of automation level and driving mode, etc.) to operation safety (how safe is safe enough?). Therefore data analysis is manifold. Ideally the data is automatically classified into single driving scenarios, which can be further processed in terms of parameter analysis, correlation, etc.

The automated classification of scenarios needs a classifier in which each single scenario is defined. In simple environments (e.g. selected motorway tracks) such a classifier can be determined manually. In this case rules are derived from measurement data, tested and then applied to the classifier. Of course such a classifier is only capable to classify scenarios which are known beforehand. By means of machine learning techniques such classifiers can be trained in order to determine scenarios which have not been described in detail beforehand. This requires a large amount of training data, but allows scenario detection in large data sets and complicated scenarios.

Finally automated video analysis needs to be established. Automated vehicles produce large amounts of video data, which cannot be processed manually. This video data is used in order to test automated classifiers in random samples. In the future automated video analysis tools will be able to determine relevant information directly from the video data and thus provide another important source of data.

5.3 User acceptance

User acceptance is a very interesting topic in automation studies. In FOTs it was relatively easy, participants were driving for a relatively long period (sometimes many months) with a system in their car, so they got used to it and were able to form their own judgment on whether the system worked well for them. Using questionnaires, the users could be asked questions about their trust in the system, how easy it was to use, whether they would buy it themselves, and for how much money, etc., etc. With automation FOTs and pilots, we will usually not have this same situation. Regulations and ethical considerations often require a person from the (research) organisation that is responsible to be in the vehicle, being able to intervene when something goes wrong. Pilots may have the character of a demonstration where the user participants will only be in the vehicle for a short period. In FOTs on ADAS system users could easily compare the situation with and without the system. Automated driving may bring a whole new dimension to driving or maybe even being driven. The general public is not very aware of automation at this moment, so we cannot assume much previous knowledge from participants.

User acceptance is often measured by using a questionnaire based on Technology Acceptance Models (TAM). In these models the intention to use the technology is based on the perceived ease of use, perceived usefulness and attitudes towards the technology. There are many variations among these models, a unified view has been proposed by Venkatesh et al., 2003. Madigan et al. (2016) developed this unified model for evaluating user acceptance in the CITY Mobile project, where a small automated bus drove passengers in La Rochelle and Lausanne. They asked passengers about performance expectancy, effort expectancy, social influence, and behavioural intentions. Although the participants had experienced the bus, it is hard to draw conclusions for a longer exposure, such as using such a bus every day. A more fundamental problem with TAM is that it was developed for the use of technology. Although automated vehicles are a highly innovative technology, it is not clear whether people perceive it in the same way as they would a computer or an app on their mobile phone. Automated transport for users is transport in the first place. Low type technology such as an ordinary non-automated bus may evoke the kind of answers associated with the transport mode (it is easy/difficult to use the bus, too expensive, no-one in my family uses the bus etc.). TRL recently performed a study in the UK on a survey of 233 people interested in the current automation projects, measuring current attitudes to autonomous vehicles. 81% of respondents agree that 'driverless cars are a good idea' and 55% respond that they would trust a driverless vehicle (Hyde et al. 2017). Also in 2017, an AAA survey found that 75% of Americans reported feeling afraid to ride in a self-driving car. Schoettle and Sivak, M. (2014) did a survey in the US, the UK, and Australia, reporting positive opinions but also many concerns about self-driving cars.

These findings are, of course, very interesting, and these types of questionnaires are needed to verify the opinions of the general public, but we need more in-depth research to understand what automated driving would mean for ordinary road users, not only in the role of drivers, but in all citizen roles. Only when there is more substantial hands-on (or hands off the steering wheel) experience with automated road transport will we know more about the real acceptance, trust and potential adoption. In the meantime we will have to use and develop creative ways to measure user acceptance among a very wide range of people, taking into account different groups, also the less obvious ones like old people and children, people with no affinity or experience with modern technologies. General public awareness needs to be raised; often major news sources like quality papers and television news broadcasters (for example the BBC) classify news items on this subject under business, economy, science or technology; categories usually followed by a limited number of interested people. It would be very useful if we could develop visioning methods to allow people to project themselves in a future transport system, and to empower them to develop nuanced ideas, and be part of shaping their transport future.

We should also not only focus on attitudes and perceptions but also on user understanding. For example, Pampel et al, (2013) studied mental models of eco-driving, and this approach may also be used for studying mental models of driving automated vehicles. We should also devise ways in which to influence them if they are incorrect or insufficient.

5.4. Impact assessment

In assessing the impacts of Intelligent Transport Systems usually the findings from a FOT are scaled-up to the national or European or another regional level. This is already quite a complex process with many uncertainties. The basic assumption is that the effects found in the analysis will be the same for similar vehicles and or traffic situations. For example, we can calculate what would happen if every car (or a certain percentage of cars) had a speed control system, based on the effects found with the cars and the drivers in a FOT. However, with automation FOTs this is becoming very difficult. Automation comes in all kinds, and is developing very fast. In a few years' time the vehicles that are tested today may already have changed considerably. Traffic behaviour and mobility patterns may be very different depending on whether there are a few automated vehicles on the road or a large percentage. Cost benefits analysis is similarly complex and uncertain.

In order to be able to build future scenarios, to investigate different possible impacts, we need a strong multi- and inter- disciplinary approach to impact assessment, combining methods from different disciplines. Also more prospective methods are needed. For quantitative assessment, a large amount of realistic data is needed, but this is not always easy to obtain. Industrial competition is intense in the automation area, and data may be confidential.
In order to get a grip on the future of automation, roadmaps are being developed, such as the ERTRAC ((European Road Transport Research Advisory Council) roadmap (2017) in which development paths are provided for the different categories of vehicles.

Impact assessment requires stakeholder involvement from industry, public authorities, user associations and research organisations. A lot of new players are becoming involved in automated driving, such as IT industries that were not traditionally involved in car manufacturing, and start-ups developing completely novel types of vehicle. There will be new service providers for innovative transport services, for example 'people movers' (small automated busses), transport on demand and car sharing providers. User organisations representing people who had problems with normal driving, for example due to disabilities or age, may become interested in the opportunities automated driving will bring. Local authorities and city planners will be faced with new challenges. Impact assessment will have to start with a thorough stakeholder analysis, and needs to rely on the input and feedback from stakeholders.

6. Sharing of data, knowledge and experiences

One of the most important ways forward is the sharing of data, knowledge and experiences. Only by combining the knowledge sources will we be able to get a clearer picture of what the future impacts of road automation will be.

The sharing of data is essential for the development of automation services. It is also a topic with many issues to be solved, such as the inclusion of both competition- and privacy-sensitive data, the different legal and ethical conditions at locations where data is collected and analysed, and finally the cost of storage and provision of data. In the FOT-Net Data project, a data sharing framework was developed to address these issues (Gellerman et al., 2017). The Data Sharing Framework consists of seven areas, all essential for a smooth data sharing process:

- Project agreements set the pre-requisites and the borders for data sharing together with legal and ethical constraints (Gellerman & Svanberg 2016)
- Documented, valid data and metadata, including a recommendation for a “standard” description of the data
- Data protection requirements, both on the data provider and re-users´ analysis site, including security procedures (Gellerman, Svanberg & Kotiranta 2016, Barnard et al. 2016a)
- Security and personal integrity training content for all personnel involved
- Support and research functions, to facilitate the start-up of projects, offer research assistance and analysis tools
- Financial models to provide funding for the data to be maintained and made available, and access services
- Application procedures, including content of application form and data sharing agreement

If we follow this framework, a platform can be built on which data providers and automation services providers can meet and discuss which data can be provided under which conditions. It is important for the data to be open, meta-data comparable and adhering to standards, to provide a known interface to the data for the different re-users. During the last decade, the European FOT-Net projects have gathered stakeholders within the FOT community to exchange experience and knowledge gained during the many FOTs and pilots. This work is to be even more focused in the automated vehicle era, as the stakeholders have a stronger interdependence and therefore need to understand each other´s needs and provisions to create a resilient automated transport system. Knowledge and experience exchange apply to the testing of the automated vehicle according to the FESTA model, as well as the different impact assessments and how they contribute to the wider picture of what automation could imply, and where the pitfalls are. Moreover, not only have the stakeholders a stronger interdependence, there is also a wider range of stakeholders than in previous FOTs and pilots, as automation will affect the larger part of society. Different projects address specific parts of society, and by putting the results from each of these projects together we can build something from which we may all gain essential knowledge and start forming a vision of the automated future.

Automated vehicles cross borders, and to be able to have a seamless transport system international collaboration is a prerequisite. It is therefore essential to put efforts into community building, to create numerous opportunities for different stakeholders to meet and address the many challenging issues associated with an automated transport system.

7. Discussion

A final remark on the benefits of conducting FOTs. FOTs provide us with insights into how automated vehicles (and the drivers if they are involved) behave, and this is valuable input for assessing the impacts of the large scale introduction of automation in road transport. In this paper we have asked many questions about how best to design FOTs, how to analyse the data, and what we may learn from the results. Many questions remain open but we hope to have made a contribution in asking the right questions and having made a start on the way towards solutions.

However, a lot of work has been done in the past on the evaluation of driving with driver assistance systems and cooperative systems. This work provides us with valuable and detailed information on what is currently happening and on how people behave on the roads. One special type of FOT is Naturalistic Driving Studies (NDS). In these studies people drive for a long period (even years) with any additional technology to what they already have in their cars, and drive as they would normally do in everyday life. Cars are equipped with many sensors including video so that the driver behaviour can be monitored in detail. In the US the 100 car study and SHRP2 study were conducted, in Australia a NDS is ongoing (Regan et al., 2014), and the European NDS UDRIVE (Barnard et al., 2016b) has just been finished.

Based on the insights delivered by these studies we can ask another question: **what can automation learn from human drivers**? Automated vehicles are very good in driving according to the rules, following procedures, and are not supposed to do stupid things like engaging in risky driving. However, humans are very good in improvising and can be resilient in unusual and unexpected situations. In safety research there has been a paradigm shift away from designing ever more detailed safety procedures and regulations towards processes that boost resilience, as not everything that might go wrong can be predicted. From FOT data, and specifically from NDS, we may be able to learn something about human flexibility and resilience, and this may be of value for the development of automation.

In this paper we emphasised the sharing of data, knowledge and experiences. Only by combining the knowledge sources will we be able to get a clearer picture of what the future impacts of road automation may be.

8. References

AAA (American Automobile Association) NewsRoom, 2017. Available at: http://newsroom.aaa.com/2017/03/americans-feel-unsafe-sharing-road-fully-self-driving-cars

Barnard, Y., Koskinen, S., Innamaa, S., Gellerman, H., Svanberg, E., Zlocki, A., Chen, H., 2016a. Data Management and Data Sharing in Field Operational Tests, In: P. Pagano, Intelligent Transportation Systems: From Good Practices to Standards. CRC Press. pp. 60-72.

Barnard, Y., Utesch, F., van Nes, N., Eenink, R., Baumann, M., 2016b. The study design of UDRIVE: the naturalistic driving study across Europe for cars, trucks and scooters, European Transport Research Review, 8:14.

Barnard, Y., Gellerman, H., Koskinen, S., Chen, H., Brizzolara, D., 2016c. Anonymization of Data from Field Operational Tests, ITS European Congress Proceedings.

Barnard, Y., Carsten, O., 2010. Field Operational Tests: challenges and methods. In: J. Krems, T. Petzoldt, M. Henning (eds.): Proceedings of European Conference on Human Centred Design for Intelligent Transport Systems. Lyon: HUMANIST publications. pp. 323-332.

CARTRE project: http://connectedautomateddriving.eu/

ERTRAC, 2017. Automated Driving Roadmap. Available at: http://www.ertrac.org/uploads/documentsearch/id48/ERTRAC_Automated_Driving_2017.pdf

FESTA Handbook, version 6, 2016. Available at: http://fot-net.eu/library

FOT-Net: http://fot-net.eu

FOT-Net wiki: http://wiki.fot-net.eu

Hyde, S., Dalton, P., Stevens, A., 2017. Attitudes to Autonomous Vehicles. No. PPR823. London: TRL.

Innamaa, S., Smith, S., Barnard, Y., Rainville, L., Rakoff, H., Horiguchi, R., Gellerman, H., 2017. Trilateral Impact Assessment Framework for Automation in Road Transportation. Trilateral Impact Assessment Sub-Group for ART, Draft 1.0. Available at: https://connectedautomateddriving.eu/wp-content/uploads/2017/05/Trilateral_IA_Framework_Draft_v1.0.pdf

Gellerman, H., Svanberg, E., 2016. FOT project agreements are crucial for data sharing. Proceedings of the 23rd ITS World Congress, Melbourne, Australia.

Gellerman, H., Svanberg, E., Kotiranta, R., 2016. UDRIVE Data Protection Concept. Proceedings of the 23rd ITS World Congress, Melbourne, Australia.

Gellerman, H., Svanberg, E., Kotiranta, R., Heinig, I., Val, C., Koskinen, S., Innamaa, S., Zlocki, A.,Bakker, J., 2017. Data Sharing Framework, FOT-Net Data Deliverable D3.1. Available at: http://fot-net.eu/Documents/d3-1-data-sharing-framework

Madigan, R., Louw, T., Dziennus, M., Graindorge, T., Ortega, E., Graindorge, M., Merat, N., 2016. Acceptance of automated road transport systems (ARTS): an adaptation of the UTAUT model. Transportation Research Procedia, 14, pp. 2217-2226.

Pampel, S.M., Jamson, S.L., Hibberd, D.L., Barnard, Y., 2015. How I reduce fuel consumption: An experimental study on mental models of eco-driving. Transportation Research Part C: Emerging Technologies, 58, pp.669-680.

Regan, M. A., Williamson, A., Grzebieta, R., Charlton, J., Lenne, M., Watson, B., Haworth, N., Rakotonirainy, A., Woolley, J., Anderson, R., Senserrick, T., Young, K., 2013. The Australian 400-car Naturalistic Driving Study: Innovation in road safety research and policy. In: Proceedings of the 2013 Australasian Road Safety Research, Policing & Education Conference, Brisbane, Queensland. Australasian Council of Road Safety.

Schoettle, B., Sivak, M., 2014. A Survey of Public Opinion about Autonomous and Self- Driving Vehicles in the U.S., the U.K., and Australia, Technical Report, The University of Michigan Transportation Research Institute.

SHRP2: http://www.trb.org/StrategicHighwayResearchProgram2SHRP2/Blank2.aspx

Venkatesh, V., Morris, M. G., Davis, G. B., Davis, F. D., 2003. User acceptance of information technology: Toward a unified view. MIS Quarterly, 27 (3); pp. 425–478.