# Rethinking transport

27–30 April 2020

**TRA 2020 HELSINKI**

*Proceedings of 8th Transport Research Arena TRA 2020, April 27-30, 2020, Helsinki, Finland*

# Overview of connected and automated driving test sites

Adewole Adesiyun[a]*, Isabela Erdelean[b], Abdelmename Hedhli[c], Martin Lamb[d], Wolfgang Ponweiser[b], Niklas Strand[e], Ewa Zofka[f]

[a]*Forum of European National Highway Research Laboratories (FEHRL), Blvd de la Woluwe 42/B3, 1200 Brussels, Belgium*
[b]*Austrian Institute of Technology (AIT), Giefinggasse 4, 1210 Vienna, Austria*
[c]*Institut français des sciences et technologies des transports, de l'aménagement et des réseaux (IFSTTAR), 14-20 Boulevard Newton Cité Descartes, Champs sur Marne, F-77447 Marne la Vallée Cedex 2, France*
[d]*Maple Consulting, Britannia House, Caerphilly Business Park, Van Road, Caerphilly CF83 3GG, Wales*
[e]*Swedish National Road and Transport Research Institute (VTI), Olaus Magnus 35, Linköping, Sweden*
[f]*Erica Consulting, Liliowa 3, 04-953 Warsaw, Poland*

## Abstract

Connected and automated vehicles potentially offer solutions to some key challenges for National Road Administrations (NRAs), such as reduction of accidents, increasing network capacity etc. As a result of this potential, both industry and certain national governments are undertaking trials that are mainly focused on technological challenges such as the ability of vehicles to drive safely in "random" situations etc. Far less attention has been paid to questions around the implications for NRAs. The overall aim of the STAPLE project is to provide a comprehensive review of technological and non-technological aspects of the most relevant connected and automated driving test sites in order to understand the impact of these sites on the NRAs' core business and functions.

*Keywords:* connected and automated vehicles, catalogue of test sites, National Road Authorities, key performance areas, key performance indicators (KPI).

* Corresponding author. Tel.: +32 2 775 8234;
  *E-mail address: adewole.adesiyun@fehrl.org*

## 1. Nomenclature

CEDR        Conférence Européenne des Directeurs des Routes / Conference of European Directors of Road
NRA         National Road Administrations
CAV         Connected and Automated Vehicles
V2I          Vehicle to Infrastructure communication
I2V          Infrastructure to Vehicle communication
PEB         Programme Executive Board of CEDR Automation
RSUs        Road Side Units
V2V         Vehicle to Vehicle communication
V2X         Vehicle to other communication

## 2. Introduction

Autonomous vehicles have been in use for many years in factories, based on fixed routes and mass transit systems, for example the Docklands Light Railway in London. Research efforts into driverless vehicles also have a long history, with TRL trials of a Citroen DS in the 1960s and Carnegie Melon NAVLAB4 research from the 1980s, but significant public attention has been achieved in the past 10 years or so, partly as a result of advances in technology and partly due to new entrants to the market, such as Google, Uber and others promoting new mobility concepts. This in turn has led to vehicle manufacturers to advance their own research into the area and collaborate with the IT companies.

Connected and automated vehicles (CAVs) potentially offer solutions to some key challenges for National Road Administrations (NRAs), such as reduction of accidents, increasing network capacity and extending mobility to those who are unable to drive. As a result of this potential, both industry and certain national governments are undertaking trials to test the technology for specific scenarios and also to understand the human acceptance and perception of such systems. There are numerous test sites, both off and on road started around the globe to test automated and connected technology for a number of applications. These generally fall into the following categories:

- Test sites of automated vehicles on closed tracks, with or without a driver at low and high speeds;
- Testing of vehicles on the public road, with a driver ready to take over at low or high speeds;
- Testing of low speed pods in urban areas for specific applications;
- Testing of vehicle platoons, operated through V2X communication.

As stated above, the trials noted to date have tended to focus on technological challenges such as the ability of vehicles to drive safely in 'random' situations, or to understand human factors acceptance of driverless vehicles and to a degree questions about legal and insurance aspects and even 'morality'. Far less attention has been paid to questions around the implications for NRAs.

The CEDR funded project STAPLE (SiTe Automation PRactical Learning) aims to provide a comprehensive review of technological and non-technological aspects of the most relevant connected and automated driving test sites in order to understand the impact of these sites on the NRAs' core business and functions. This paper presents the outcome of the work done both within Europe and worldwide to undertake a thorough scan of connected and automated driving test sites operating worldwide, the partners and main actors involved and the main focus of the sites, such as vehicle technology, sensors, ICT, human factors or application specific. The key performance areas relevant to the core business of NRAs which are mostly impacted by automated driving are also presented.

## 3. Catalogue of connected and automated driving test sites

### 3.1. Initial review

The aim of this review was to get a broad overview of the existing connected and automated test sites across Europe and beyond. A comprehensive desk study was carried out to identify the most relevant test sites and test beds across Europe as well as the USA, South Korea, China and Australia. This was complemented by the consortium's knowledge and involvement in connectivity and automation related projects, as well as the support of CEDR. The review encompassed a wide variety of sites, in terms of location, size, years of operation, experience and other factors. The project looked at existing sites with years of experience as well as new and developing ones.

The focus was on test sites and test beds for passenger cars, freight transport operations and shared mobility services. The search yielded over 70 test sites and test beds in 20 countries inside and outside Europe, including the USA, China, Australia and South Korea (Erdelean et. al (2019)).

*3.2. First data collection and criteria*

After the identification, the next step was to learn more about each individual test site/bed to investigate which ones would be most relevant for the CEDR NRAs. To this end, a set of 16 criteria were taken into account. The following criteria were considered and collected:

1.  Name: Full name of test site or test bed
2.  Short name: Abbreviation
3.  Partners/Consortium: Specification of the organizations that own and/or manage the site/bed
4.  Location: Coordinates, city and/or address of the test site area
5.  Type of ownership: Specification whether it is a public /private site or other type of joint/separate ownership
6.  Lifespan: Definition of the start of the operation of the test site/bed, as well as the planned duration (e.g. 0 to 2 years, more than 5 years, undefined)
7.  Business areas: Statement on the specific focus of the site/bed, such as road safety, traffic efficiency, customer service and maintenance /construction
8.  Use cases tested: Specification of the connected and automated use cases that could be tested on the premises of the test site/test bed, such as Highway Chauffeur, Automated Shuttle Bus, Freight Vehicles Platooning, Driverless maintenance and road works vehicles, etc.
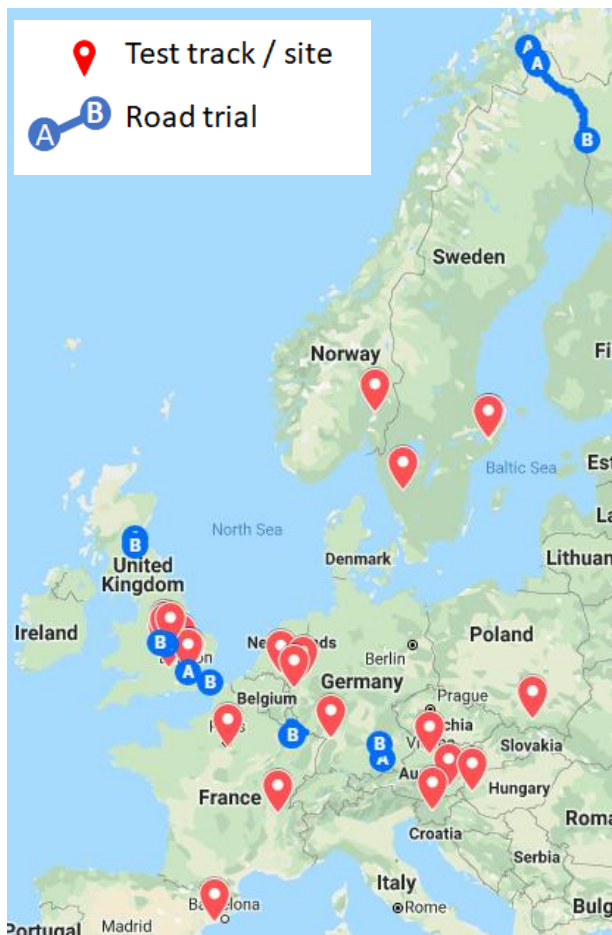9.  Size: Size of the test site/bed, in km or km$^2$
10. Business model: Description of the business model employed by the site/bed consortium for running the test site/test bed
11. Environment: Statement on whether the site environment is closed or an open area (e.g. closed test track, public road, public urban area)
12. R&D/ Industry projects that are/were conducted: Specification of previous or current research or industry projects where connected and automated driving tests were/are performed at the specific site/bed
13. Type of environment: Specification of the type of road environment encompassed in the test site/bed, e.g. urban, motorway, inter-urban, rural
14. Connectivity employed: Description of the network technology employed at the site/bed to facilitate testing, e.g. ITS G5, 3G/4G/5G, LTE V2X, others
15. Infrastructure support: Description of the physical and digital infrastructure that the test site/test bed is equipped with, e.g. cameras, HD maps, road markings, RSUs, radar.
16. Other specific characteristics: Description of other particular characteristics of the test site/test bed, such as electric vehicles charging, intersections, tunnels, speed limits and others.



Fig. 1 Overview of main CAV test tracks and test areas in Europe

The data collection was divided into two phases, which were conducted consecutively. First, publicly-available data was collected for each identified test site/test bed. Secondly, test site owners and operators were contacted towards providing more information on each of the criteria described above. In order to facilitate the data collection, a Description Form was developed that site operators could fill in and send back to the project

consortium. The operators were identified and contacted through the consortium's wide network of contacts, with additional support from CEDR.

The outcome of this work is a catalogue of 37 test sites and test beds that forms a reference for NRAs to inform of current and future work (Erdelean et. al (2019)). These are shown in *Fig*, above. Dependent on client approval, the project team will extend this catalogue to an online searchable database of connected and automated test sites that will give NRAs and researchers the opportunity to search and identify test sites according to their interests – such as country, region, partners involved, on-going projects, tests.

### *3.3. Shortlist of selected sites*

Further discussion and selection of the test sites have been performed to focus only on those that directly address the following criteria:

- Purpose of test site/test bed in terms of use cases tested, e.g. focusing on identified use cases such as interurban operation, construction and maintenance and communications.
- Test sites/beds located in Europe.
- Test sites that have engaged so far and provided feedback and expressed a willingness to further cooperate.
- Test sites that will be in operation beyond the lifetime of this project, i.e. beyond August 2020 and ideally long term.
- Non-confidential sites, i.e. openness to cooperate.

This process was completed to focus only on those test sites which can be taken for further detailed analysis and KPIs collection in order to perform socio-economic impact assessment, identifying relevant roles and responsibilities and assessing the road authorities' core business priorities. The results of this selection yielded a list of 16 sites in Europe, including two identified by relevant experts at a Stakeholder Workshop, held at the CEDR Working Group Automation meeting in Tallinn, Estonia, shown in *Table*, below.

Table 1.  List of shortlisted connected and automated test sites/beds

| No | Test site/bed | Country |
|----|---------------|---------|
| 1. | Alp.Lab | Austria |
| 2. | Test region DigiTrans | Austria |
| 3. | Testbed Lower Saxony | Germany |
| 4. | A2-M2 Connected Corridor | UK |
| 5. | Testbed Midlands Future Mobility | UK |
| 6. | Testbed Colas IPV | UK |
| 7. | Horiba-MIRA | UK |
| 8. | AURORA | Finland |
| 9. | BOREALIS | Norway |
| 10. | AstaZero | Sweden |
| 11. | ZalaZONE | Hungary |
| 12. | TRANSPOLIS | France |
| 13. | Catalonia Living Lab | Spain |
| 14. | IDIADA Proving Ground | Spain |
| 15. | Brainport | Netherlands |
| 16. | A9 ITS corridor | Germany |

The Stakeholder Workshop held on March 6th 2019 with the project officers, members of the PEB and other experts was organised to discuss the final list of test sites to be taken forward for further investigations, and to identify and discuss the key performance areas for NRAs' core business.

A further workshop was undertaken at FEHRL's FIRM19 (FEHRL Infrastructure Research Meeting) conference in Brussels April 27th, where additional insights and information was collected from European and international stakeholders.  At a meeting following the FIRM conference, the consortium agreed on the final selection of sites to be visited by members of the project team and open to PEB members, identified in *Fig.*, below. An in-depth data collection from online surveys, telephone interviews and face to face discussions (during the visits) was conducted towards investigating the impact of test sites' activities on core NRAs' business. It is also hoped that during the winter of 2019-2020, the team will visit the Aurora / Borealis test sites in northern Finland and Norway
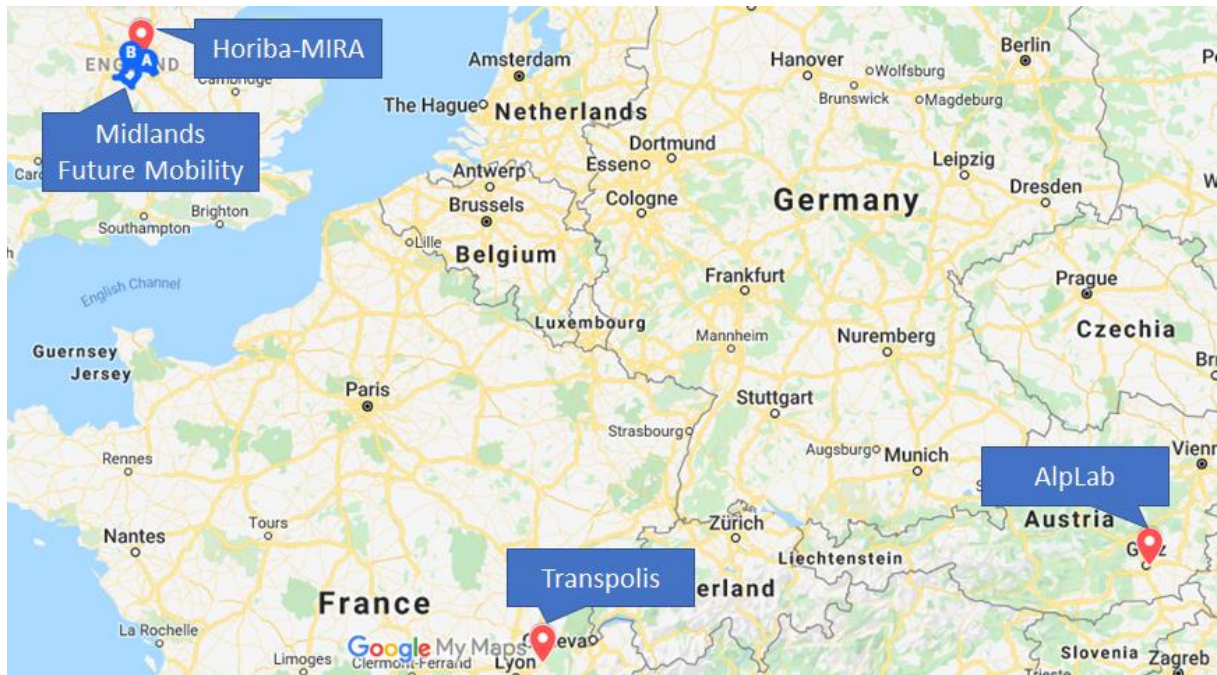
respectively.



Fig.2 Test sites visited in Summer 2019

## 4. Performance areas

The performance areas are defined as the areas where national road administrations/agencies need to focus the most in order to operate and provide services to the road users. The key performance areas identified in the project are:

- Road safety: the developments in connected and automated driving include several research areas regarding road safety, e.g. active and passive systems in vehicles, the driver aspects and safe roads and infrastructure for automated driving.
- Construction and maintenance: the area of construction sites and maintenance covers a wide range of specific challenges for connected and automated driving. The main topics to be addressed are to improve work zone safety including multilevel data and traffic management and on the other hand to increase efficiency by automation in highway maintenance.
- Traffic efficiency: road congestion is one of the most serious transport problems we face today, having negative impact on motorists, business and the environment. Thus, NRA's need to tackle overcrowding on their busiest routes today to avoid gridlock tomorrow is paramount. This area focuses on establishing what will the impact be of automated and connected driving on the traffic flow. The main topics include cooperative vehicles and automated traffic control strategies, more efficient use of road capacities.
- Customer service: this area focuses on road users as customers of the road infrastructure and its services provided by the road operators - infrastructure as a service. The key considerations here include customer satisfaction due to availability of road infrastructure, clearing of incidents and providing users with real time "user information" necessary to safely and efficiently travel.

The four performance areas were discussed during the first Stakeholder Workshop in Tallinn. This exercise resulted in identification of other aspects to focus on in each of the performance areas. Those aspects include, for each area:

- Road safety: human factors; reports of accidents; the maximum velocity supported by the test sites (testing increasing speeds); and breaking distance between vehicles
- Construction and maintenance: roadworks warnings, impacts on physical and digital infrastructure, use of robotics for asset management: some level of automated maintenance needs to be included in specifications for new roads, potential cost savings from automation as well as safety improvements, impacts on workers safety, automated grass cutting robots.

- Traffic efficiency: connected traffic lights system and impact on traffic efficiency, reduction of emissions (GLOSA); open roads vs. closed tracks, automated in-vehicle or roadway systems, vehicle platooning, high penetration of AVs.
- Customer service: infrastructure as a service, user information: reliability, timely information, robustness of data; data safety, security; user-centric design: customer satisfaction; user information in vehicles (A2M2 test site); road related weather information; acceptance of tested technologies; human health issues/societal issues of automated driving.

## 5. Stakeholders consultation and test site visits

Next step included Stakeholder Consultation to receive detailed information from the test site operators. Initial consultation was in the form of interviews and an electronic survey. The computer aided survey was sent to all test sites identified in the previous work task (total of 72 test sites). The idea was to collect test site operators' points of view on how their automated and autonomous vehicle sites can contribute to the national road administrations/road authorities (NRAs) priority areas.

Questions in the survey were intentionally spread throughout the four priority areas. Out of the 72 requests sent, only 10 answers from the test site operators were received. Even though it's a relatively small sample, it suffices the purposes of the STAPLE investigation in this task as all performance areas were covered and the mix of countries also provides a fair representation of various operating test sites in Europe as presented in figure 3. In total 9 countries participated in the survey with 10 test sites.



Fig. 3 Map of countries and test sites that participated in the survey

One of the questions asked in the survey pertains to the expectations of the test site operators from the cooperation with the NRAs; these were described as:

- Gaining knowledge of the NRAs networks, vision of the future and available resources
- Ensure close and safe test environment to public road testing
- Automated driving legislation, GDPR, privacy,
- Assurance of legal framework and legal viability, infrastructural adaptations
- To facilitate the following CAV equipment and services: GNSS correction data (for vehicle localization with high accuracy), HD maps, dedicated communication networks (for example ITS-G5), sensor

networks (for example CCTV) and a data management and control center (similar to a traffic management center).

- Becoming a certified tests site for public highways and city testing
- Find out what are the necessary adaptations in road infrastructures, road equipment, and in vehicles
- Knowledge and understandings to inform future policy for CAV related infrastructure.
- Improve safety and reduce congestion and so improve customer experience.

The second part of stakeholder consultation were the test site visits organized by the STAPLE consortium to get hands-on experience from the test site operators and collect additional feedback. The sites identified for these field visits were selected to address most of the NRAs priorities in automation of road transport (as depicted in figure 2). Based on this selection, four test site visits were performed together with PEB representatives to collect even more information about the test sites. Those sites were Midlands Future Mobility and Horiba Mira in the UK; ALP.Lab in Austria and TRANSPOLIS in France. Based on the results of this exercise, it seems that there is a lot of potential of using UHD maps in construction and maintenance. Utilising data from sensor fusion can support NRAs in their decision-making process for managing highway performance in terms of traffic management, traffic safety and efficiency as well as digitalization of infrastructure and its roadside furniture. Highways England has also some good experience of customer service so this all be included onto the next step evaluations.

Four test sites offered data sharing for road safety, traffic efficiency, customer service and construction and maintenance so further analysis of the most usable case studies in terms of impact and socio-economic assessment can be undertaken.

## 6. Conclusions

The STAPLE project strengthens the position of NRAs in the field of connected and automated driving, not only as it provides a valuable contribution summarizing the current experience of test sites, but through the involvement of NRAs and other key stakeholders in workshops and scanning tours. As a result of the STAPLE project a searchable data base with GIS functions of the catalogued test sites will be produced and available for NRAs to support their decision processes regarding automated mobility. STAPLE will also produce a set of best practices and recommendations on how to implement test sites as well as how and which information/data/features of the CAVs currently tested at the sites can benefit and influence the business processes of the NRAs.

## References

Erdelean, I., Hedhli, A., Lamb, M., Strand, N., Zofka, E., 2019. Catalogue of connected and automated driving test sites, Deliverable 2.1 – STAPLE (SITE AUTOMATION PRACTICAL LEARNING) project, https://www.cedr.eu/strategic-plan-tasks/research/call-2017/call-2017-automation/