Final Version, approved by CEDR GB

National Road Authority Connected and Automated Driving strategy 2018-28

May 2018

Rationale

This preliminary discussion paper explores the likely impact of Connected and Automated Driving (CAD) on road authorities. It explains the major disruptive changes that will significantly alter the fulfilment of roles and responsibilities of National Road Authorities in the near future, highlighting the need of international cooperation. CEDR's Connected Automated Driving working group – as part of the European umbrella organisation of NRAs – addresses this challenge by taking stock of the individual NRAs' expectations for infrastructure changes needed in the next decade. The time span has been considered as striking the best balance between short-term stable plans and a long-term vision required to address such significant change.

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Disclaimer

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Introduction

CEDR is of the opinion that digitalisation will influence all aspects of transport. This includes the aspects of traffic operations such as connected vehicles, integrated network management (including intermodality) as well as the planning and management of infrastructure with tools such as Building Information Modelling (BIM) and the Internet of Things. Perhaps more importantly it will influence the relation between transport providers and users. Social media and the transparency of data are increasingly involved in both long-term planning and day-to-day management. The role of digitisation in the financing of our transport systems is another area of great interest. The internet has revolutionised commerce, but we are still at the beginning of the journey in terms of transport.

Connected and Automated Driving (CAD) is part of this development. The continuing acceleration of CAD by vehicle manufacturers is going to have a significant impact on road operation, traffic regulation and traffic management. NRAs can benefit from CAD if it can be implemented in order to improve policy objectives of safe, reliable, efficient and environmentally friendly mobility in the face of traffic growth, ageing infrastructure and limited public financing.

The European Commission has already published four Delegated Regulations - 885 (on safe and secure parking of commercial vehicles), 886 (on safety related traffic messages), 962 (on real-time traffic and travel information) and 1926 (on multimodal travel information services) – issued under the umbrella of the ITS Directive – that indicate a clear shift from systems to digital (data) services. Connected vehicles and connected nomadic devices (e.g. smartphones) have opened up a new and powerful channel directly into the vehicle and to the human driver.

While NRAs, road operators and traffic managers so far primarily emphasised the roll-out of roadside equipment, in particular for road side signalling, CAD now means that focus will shift towards ensuring availability of a 'digital infrastructure' enabling the use of Information Technology and data for managing roads, which will provide high quality information for drivers using real-time in-vehicle services. Cooperative ITS (C-ITS) is just one more step in the logical evolution of this development, ensuring that information – especially when it is safety relevant – is always available at the point when it is needed. The innovative technologies needed to take this next step in ITS deployment are available today. To make the most of the opportunities available from CAD it needs the cooperation and coordination of NRA efforts to successfully establish a European roll-out (a joint effort from the public and private sector).

In the coming years, we will see the introduction of highly automated vehicles (level 3/4). These vehicles will have to operate in a mixed fleet (automated and non-automated) environment for the foreseeable future. In order for NRAs to benefit from the technological opportunity and changes in societal demand CAD will bring, NRAs need to focus on developing ever more automated processes for managing traffic, objects and incidents. Automation of these processes will require substantial investment before delivering cost savings in the long run.

NRA involvement

The developments mentioned imply new challenges, but also new opportunities for national road authorities, road operators and traffic managers and cities. Highly accurate, real-time safety related information via short range and cellular connectivity is already expected to significantly improve road safety in the next few years. Cooperative navigation services will have significant impact on transport efficiency and consequently also reduce the environmental footprint of road traffic as a whole, as will electrification of vehicles.

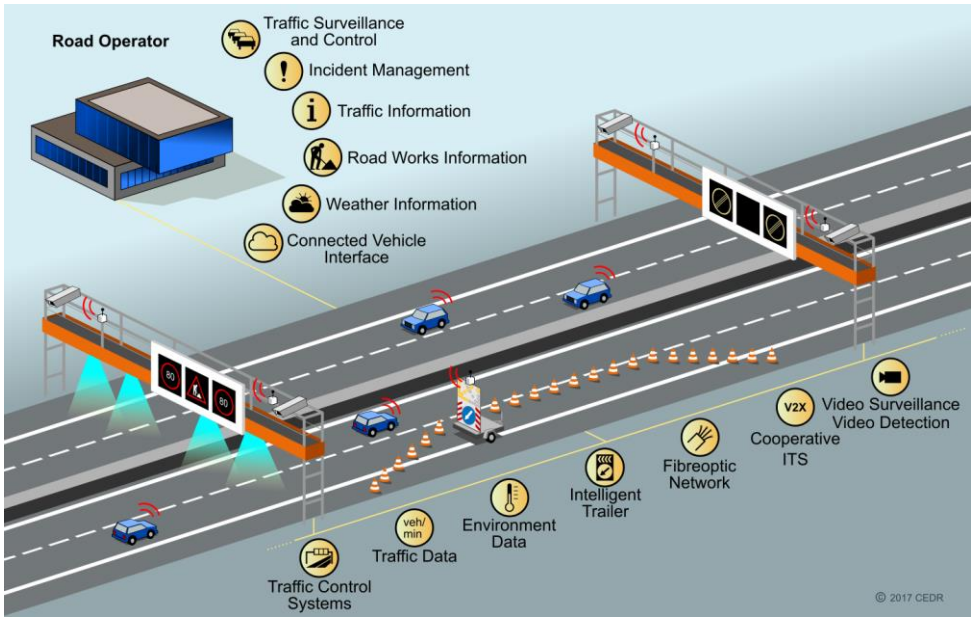
The current infrastructure – physical as well as digital – is not necessarily well prepared to facilitate this change for NRAs to perform their typical roles and tasks. Significant change is expected from the deployment of new technologies like C-ITS or connected automated driving, as well as electric vehicles' demands for re-charging infrastructure. What's new in the current situation is on one hand the magnitude of the needed actions, especially if the roll-out of digital infrastructure is considered, and on the other hand the significance of the European – if not international – dimension if we consider systems and services where infrastructure directly interacts with in-vehicle systems. This implies that more and more impact of traffic management is generated in a cooperation setup rather than by isolated systems under total control of the road operator.

Different scenarios for implementing Connected and Automated driving are possible, with varying levels of NRA involvement. Of course, other stakeholders need to be involved as well. On the advice of the their CEDR CAD working group, it is view of CEDR that it is essential for NRAs to recognise the opportunities and challenges brought by CAD development and to act on them because:

- It safeguards the NRA interests. NRAs can only affect the developments described by participating in them. Otherwise, NRAs will have no other option than to adapt to or comply

with what will be delivered by industry (at the risk of putting things on the road that actually adversely affect road safety, traffic flow and the environment);

- NRA may contribute to drastically improve the effectiveness of new technologies and services. For example, NRAs can extend the vehicle sensor horizon from the current 30…200 m to much longer distance and also around corners by deploying roadside sensors/equipment, and this is specifically relevant in the first years with low penetration rates when there are too few cars in the neighbourhood that can act as sensor;
- Following headways due to existing Adaptive Cruise Control applications improve safety but have a negative impact for both the individual vehicles and road traffic throughput; there are measures (e.g. mandatory V2V deployment to enable short following distances) to gain safety and efficiency benefits at the same time;
- NRAs are needed to establish a smooth transition from the current situation to the new reality by effectively managing mixed traffic situations without a loss of service for non-connected vehicles and at the same time ensuring safe and smooth driving conditions for all vehicles on the road;
- It benefits the competitiveness of Europe. NRAs will act as partners of vehicle manufacturers, service providers, etc. to jointly develop the best solutions, preventing the risk that e.g. a big software supplier dominates the market. This knowledge can be exported to other parts of the world;
- Showing the public that NRAs are actively involved in the development, will increase the people's trust in the new technologies and their willingness to use them, thus leading to a quick uptake.

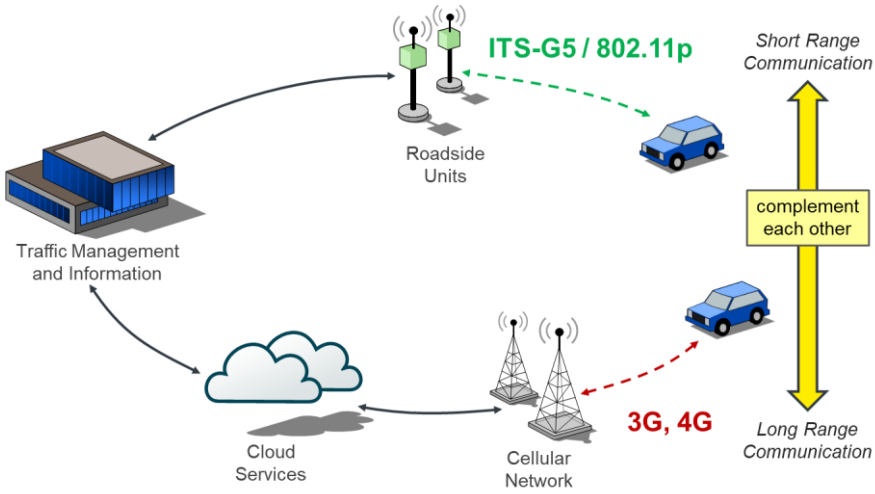


In the scope of this initiative, the NRAs have addressed different fields where actions will be required to cope with the rapid technical evolution. These include:

- Developing a ***digital road infrastructure*** enabling the use of Information Technology and data for managing roads: two main fields of activities must be expected here. On one hand, ***intelligent infrastructure on the road side*** (e.g. connectivity, sensors and landmarks) may be required to complement and improve the situational awareness, positioning accuracy and necessary context for automated driving. Furthermore, there is a currently a debate on needed ***roadside infrastructure to facilitate vehicle-to-infrastructure communication.*** Various NRAs

already decided to deploy ITS G5 roadside stations or similar equivalents to utilise new technologies (like LTE-V2I). Another open question is what budget implications future cellular technology developments (e.g. 5G) will have. The use of satellite technology (Galileo) could contribute to reaching goals as well, and introduction may have budget consequences.

- Recognising substantial improvements in ***backend systems, services and underlying processes***: It can be expected that any type of future connected automated driving scenario will require substantial improvements in content delivery from road authority backend systems to feed other service provider backends (cloud-to-cloud services) but potentially also towards providing data services directly into vehicles (or mobile devices used inside vehicles, like smartphone or in-vehicle Apps) in a hybrid communication scenario (see figure below). Beyond the functional improvements stated so far, actions required in this sector may also have to cover improved framework conditions, e.g. in terms of IT security and privacy.



These considerations are based on the assumption that in ten years from now we must expect:

- a road transport scenario that includes a majority of connected vehicles;
- with C-ITS Day 1, 1.5 and 2 services being rolled-out where applicable (for instance Road works warning and In-vehicle speed limits; it was agreed by the EC C-ITS Platform that these services are expected to and should be available in the short term because of their expected societal benefits and the maturity of technology);
- vehicles have a Human Machine Interface (hardware and software that enables humans to provide input to technology and receive information back);
- automation level 3/4 is enabled on motorways and truck platooning is implemented, but there is still a mixed fleet with varying levels of automation (level 0 = no automation, level 5 = full automation);
- an up-to-date digital infrastructure incorporating cyber security and privacy by design (meaning that privacy is an integral part of the design instead of an additional layer);
- standardisation is ready, safety and reliability are ensured and legislation is in place;
- 3G/4G cellular communication is available everywhere and 5G cellular (the fifth generation of cellular communication with improved features) in some places – for 5G some government/NRA investment is likely to be needed to provide road network coverage where required;
- Mitigation of negative/positive effects of connected and automated driving is arranged;

The following table provides a first overview about expected benefits of such a scenario, also stating the potential threats that can be expected if the required action is not taken.

Action to be taken	Expected benefit	Threat of not acting
Roll-out of digital and physical infrastructure including local vehicle-to-infrastructure connectivity, including required infrastructure sensors and backbone communication networks	Improved road safety e.g. because of an extended sensor horizon, in particular in safety hot-spots (roadworks, incident management, etc.); this is in particular needed in the mixed fleet scenario, expected at least for the next ten years.	Remaining safety problems No deployment of V2I on vehicle side.
Improve backbone content provided cloud-to-cloud to providers of in-vehicle services. This does not focus on infotainment but on in-car safety applications and traffic management measures.	Increased traffic efficiency Increased road safety (specific use cases require V2I) Establish a cooperation model between traffic management services and private sector (e.g. navigation)	Traffic management becomes increasingly difficult in automation scenarios, and out of reach for NRAs. Vehicles/drivers increasingly follow digital information rather than traditional signalling channels
Fully digitalise and manage electronic traffic regulations	Increased road safety by increased compliance Increased flexibility enables better traffic management No double-channel, redundant solution as needed for safety systems that require a, i.e. image processing of signs in parallel to digital provision of regulations by the infrastructure	Autonomous development will fail to achieve the full benefits;
Adapt working processes, organisational architecture and system landscape (see annex of this paper)	Exploit the full benefit of new technologies	Outdated organisational and technical architectures are slowing down innovation and are increasingly vulnerable (e.g. to cyber-crime)

Possible implications for NRAs

CEDR's CAD working group is currently trying to provide indicative NRA estimates of budgetary implications regarding the presented NRA actions which these requirements may impose, differentiating the presented types of required actions as separate cost categories. As said before, different scenarios are possible with different levels of NRA contribution, potentially leading to different levels of NRA investment, but it should be noted that if the described (societal) benefits are to be achieved, investment is needed. Congestion will never fully disappear, but its impact can be substantially mitigated by appropriate NRA actions.

The process is still ongoing, but very first indications show that for the 43,000 km European motorway road network in CEDR countries (including approx. 29,000 km of TEN-T core network), an overall investment in the order of over €10 billion can be expected over the next 10 years. These values will of course significantly vary from country to country. Note that this does not imply the same level of equipment and service everywhere. At this time, the values provided can only be rough estimates with a value range of at least +/- 20%, and it should also be noted that they do include costs that may already be partially covered by current budget plans. Nevertheless, they give

a first indication of the overall dimension of transitional change and related investments that NRAs will face in the next ten years.

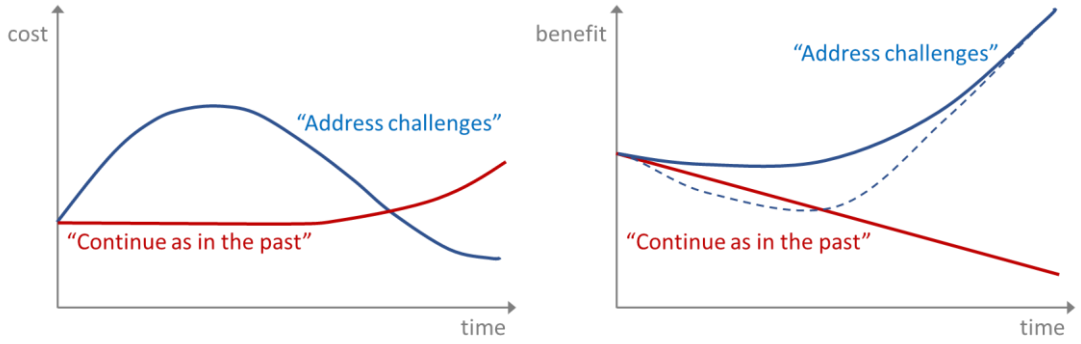
The commercial requirements of market introduction of such vehicle systems require pan-European, coherent roll-out on the infrastructure side to provide seamless interoperability across the European road network, which will also inevitably have an impact on budget requirements.

A **'Transformation Premium'** is needed. NRAs need budgets to make the transition towards the smart mobility future. Certainly, in the next ten years, there will be a mixed traffic situation. Renewing the vehicle fleet fully will take 20 years. Existing tasks and duties of NRAs continue (NRAs will remain system responsible), while additional time and money is needed to develop and implement smart solutions.

We face an enormous **'Investment Bump'** that needs to be managed to deal with the structural changes that are happening anyway across all sectors. Benefits will likely be much higher than money spent in both investment as well as the maintenance and operation. Many of the benefits will take effect on the longer term, not only for NRAs but for society as a whole.

'Value capture' is the key word here: NRA investment will have strong societal benefits, but also commercial benefits for other stakeholders. NRAs will ask them to share the costs of these benefits, e.g. OEMs may pay[1] NRAs for delivering a certain service level on the roads for automated driving.

Since investment comes upfront but benefits – especially societal benefits – may not come immediately at low penetration rates, the expected benefit-over-time curve is likely to look like in the figure below. The dotted line depicts a scenario where benefit upfront actually even slightly decreases due to negative effects of mixed fleet and low penetration. Note that the related cost-over-time curve is also eventually expected to supersede the 'business as usual' scenario, i.e. the options of NRAs just continuing as now without addressing the required change processes. This is because continuing with outdated technology will eventually create excessive maintenance cost, whereas innovation will eventually save cost after an initial investment phase.



Conclusion

CEDR is of the opinion that digitalisation will influence all aspects of transport. This includes the aspects of traffic operations such as integrated network management, intermodality, as well as the planning and management of infrastructure with tools such as Building Information Modelling (BIM) and the Internet of Things.

[1] This does not have to be 'payment in money', it could be by generating other benefits in return, e.g. reducing road maintenance costs by using the road space more evenly.

Connected and Automated Driving (CAD) is part of this development. It is essential for NRAs to recognise the opportunities and challenges brought by CAD development and to facilitate these processes. The budgetary implications for NRAs and road operators are not limited to investments in digital infrastructure. Instead, they cover all aspects of the domain, from digital infrastructure towards backend services on operational processes and also physical infrastructure. Not only is the required investment considerable, it also requires a pan-European coordination effort, since innovative technologies directly connecting to vehicles require pan-European interoperability and coverage, as only seamless European wide service will in the long run attract the corresponding investment on the vehicle side. Nevertheless, not reacting to the situation will in rather due time most likely mean that NRAs continue an outdated, low impact infrastructure and traffic management approach, while at the same time the potential benefits of connected and automated driving – especially the societal ones – may be lost.

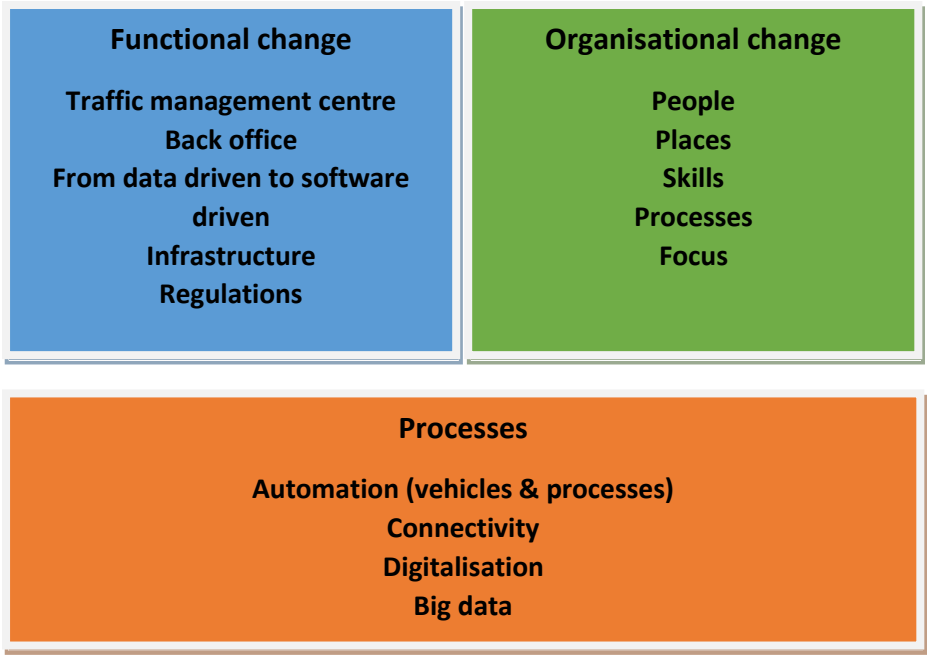
NRAs are clearly recommended to take an active agile role in CAD to ensure that the potential benefits of connected, automated driving can be harvested. Depending on the extent to which NRAs want to facilitate the development in order to harvest the potential benefits of connected and automated driving – especially the societal ones – the budgetary impact on the public side will vary.

On the advice of the CAD group, CEDR recommends a set of concise actions:

- **Initiate a discussion for the strategy for CAD within individual NRAs.**
- **NRAs and road operators could detail their plans that make specific the necessary investments on a national scale.**
- **The CAD working group can continue to facilitate the gathering of individual NRA strategy and roadmaps input.**
- **The CAD working group can continue aligning the input to come towards a coherent strategy (compare, look at overlaps, check missing elements).**
- **Prepare a coherent roadmap for CAD deployment in the next ten years (not aimed at harmonisation of individual ones, but at providing an overview picture).**
- **With the goal to support individual NRAs to strengthen their approach and seek liaison with key actors such as the OEMs (ACEA in particular), European Commission and other stakeholders.**

Annex:

In this paper, the 'Actions to be taken' column in the table above included 'Adapt working processes, organisational architecture and system landscape'. This annex provides a flavour of what this may involve:



The CEDR CAD group will elaborate on the topic 'change needs for NRAs' in their future work.