DIRIZON: Developing a practical roadmap for the step by step transition towards Digitilisation and Cooperative Automated Driving on the European Road Networks.

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ABSTRACT: The Digitalisation of road networks and the rapid developments in Automated Driving will affect the core activities that National Road Authorities (NRA's) undertake, offer new business opportunities and provide them with new and more efficient ways to achieve goals for road safety, traffic efficiency, the environment and customer service. As a result of Digitalisation, NRA's can benefit from new opportunities resulting from data sharing and the improvement of traffic management and asset management processes. Equally, the extensive data collected can support the safe and efficient use of automated vehicles on their networks. To assist the NRA's in this regard and realising the benefits of Digitalisation and Cooperative Automated Driving (CAD), the CEDR* funded DIRIZON** project's goal is to support NRA's in identifying how these developments will affect their operations and their interaction with other actors. Focusing on a growing technical cooperation between NRA's, service providers and Original Equipment Manufacturers (OEMs), this goal is achieved by providing a concept for a technical data-exchange platform with corresponding business models archetypes for its exploitation through the use of three use cases particularly affected by Digitalisation and Connected Automated Driving namely; Provision of (High Definition) HD Maps for Automated Mobility; Distribution of Digital Traffic Regulation and Infrastructure Support Services for CAD. The actors relevant to each use case are identified as well as their current and future roles/ relationships between them in the short, medium, and long term. Ultimately, the DIRIZON project provides a practical roadmap for step-by-step development and transition of road operation to digitisation. Equally, a set of business models for co-financing and operation of a suitable platform for data sharing between public and private sectors and a suitable standard for a platform at the EU-level are proposed.

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KEY WORDS: CEDR; Digitalisation; Connected Automated Driving; Asset Management; Data Exchange Platform; Business Models; Connected Automated Mobility; Digital Traffic Regulation; C-ITS; ITS; ISAD.

1 INTRODUCTION

Digitalised data facilitates new activities on road networks and changes the way these activities are carried out. Data plays a key role in these activities and enables the Connectivity needed to improve efficiencies in managing, maintaining, and operating the road network. Equally Digitalisation, along with Connectivity, are crucial prerequisites to enable Automated Driving.

NRAs are already working on Digitalisation and Connectivity as enablers for improved services of the future, particularly in respect of Automated Driving. This will affect the core activities that NRAs carry out, offer new (business) opportunities and provide new and more efficient ways to enhance road safety, traffic efficiency, the environment and customer services. Equally, Digitalisation offers the opportunity to extend data exchange mechanics via, for example, cloud services, which will be the basis for the forthcoming development of connected and Automated Driving on European roads.

These developments will change the way NRAs interact with the existing actors but also will lead to new opportunities with new ones. Fundamentally, the roles and responsibilities of both NRAs and other relevant actors will change as the transition occurs to the full Digitalisation of road infrastructure. Equally, when considering Automated Driving, cooperation between the relevant actors will change and the roles and responsibilities will need to be defined considering the challenges ahead. However, what exactly are these challenges? What changes are on the horizon and how can the road authorities deal with these changes? Where do they need to invest? Where do they need to start new types of cooperation? It is envisaged that there will be a growth of C-ITS services in the future and this will encourage industries such as, for example, the automotive industries and the communication service providers, to invest further in these areas. Even though C-ITS services are about to be deployed based on harmonised specifications, it is important to note that they are only one element making Automated Driving a reality. Major elements of the digital and physical infrastructure, including, among others, data access and data storage, HD maps and physical landmarks, are not harmonised. Implemented test systems for Automated Driving vary across different European countries and as a result, Europe is not homogeneous in these areas. Equally, heterogeneousness on automated tests can exist in the same country.

In light of the step-by-step Digitalisation of NRAs' road assets, DIRIZON seeks to address these issues and questions. Through exploring the current and expected status of Digitalisation and Automated Driving in European countries,

the project aims to not only take a deeper look at the challenges faced but also to assess the NRA's roles and responsibilities which will be assessed in the context of the three analysed Use Cases and provide a concept for a technical data-exchange platform, with corresponding business models for its exploitation.

2 WORK STRUCTURE

2.1 Overview

Realising the project objectives is achieved through a set of structured Work Packages (WPs), Figure 1.

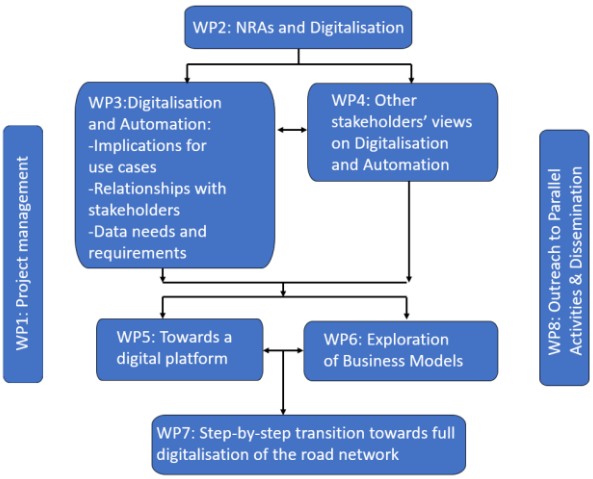

Figure 1. DIRIZON work package structure

As NRAs move towards Digitalisation of their infrastructure assets, operations and Automated Driving, it is essential not only to understand how Digitalisation and Automation will impact the management of their assets in the future, but also to understand their current levels of Digitalisation and what is needed to enable Automated Driving on the existing road networks, thus providing a baseline from which a seamless transformational change to Digitalisation and Automated Driving can take place. As such, the focus of WP2 is to define Digitalisation and Automated Driving in the context of NRAs' current and future operations and assess, which assets require Digitalisation and identify not only the roles and responsibilities, both technical and regulatory of NRAs, but also relevant actors. Finally, within WP2, three Use Cases particularly affected by Digitalisation and Automated Driving deployment, are proposed based on the output of the literature review, interviews and a multi-criteria selection process. The latter received input from the CEDR Connected Automated Driving (CAD) working group.

Using the Use Cases selected in WP2, WP3 will map the actors and determine the data issues, data requirements and new opportunities for each Use Case, analysing the data requirements, its quality, and potential sources.

WP4 will discuss the different actors' roles within the Use Cases and identify the congruent and conflicting views in the present and future with respect to data exchange.

WP5 will focus on a growing technical cooperation between NRAs, service providers and OEMs. To define such a data-exchange options platform (or integrated platforms) it is assumed that appropriate backends e.g. already existing systems platforms or clouds of different stakeholders have to be connected in order to maximise the benefit.

WP6 will derive requirements, strategic considerations and propose business model options for NRAs to exploit a data-exchange platform. Business model scenarios will be developed for each Use Case that promise additional benefit through cooperation. The analysis will determine which business model scenarios score high on compatibility and consistency, and draw conclusions, providing input to WP7, in which the implementation of a road map is presented.

3 MAIN FINDINGS

3.1 NRA's and Digitalisation

The objective of this work stream was to understand the current and expected Level of Digitalisation and Automated Driving across Europe, allowing gaps to be identified and recommendations to be made for the step-by-step transition toward full Digitalisation and Automation of the NRA's road networks. To this end, the primary objectives were to;

1. Establish what NRA assets and operations are currently digitalised, and what Digitalisation is required to facilitate Automated Driving.
2. Identify fundamental roles and responsibilities of NRA's and private actors regarding the Digitalisation of their assets.
3. Assess the current policies and regulations in place and how these may be required to change.
4. Identify key areas of operation of NRAs in respect of Automated Driving and Digitalisation

These objectives were accomplished by conducting an extensive literature review in combination with a series of interviews with NRA and road operator representatives. From the findings of this work, the Use Cases (Section 3.2) were selected for further assessment in subsequent work streams. Full details can be found in Tucker et. al. [1]. The main findings of this work stream include;

Collaboration is a significant barrier which can only be improved through the NRA's direct involvement in projects with other relevant actors. Through collaboration 'trust' will be built between the actors, particularly in relation to data exchange, sharing and usage;

A *holistic approach* is required with involvement of all actors, including but not limited to NRA's, Governments, third parties, road operators and other stakeholders;

Testing is a significant prerequisite for the implementation of C-ITS and even more for Connected Automated Driving;

Disparity in levels of Digitalisation & Connected Automated Driving across countries is evident (planning, development, implementation/deployment)

Equally, other findings include - Financial barriers/uncertainties; Roles and responsibilities unclear; legal/regulatory issues; public acceptability; Interoperability; Data issues (privacy, cybersecurity, sharing, quality, ownership etc.); Skills requirements.

3.2 Use Cases and Data Requirements

3.2.1 Overview

In WP3, the use cases selected, as presented in [1], were expanded by developing a future view of the process flow in

each use case and identifying the data requirements and data quality criteria in providing the use cases. This involves exploring the use cases of the future in which different Society of Automotive Engineers (SAE) levels of vehicles use the road, and the activities of the process flow. The process flow describes how the service is provided and the roles and activities that are carried out.

Together with the CEDR and the CAD working group the following sections briefly describe the use cases selected for DIRIZON and the data requirements. Full details can be found in Malone et. al. [2]. It should be noted at this point that the activities described in Sections 3.4, 3.5 and 3.6 are ongoing and due for completion in September 2020.

3.2.2 Use Case 1: Provision of High-Definition (HD) Maps for Automated Mobility

High-Definition (HD) maps are defined here to be the provision of detailed mapping in a machine-readable format to support a CAV's ability to understand its precise positioning, plan beyond sensor range, possess contextual awareness of the environment and local knowledge of the road rules. Hence, HD Maps can assist automated vehicles to optimize their precise positioning and control on the road surface and potentially extend their Operational Design Domain (ODD). The process flow is shown in Figure 2.

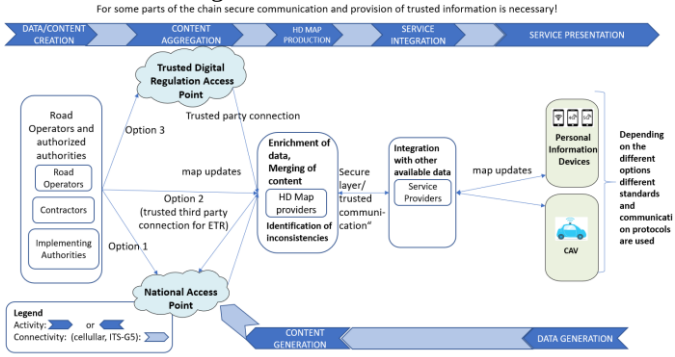

Figure 2. Use Case 1 - HD Maps for Automated Mobility.

At this point in time, there are no publicly available explicit data quality requirements for data to be used by automated vehicles. Therefore, the focuses is on providing a framework for thinking about which data quality criteria are appropriate, the identification of classes of data, and making initial suggestions for the data criteria. The initial suggestions are based on the EU-EIP [3] as a starting point. These criteria need to be checked with the actors involved. The actors would also need to establish the responsibilities for checking of the data.

Static data means digitized information about the road and traffic regulations. These include the road model (geometry, road width, gradients, and junctions), road classification, lane model (number of lanes and link attributes), HD localization model (beacons, landmarks), locations of, for example, tolling stations.

3.2.3 Use Case 2: Distribution of Digital Traffic Regulations

Distribution of digital traffic regulation becomes more and more relevant for Connected and Automated Mobility (as well as for other areas e.g. smart cities) and is currently being standardized within CEN/TC 278 WG17. Current legal responsibilities and authorisation schemes vary a lot between countries, states and cities and rules are time-and-place referenced similar to a digital map. This implies traffic regulations need to be maintained and encoded electronically to be machine readable, processed and correctly interpreted by a receiver.;

The process of creating legislation at different governmental levels (national, regional and local), creating a harmonized digital equivalent for traffic regulations (e.g. normally represented thought physical signs) across Europe. and the enactment of these regulations are prerequisites but not part of the operations of distribution of digital traffic regulations. This use case focuses on how the static and dynamic regulations are distributed to the users (map providers, etc.). The process flow is shown in Figure 3.

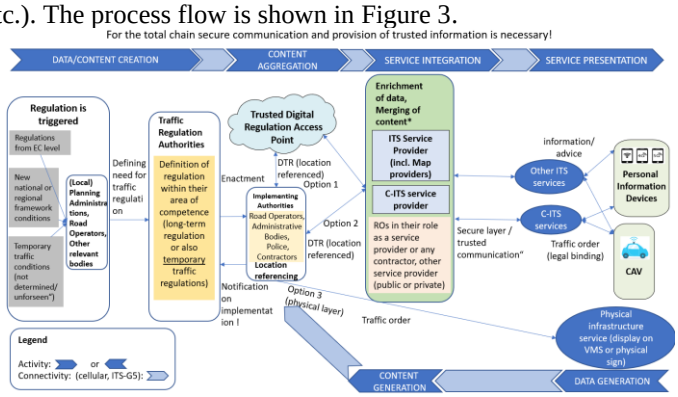

Figure 3. Use Case 2 – Distribution of Digital Traffic Regulations.

The static and temporary (dynamic) regulations can be triggered by different sources such as European legislation; New national and regional framework conditions and current (pre-defined) situations to react on (e.g. weather-related, traffic condition related, environmental conditions (e.g. within low emission zones)). A traffic regulation can be the effectuation of a traffic ban, traffic restriction or a traffic facilitation (either route/section-related, vehicles category-related or time-related or a combination of these). The traffic regulation authorities define the regulation within their area of competence, whether it be long-term static regulations or temporary traffic regulations. The enacted regulations are implemented by the implementing authorities (Road Operators, administrative bodies, police, etc.). The implementing authorities notify the traffic regulation authorities of the implementation. Currently, first standardisation activities in the light for digital traffic regulations have started. Therefore, this use case is in a nascent stage. The data needs will be both static, as listed in Use Case 1 on HD maps, and dynamic. Dynamic regulations include dynamic speed limits; road, lane and bridge closures; and road works. The definition of the specific content of the digital traffic regulation also needs further definition and standardization, and profiles need to be developed. The profile will include many of the same data definitions already defined for C-ITS use cases, for example, road works warnings.

3.2.4 Use Case 3: - Infrastructure Support for CAD

Infrastructure Support for Connected and Cooperative Automated Driving (ISAD) is digitized information, on top of the HD map and the digitized traffic regulations, to support CAV functioning. This core topic covers vehicles in a mixed

environment, supporting CAVs by extending their ODD and improving safety, traffic flow and environmental impacts. The focus within this use case is the infrastructure support services provided by the road operator. The type of data that CAVs need to extend their ODD are related to the local traffic situation, by definition beyond its sensor system scope, like data based on measurements of other vehicles' real-time speeds and travel times, traffic volumes, and detection of incidents and accidents, on the road segment level and, if possible, at the lane level.

Figure 4 shows the process flow diagram for the infrastructure support for CAD. Data on traffic, incidents and accidents and environmental data generated by various sources (loops, cameras, etc) are collected and made available, either via the National Access Point and/or the Traffic Management Centre.

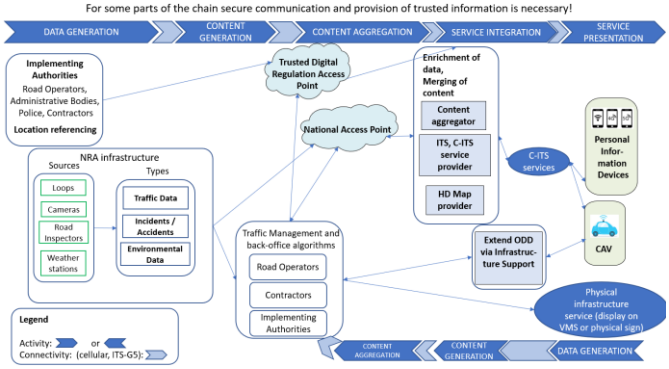

Figure 4: Use Case 3 - Infrastructure support for CAD.

The same data required for HD maps and Distribution of Digital Traffic Regulations is required for ISAD. At this point in time, there is no definitive list of data required to provide ISAD. There are some indications of which type of data is necessary, on the basis of existing documents and direct contact with the INFRAMIX project [4], and from the Proof-of-Concept currently being carried out by the Data Task Force [5]. Traffic data includes, for example, traffic volume, speed, occupancy, and travel times per lane, percentage of automated vehicles in the traffic stream (in space and time), if possible, enriched with vehicle sensor data. The concepts in INFRAMIX require knowledge of SAE-levels. Events or conditions are primarily safety-related and are covered by the Safety Related Traffic Information (SRTI). These include temporary slippery road, animal etc. on the road, unprotected accident area, short-term road works, reduced visibility, wrong-way driver, unmanaged blockage of a road, and exceptional weather conditions. Additional data include location and length of traffic queues, accidents and incidents, availability of parking and parking costs, and weather conditions.

3.2.5 Data Categories and Quality Criteria

Sections 3.2.2, 3.2.3 and 3.2.4 provide information on the data needed in the use cases. The paragraphs below provide a non-exhaustive list of a categorisation of the data needed.

- Static data means digitized information about the road and traffic regulations. These include the road model, road classification, location of tolling stations, lane model including speed limits, access conditions, and other traffic regulations, the HD localization model (beacons, landmarks), the locations of, for example, parking spaces and service areas, charging points, public transport stop, and delivery areas. Note that HD map providers may provide the locations of parking spaces etc. in a basic map or in a premium version, depending on the specific client group.
- Traffic data includes, for example, traffic volume, speed, occupancy, and travel times per lane, plus vehicle types and the SAE level of vehicles.
- Events or conditions are primarily safety-related and are covered by the SRTI. These include temporary slippery road, animal etc on the road, unprotected accident area, short-term road works, reduced visibility, wrong-way driving, unmanaged blockage of a road, and exceptional weather conditions. This list can be expanded to include additional services, like end-of-queue warning.
- Dynamic regulations include dynamic speed limits; road, lane and bridge closures; and road works.

These four categories place requirements on the data quality criteria for CAVs, which are provided below as identified in the literature and through interviews and include;

- Geographical coverage
- Refreshment rate
- Availability
- Timeliness/ Latency
- Location accuracy
- Classification correctness
- Event Coverage
- Variance
- Predictability
- Event coverage

3.3 Other Stakeholders Views

The main objectives of this work stream are to challenge the views of NRAs with the results of other stakeholder groups. Therefore the aim was to collect views of NRAs and other stakeholder groups on data needs, data exchange (incl. prerequisites), roles and responsibilities, security, data protection, privacy and governance issues in respect of the three aforementioned Use Cases. These objectives were achieved by desk top studies and a web-based questionnaire which provide the basis for the further developments regarding an exchange platform and the related business models in the subsequent WPs. The findings of the web questionnaire are based on quantitative analysis methods and analysed using suitable statistical methods. The main stakeholders targeted by the questionnaire were identified as follows;

- Road Operators (public/private)
- Transport authorities (national/regional)
- Communication network providers
- (Digital) Map Providers
- OEMs
- Platforms and Associations

The web questionnaire was divided into seven main sections, as listed below, and then conclusions are drawn based on the findings under the following headings.

- General Organisational Information on the respondent;
- Description of the core topic incl. overview, process flow diagram, storyline;
- Evaluation of activities and actors for each phase in the process flow;

- Evaluation and feedback on data and data provision;
- Risks, challenges, opportunities and benefits for the core topic;
- Overall evaluation of the process flow and storylines as basis for the reflected process;
- Contact data / request for further information on the project.

The findings from the activities in this work stream will be published in [6].

3.4 Towards a Digital Platform

This workstream focuses on a growing technical cooperation between NRAs, service providers and OEMs. In order to make this cooperation efficient in the long term, WP5 will provide different data exchange options depending on the requirements of each use case by concentrating connected stakeholder backends (cloud-to-cloud services) and elaborating the necessary key requirements.

Appropriate services would pave the way for providing data services directly into vehicles, mobile devices or aftermarket devices used inside vehicles and, vice versa, providing sensor-data back to the connected backends. Assuming that such cooperating backends in combination with an appropriate business model in the sense of a joint venture (shared costs principle) will maximise benefits, WP5 will examine the technical aspects of such a collaboration with regard to the evolvement over the time (short-, mid-, long-term).

WP5 starts with the thesis that any type of future connected automated driving scenario will generate a need for substantial improvements in data exchange between road authority backend systems, service provider backends and OEM backends (cloud-to-cloud services). The work is split up in 3 tasks:

Task 1: Analysis of results from previous work streams, with the requirements of the use cases being derived in terms of the content to be exchanged (e.g. safety related data, map data, traffic data, traffic management); Appropriate existing standards for data-exchange and required new standardisation; Data ownership; IT security; Privacy and availability requirements (Service Level Agreements)

Task 2: Development of data exchange options, using existing data exchange concepts (e.g. existing national access points or existing platforms in other domains. The architectural concept will reflect the setup of road authority backend and the connection to service provider backends and OEM backends on a European level. The data exchange options will be elaborated considering the evolvement over the time (short-, mid-, long-term). The cooperation as such depends strongly on the business models identified in WP 6 and the benefits for the stakeholder.

Task 3: Validation of the data exchange options together with NRAs and additional stakeholders.

Any future Cooperative Connected and Automated Mobility (CCAM) scenario will generate a need for substantial improvements in data exchange between backends of road authorities, service providers & OEM backends (cloud-to-cloud services). Appropriate services would pave the way for providing data services directly into vehicles, mobile devices or aftermarket devices used inside vehicles and, vice versa, providing sensor-data back to the connected backends. Potential cooperation models between NRAs, service providers and OEMs like the proof of concept signed on the ITS Europe Congress or further developments regarding National Access Points will be assessed.

For these reasons, different data exchange options will be provided according to the use case requirements instead of creating a concept for a single and unified platform for all NRAs. In order to provide these data exchange options and requirements, the current focus of the methodology is on:

- Checking developments and transferable, decentralized platform concepts like e.g. the International Data Space.
- Definition/Selection of a Meta Model for data-exchange.
- Definition of a potential platform independent data-exchange concept.
- Derivation of data-exchange requirements and related data-exchange options.

In order to enable seamless and interoperable exchange of traffic and travel data between NRAs, service providers and OEMs, an approach is also needed which allows the implementation of the data exchange options in the NRA specific platforms. For this approach, the Platform Independent Model, developed within the DATEX II specifications, can be used and further developed based on the requirements agreed with the NRAs. The findings from the activities in this work stream will be published in [7].

3.5 Exploration of Business Models

The purpose of this work stream is to identify the roles and business models that drive the exploitation of the proposed technology platform.

Digital services in any future CCAM scenario will be created and delivered by an ecosystem of international and national, governmental and commercial, small and large service providers using in-car, mobile or aftermarket devices. The data-exchange platform and its governance must ensure that these service providers are optimally facilitated in the creation and proper functioning of these services is, e.g. by providing added value elements, e.g. by enriching services, toolkits, good governance and consistent access in all countries.

From the perspective of the service providers, whose use determines the value of the data-exchange, a “google”-like platform that is available everywhere for building their services on top of would be ideal but some questions remain, i.e. how is this realised decentrally, and under which governance and conditions?

The findings from the activities in this work stream will be published in [8] but currently work is focusing on the current developments and transferable, decentralized platform concepts like the International Data Space. Equally, the potential governance models between NRAs among themselves and, service providers and OEMs is being considered. Ultimately it is envisaged that the business models will be based on a Collaborative network framework, Figure 5.

However, the agreement on a uniform architecture for the exchange of traffic data between NRAs, service providers and OEMs seems rather unlikely. The further investigations in the context of data exchange must take up the heterogeneity of the national system landscapes and examine various options for a more individually organised data exchange between the stakeholders. Governance, security mechanisms (e.g. authenticity of the data source) and technical design options are expected to play a major role.

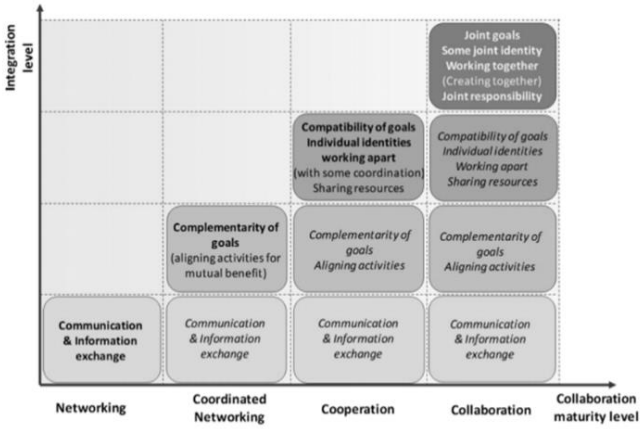

Figure 5: Collaborative Network

In relation to business models for the NRA, the data-exchange platform is also affected by the various opinions. However, the 'common' opinion can be summarized as NRAs are willing to take a leading, initiating role in the ecosystem and see as clear, yet specific and unique role for themselves in content aggregation. Dealing with the ecosystem and expected data change would require medium governance. The NRAs currently do not see the necessity to present themselves as a single seamless platform. Stimulating service innovation on the platform is seen as public responsibility, yet not exclusive to the NRAs. This seems to point in a direction where the data access for service providers is arranged not only on a national but internationally coordinated level. It will not pursue a 'one-stop shop' strategy. NRAs will create some NRA specific/unique data driven services on top of these platforms. NRAs will participate in international governance bodies and pro-actively set these up, if needed. Yet such governance body will probably be focused on consensus rather than decisive power.

3.6 Step by step transition towards full digitalisation of the road network

This workstream focuses on analysing the outcomes of previous workstreams and developing a roadmap for a step by step transition towards full Digitalisation of the road network, elaborating on a sequence of actions/measures, ensuring a proper sequence from a technical, as well as process point of view. Additionally, the use-cases will be analysed to identify recurring patterns, based on abstractions and generalizations. Such recurring patterns will help to identify areas where faster action is needed to achieve even bigger goals as synergies with other actions could be used.

Consolidating the collected material is key to enable an analysis of the Use Cases in detail and to separate them into sequences (short-, medium- and long-term). A comparison of the single sequences of the use cases will be done to identify synergies. Together with the model on the digital platform a comprehensive picture of the short-, medium- and long-term actions for NRAs will be produced.

This consolidated picture will form the basis to make recommendations not only on actions needed for NRAs, but especially also for external stakeholders. The final report [9] will not only describe the single steps in technical terms, but especially take the surrounding environment (other stakeholders, etc.) and necessary framework conditions (policy, governance) into account.

4 CONCLUSIONS

This paper presents the activities being undertaken in the DIRIZON project to develop a practical roadmap for the NRAs to enable a step-by-step transition of road operation to digitisation. This is achieved by providing a concept for a technical data-exchange platform with dedicated business models for its exploitation through the use of three use cases namely; Provision of (High Definition) HD Maps for Automated Mobility; Distribution of Digital Traffic Regulation and Infrastructure Support Services for CAD. The actors relevant to each use case are identified as well as their current and future roles/ relationships between them in the short, medium, and long term.

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REFERENCES

[1] Tucker, M., Kakouris E., Schreuder, M., Malone, K., Helfert, K., Lüpges, C., Kleine, C., 2019, NRAs and Digitalisation, Deliverable 2.1, DIRIZON project, July, 2019.

[2] Malone, K, Schreuder, M., Berkers, F., Helfert, K., Radics, L., Boehm, M., Lüpges, C., Kleine, C, Mann, Tucker, M, Kakouris, E., Digitalisation and Automation: Implications for use cases, Identification of Stakeholders and Data Needs and Requirements Deliverable 3.1, DIRZON project, January 2020.

[3] EU EIP, 2018, Determining the quality of European ITS Services, Deliverable SA 4.1, Version 1.1, 26 February 2018.

[4] INFRAMIX, 2018, Lyrtrivis, P. et al., "Requirements Catalogue from the Status Quo Analysis", Deliverable 2.1 of INFRAMIX, Grant Agreement Number 723016, February 2, 2018.

[5] Felici, E., 2019, "Exchanging vehicle-generated data for the purpose of safety related traffic information", booklet produced of the Data Task Force by Edoardo Felici of the Netherlands Ministry of Infrastructure and Water Works.

[6] Radics, L., Helfert, K., Wegscheider, S., Boehm, M, Schreuder, M, Berkers, F, Lüpges, C., Tucker, M., Kakouris, E., 2020, Report on stakeholder responsibilities in the areas of data exchange, digital platform, and actions needed for making identified use cases reality, Deliverable 4.1, DIRIZON project, 2020 – yet to be published.

[7] Lüpges, C., Kaltwasser, J., Malone, K., Schreuder, M, Berkers, F, Helfert, K., Radics, L., Boehm, Tucker, M., Kakouris, E., Kleine, C., Matthias Mann, 2020, Data-exchange concepts for NRAs in the light of connected automated driving, Deliverable 5.1, DIRIZON project, 2020 – yet to be published.

[8] Berkers, F, Lüpges, C., Szijjarto, V., Radics, L., Helfert, K., Wegscheider, S., Boehm, M, Schreuder, M, , Tucker, M., Kakouris, E., Final Proposal for Exploitation models, Deliverable 6.1, DIRIZON project, 2020 – yet to be published

[9] Radics, L., Helfert, K., Wegscheider, S., Boehm, M, Schreuder, M, Berkers, F, Lüpges, C., Tucker, M., Kakouris, E., 2020Report on the step by step transition towards a full digitalisation of the road network, DIRIZON project, 2020 – yet to be published.