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Harmonization of National Access Points to Intelligent Transport Systems data: A data content and added value perspective

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Abstract

Intelligent Transport Systems (ITS) constitute a key driver for the adaptation of transport sector to the concurrent digital era. Therefore, the necessity to develop a solid framework under which specific norms will be followed by ITS applications, such as being accurate and up to date seems more than important. This is the prime mission that National Access Points (NAPs) aspire to accomplish. However, the architecture and implementation of NAPs varies across Europe. Hence, all Member States have joined their forces, through the project "National Access Point Coordination Organization for Europe (NAPCORE)", to harmonize their NAPs. This paper aims to describe the scenery of ITS-related data exchange by highlighting the benefits resulting from NAPs and the challenges that need to be overcome. Finally, it aims to present planned activities related to the required content of NAPs.

Keywords: National Access Point (NAPs); ITS - Intelligent Transport Systems; harmonization; data exchange; Digitalization in mobility

1. Introduction

The last decade the usage of Information and Communication Technologies is entering even more in the everyday life, affecting a wide range of domains. Intelligent Transport Systems (ITS) services, for instance, focus on the application of ICT to the transport and mobility domain. As such, it is fundamental to recognize the benefits arising from these services given their increased penetration rate and their implications on the quality of life once provided and utilized properly by the end users. A characteristic example could be the reduction of fuel consumption by the utilization of eco-driving mode in vehicles (Grant-Muller & Usher 2014). The extent to which the provision of an ITS

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service can be addressed as proper heavily depends on the availability of suitable, up to date, and reliable data. Hence, data can be viewed as a 'new form of oil' for the sector's future trajectory (Catapult Transport Systems, 2015). Nonetheless, several limitations, ranging from the scarcity of appropriate data with the proper documentation to their sequestration in 'silos', hinder the deployment of ITS services and the sector's overall potential for adaptation (Catapult Transport Systems, 2015). These limitations may be overcome with the deployment of various forms of data platforms, which could enable a seamless life cycle of data harvesting, processing, and exchange (Bacon et al., 2008). In line with this concept, the EU has proposed the deployment of National Access Points (NAPs) for the exchange and distribution of ITS data. This proposal was made within the context of the Delegated Regulations No. 885/2013, 886/2013, 962/2015, and 1926/2017 that supplement the ITS Directive (2010/40/EU). In that context, a NAP may be viewed as a single digital platform at a national level, which provides access in a centralized or decentralized manner to properly formatted ITS-related data accompanied by appropriate metadata.

2. Adopted approach

The aim of this paper is twofold. Firstly, it aims to describe the importance of NAPs within the data exchange domain explaining the necessity of data, both for the NAPs themselves and for the evolution of the whole transport field. In the frame of defining the role of NAP, the benefits and challenges arising from the operation of these platforms are provided in depth. Secondly, it aims to present the NAPCORE project as well as the approach through which it will seek to provide solution to the difficulties and technical issues attributed to the varying implementation of NAPs across Europe. In this context, it provides a preliminary analysis of activities related to the identification of data content requirements of NAPs. This is done by, firstly, reviewing the Delegated Regulations supplementing the ITS Directive (2010/40/EU) and, secondly, identifying requirements stemming from other data categories that are not thoroughly described at the moment in these legislative documents. Moreover, in the same context, it provides an analysis of added value scenarios of ITS-related data, including the use of NAPs to support: a) the operation of virtual traffic management centers and road safety observatories, b) the centralized provision of Cooperative Intelligent Transport Systems (C-ITS) services, and c) the assessment of the impacts of natural and man-made disasters. The current paper concludes by summarizing the findings of the above research and by connecting the activities of NAPCORE with the challenges that are expected to be solved.

3. The significance of NAPs

Before presenting the benefits of NAPs, and in an effort to facilitate their understanding, it is worth to analyze the real concept behind these platforms. A NAP is, in a nutshell, a node in which ITS-related data are concentrated and published in the form of datasets. Each dataset is described by metadata that should conform to a certain terminology or control vocabularies and may include one or more data resources of varying types that should comply to standardized formats. The standardized formats to which data resources should comply is to a great extent determined by their content or their relevance with the data categories described within the Delegated Regulations supplementing the ITS Directive. For instance, data resources related to real time traffic information should comply to the standards developed by the DATEX II forum, while static multimodal information should comply to the NeTEx standard developed by CEN. These data resources may be hosted on the NAP's platform (centralized approach) or, alternatively, the NAP's datasets may include links that provide access to these data resources (decentralized approach). The former more closely resembles the concept of a database, while the latter more closely resembles the concept of a metadata registry.

As becomes readily observable by the monitoring activities of the European ITS Platform (2020) and other literature findings (Mylonas et al., 2020), the implementation approach of NAPs across Member States is not homogeneous. However, all of them recognize (or should) the necessity of data for the provision of seamless ITS-related services. Some of the most prominent such applications of ITS that have been developed so far include, among other, services that allow for electronic payment of tolls as well as advanced traffic management, vehicle and highway control, traveler, traffic, and public transport information (An et al., 2011). All these services either require or produce data of a variety of types (Staron and Scandariato, 2016). The various types of data can be collected in different ways and from a wide variety of sources (e.g., infrastructure-based detectors, in-vehicle devices). However, it must be noted that the various types and sources of data have their own inherent strengths and weaknesses. For instance, Floating Car Data (FCD) have the benefit of allowing the collection of information over a wide area at a low cost; however, a low number of vehicles may represent the traffic stream and the measurement of day-to-day variability may be difficult (Toppen and Wunderlich, 2004). Similarly, while infrastructure-based data collection may allow for increased accuracy, it provides limited coverage and has higher implementation and maintenance costs (Prabha and Kabadi, 2016). The coexistence of benefits and drawbacks in various sources and types of data highlights an additional requirement, namely the need for collecting and managing multi-source data. Mutli-sourcity also becomes a requirement when one does not plan for the development of a single ITS application but rather for an ecosystem of connected and interrelated applications. Multi-sourcity combined with the increased rate of data gathering increase the value and potential of ITS but also calls for a common point of access through which the various actors may navigate the increasingly complex data environment. This is exactly the mission that NAPs are called to accomplish.

4. Benefits and Challenges

Even though the concept of NAPs is not implemented in a same manner across all Member States, it provides a rich list of benefits. A significant benefit to consider is that NAPs enhance the understandability of data (Aifadopoulou et al., 2020). Since data are accompanied by metadata complying to a certain terminology, data consumers can easily comprehend the meaning, the structure, the nature, and other interrelationships among the rest of the accommodated data records. It should be bear in mind that metadata facilitates understandability of data not only by humans but also by machines on the condition that metadata comply and can be formatted in accordance with appropriate profiles and control vocabularies (e.g., DCAT-AP). Moreover, the consolidation of data that may prove useful for ITS applications in a single point of access enhances the discoverability of data by humans. This is especially the case when useful data sources are spread-out at a national level in various portals and cyberspaces. This benefit can be enlarged in the premise that NAPs accommodate proper data discovery services, i.e., data search services making use of metadata records. This benefit is to a fair extent associated with trustability. Specifically, when data are scattered and sequestered in silos, it gets intrinsically more difficult to trust their quality. In the opposite direction stand the NAP platforms by consolidating data and providing coherent information about their quality alleviating, in this respect, feelings of uncertainty. By adopting a more technical point of view, NAPs enhance data interoperability. As already mentioned, through the adoption of certain specifications and protocols as well as the accommodation of Application Programming Interfaces (APIs), NAPs build a solid framework for supporting automated data exchange, including dynamic data, and promoting machine-to-machine communication. Finally, it is important to highlight the role of NAPs towards the cross-sectorial exploitation of ITS-related data, given that technology developers and analysts who are not familiar with the developments within the ITS domain can gain access to ITS-related without excessive effort and organizational complexities.

However, the transport sector faces a wide variety of challenges that are domain-specific or challenges that other sectors face as well. As regards domain-specific challenges, there is an inherent complexity in the operations and management of multimodal transport systems that imply increased requirements in terms of private and public resources to maintain such systems at an acceptable level of service. Such a complexity is intensified by the constant emergence of new transport and mobility services and modes, complying to an increasing rate to the concepts of autonomy, personalization, and de-carbonization. Furthermore, new sources of high-resolution data being useful for transport and mobility services and operations remain either isolated or unexploited to a great extent. This may be attributed to the lack of consensus, knowledge, and understanding of which application areas within the transport domain will be benefited from such data. In addition, there is a wide variety of challenges associated with specific facets of logistics and (global) supply chains and the increased need for optimized operations that have recently become evident due to the pressure of the global pandemic.

Further to the above, transport data exchange domain also faces great business-related challenges. The constant emergence of new heterogeneous actors penetrating transport and mobility ecosystem translates to a wide variety business models and business needs, which in several cases are of conflicting character and difficult to be combined/satisfied simultaneously. In addition, except for few private and public organizations that may be characterized as “key players”, a large portion of actors involved in transport and mobility ecosystem faces difficulties in adopting their yearlong operations and business practices and decision-making processes to the prevailing dynamic context imposed by data exchange.

A series of regulatory and institutional challenges also exist, which can be broadly attributed to the existence of regulatory frameworks for data exchange that are not widely known and utilized. In addition, existing regulatory frameworks strive to be in pace with on-going technological developments. Moreover, there is a lack of specialized (yet necessary) knowledge of related standards concerning both the formats of transport data and the transport data exchange protocols, resulting to low or limited use and exploitation of the progress recorded in this domain.

Despite being a purely technological-related field, transport data exchange also faces significant challenges of such nature. A plethora of public and privately funded research activities in this domain already exists. However, actual exploitation of the R&D results is either limited or feasible only by few actors. Available solutions often fail to meet individual actors' needs. Transport domain actors, including several of the established industrial players with global orientation, need to face a new competition with "technology giants", who are particularly interested in prevailing transport services, mostly based on big data exploitation (e.g., self-driving vehicles). There is also limited knowledge within "traditional" transport sector actors, concerning the actual ways and technologies (e.g., processing, management, fusion, and AI-based technologies) with which significant benefit can be derived by transport data for a variety of potential applications. The usually unknown costs for investing in such technologies, coupled with uncertain understanding of the potential benefits, creates further barriers and challenges for the transport domain actors. Specific types of transport data, such as open data and linked data (related to semantics), are also significantly underexploited and the opportunities resulting from their existence need to be sought. Finally, the lack of data of acceptable quality, including data needed for scientific purposes, undermines the development of accurate transport models and limits the possibilities for completely new scientific discoveries.

5. NAPCORE activities

5.1. Project overview

The main idea behind the NAPCORE project is to set upfront a mechanism and future-oriented platform for the harmonization of NAPs with the vision of establishing their role as the backbone of ITS-related data exchange infrastructure. Activities included in the project's portfolio cover several dimensions. A first dimension includes the analysis of current and future developments, including relevant EU policy developments and mobility related initiatives, in an effort to streamline appropriately the strategic position of NAPs. The second dimension is focused on the analysis of the interoperability and level of service of NAPs, including the identification of requirements in terms of data standards, reference profiles, metadata, and supporting tools. This dimension also includes the proof of concept of interoperability demonstrators. The third dimension aims to extract data content requirements as well as the monitoring of NAPs content. This dimension also includes the analysis and further advancement of quality assessment frameworks and data visualization techniques, the clarification of terms and conditions for the re-use of data accommodated through NAPs, as well as the support of the enhanced use of NAPs in key application areas. The fourth dimension involves the enhancement and further development of data exchange standards and metadata common approaches taking into consideration new requirements and harmonization roadmaps. The last dimension is devoted to the development of harmonized processes for random inspections and compliance assessment considering advancements in data quality assessment frameworks.

5.2. Mapping of data categories

Even though data required for, stemming from, or in any case related to Intelligent Transport Systems can be categorized based on various criteria (e.g., timeline, thematic area, access conditions and geographical coverage), this section goes more deeply in the mapping of ITS-related data with respect to their thematic area. This mapping is considered as an important prerequisite for the identification of data content requirements of NAPs. Moreover, such a mapping can be implemented by considering the current state of play in the ITS domain but also future services.

The current state of play in the ITS domain is governed by the Delegated Regulations of the ITS Directive (2010/40/EU). There are four Delegated Regulations published by the European Commission, with each of them targeting a specific field of ITS domain. The first one (No. 885/2013) sets the specifications for the provision of information services for safe and secure parking places for trucks and commercial vehicles. The second one (No. 886/2013) does so for the provision of minimum traffic-related information about road safety to the end users. The third one (No. 962/2015) specifies the provision of EU-wide real-time traffic information services, while the last one (No. 1926/2017) frames the provision of EU-wide multimodal travel information services. The specifications set out by the above legislative documents involve, among others, the accessibility, exchange, and re-use of data required for the provision of the appropriate ITS services, the rules based on which such data shall be updated, and the framework for assessing their validity. Furthermore, in the annexes of these documents specific data elements required for the provision of the appropriate ITS services are defined and listed. These elements, which relate to the provision of both static and dynamic information, are summarized in Table 2.

Table 1: Data categories according to Delegated Regulations

Data categories	Timeline	Delegated Regulations	Example of data elements
Information about safe & secure parking areas	Static	DR: 885/2013	Locations and access conditions of parking areas
Information about the safety & equipment of parking areas	Static	DR: 885/2013	Security and refrigeration equipment
Information about the availability of safe & secure truck parking areas	Dynamic	DR: 885/2013	Status and space availability
Information about road safety-related events/conditions	Dynamic	DR: 886/2013	Location and category of events
Information about the road network	Static	DR: 962/2015	Road width, number of lanes, speed limits
Information about the usage of the road network	Static	DR: 962/2015	Traffic regulations
Information about roadway and roadside infrastructure	Static	DR: 962/2015	Locations of toll, charging, and natural gas stations
Road status information	Dynamic	DR: 962/2015	Bridge closures and availability of parking places
Traffic information	Dynamic	DR: 962/2015	Traffic volumes and travel times
Information for location search	Static	DR: 1926/2017	Park & Ride stops, bike sharing stations
Trip plan and auxiliary information	Static	DR: 1926/2017	Vehicle facilities such as classes of carriage, on-board Wi-Fi
Information for trip plan computation	Static	DR: 1926/2017	Timetables, PT network topology
Traveler services	Static	DR: 1926/2017	Toll payment, ticket buying and car booking guidance
Information for detailed common standard and special fare queries	Static	DR: 1926/2017	Passenger classes, common and special fare products
Passing time, trip plan, and operational information	Dynamic	DR: 1926/2017	Disruptions, estimated and predicted arrival times
Availability of services and relevant infrastructure	Dynamic	DR: 1926/2017	Availability of charging stations and car-sharing services

Besides the current state of play in the ITS domain, there are also other data categories which are not fully covered by the existing Delegated Regulations and the upcoming ones. As such, these categories need more analysis before their incorporation into the legislative documents. For such a purpose, in the frame of NAPCORE project, some future services are further elaborated aiming at interpreting both data types and data elements associated with these data categories. Such services include a) floating car data from connected vehicles, b) vehicle energy consumption, c) parking management, d) traffic management plans, e) C-ITS services. A brief description of these services is provided below.

Floating Car Data (FCD) is the product of one of the most widely utilized vehicle sensing systems, involving the detection and transmission at a sufficiently high rate (typically every several seconds to several minutes) via long-range communication means of the position of a vehicle to a data aggregation center. FCD are usually stemming from commercial vehicles (e.g., taxi fleets) and are providing insight on the traffic conditions of specific segments of the road network by understanding the trajectory and speed of each vehicle (Treiber and Kesting, 2013). Therefore, FCD provide a cost-efficient solution for assessing traffic conditions, supplementing conventional, infrastructure-based, data sources.

Vehicle energy consumption data constitutes another facet of vehicle connectivity providing information on the real-world vehicle fuel and energy use. Such data are a product of systems capturing the trajectories of vehicles and timeseries of fuel, energy, speed, and auxiliary power usage collected through on-board diagnostic (OBD) units that are either installed or pre-installed in a vehicle (Oh et al., 2020). Moreover, this data is useful for extending the scope of intelligent transport and traffic management systems beyond roadway safety and traffic efficiency by incorporating energy saving and greenhouse gas emissions concerns in line with the EU 2030 Climate and Energy Framework adopted by the European Council as well as the EU Green Deal roadmap.

Parking management includes a set of policies and strategies aiming to increase the efficiency of parking facilities usage (Litman, 2019). Parking facilities can be categorized into on-street, directly accessible from a street, and off-street, accessible by barrier-based payment systems (Pribyl et al., 2021). A key tool for parking management is the provision of information to road users, about parking availability, access conditions, regulations, and pricing. However, a challenge within the smart parking ecosystem is the coexistence of multiple actors and platforms providing parking-related data and information.

The concept of Traffic Management Plans (TMPs) includes a set of traffic management measures, and its primary purpose is to orchestrate their provision in support of specific traffic situations. The functional architecture of TMPs is divided into two sub-functions. The first one concerns the activation of these measures, while the second one the deactivation. Similarly, there are two main types of TMPs. The first type focuses on the provision of rerouting itineraries in order to avoid possible incidents and the second type follows a multi-measure approach serving various purposes, including the enhancement of traffic flow (Soriano et al., 2012).

Cooperative Intelligent Transport Systems (C-ITS) constitute a group of technologies, services, and applications that are based on the effective exchange of data via wireless communication technologies between vehicles (V2V), vehicles and infrastructure (V2I), and vehicles and everything (V2X), including, for instance, pedestrians and cyclists (Rondinone et al., 2018; Anaya et al., 2015). The application areas of C-ITS encompass, among others, road safety and traffic efficiency.

5.3. Added value scenarios

A crucial concern for the sustainability of NAPs within the ITS domain constitutes its practical utilization for the provision of beneficial services and facilitation of use cases classified into specific key application areas of added value and priority. This subsection aims, firstly, to identify and, secondly, provide a preliminary analysis of these key application areas.

The first key application area for NAPs is deemed to involve traffic operations. In this application area various added value user stories can be envisaged, including the use of NAPs to support the operation of virtual traffic management centers (VTMCs) as well as the use of NAPs as a C-ITS node. According to the Federal Highway Administration (2014), a VTMC performs functions related to the monitoring, control, and management of functional elements of a transport network through computerized systems and without the existence of a physical center. Requirements for the operation of a VTMC include the fusion of data providing information about traffic conditions and the availability of the appropriate tools to implement traffic control strategies and coordinate responses. NAPs can play a key role for fusing data to a VTMC offering the possibility to road operators to make accessible in real-time and at a national level traffic-related information following the same protocols and data standards. Furthermore, a VMTC can publish the measures deemed appropriate to treat incidents and better manage prevailing traffic conditions to NAPs as means of rendering them publicly known to service providers and coordinate their actions. This vision is closely associated with that involving the use of NAP as a C-ITS node. Kotsi et al. (2020) present a bundling framework for C-ITS services based on which the appropriate C-ITS services are broadcasted to road users in accordance with a traffic control strategy selected by a traffic management authority. NAPs can provide another layer/dimension for the bundling of C-ITS services by broadly disseminating the broadcasted services and allowing all service providers to be adapted to selected traffic control strategies and the content of broadcasted C-ITS messages.

A second key application area may involve urban mobility. A focal concept in this key application area is MaaS, which, as originally suggested by Hietanen (2014), constitutes a mobility distribution model in which an end user of a transport system is offered with bundled mobility services through a single interface. A core enabler of this model constitutes the availability of a proper "transport search engine" that will respond to queries, such as "how can I reach destination A given a set of preferences B". It is readily understood that the extent to which such services are operable and capable of providing valid results relies heavily on the availability of accurate and standardized data. Providing that these data are often held by multiple parties, including public or private mobility service operators and public governments, the only viable solution for the operation of such services is the existence of a neutral platform aggregating required data. Such a purpose can be purely served by NAPs. However, a challenge that needs to be overcome constitutes the harmonization of data standards and the alleviation of existing overlaps.

A third key application area for NAPs may involve the assessment of the impacts of natural disaster to transport operations. As it has been proved by several events in the past (Faturechi and Miller-Hooks, 2015) but also from very recent events (Reuters, 2022), there is an everlasting need to increase the resilience of transport systems and networks. This can be achieved through the definition and application of ex-ante and ex-post adaptation measures to such events (Mattson and Jenelius, 2015). Ex-ante adaptation measures involve to a great extent the prioritization of investments to reduce the impacts of harmful events, while ex-post adaptation measures involve the development and application of traveler information and advice services aimed at increasing the rapidity of transport systems and networks (i.e., dynamic resilience). What is common in both types of measures is the need for data. Concerning ex-ante adaptation measures, the availability of historical data enabling the assessment of the cross-modal impacts of harmful events constitutes an important intermediate step towards the identification of these investments that will indeed reduce the vulnerability of transport systems and networks. On the other, hand the provision of traveler information and advice services depends on the availability of real-time data providing an enriched operational picture to authorities tasked with managing traffic and unexpected events (e.g., traffic and crisis management centers). Several other applications areas may be envisaged for NAPs. These areas along with those presented will feed the scope of certain activities of the NAPCORE project.

6. Discussion and conclusions

ITS constitute a core driver for the future of the transport sector and especially for its adaptation to the new digital era. However, the degree to which ITS can drive the future of the sector one step further, greatly depends on the availability of suitable and reliable data streams. Hence, it becomes apparent that the availability of accurate and up to date data is essential in any case. This is exactly what NAP platforms try to achieve by accumulating transport-related data from various data providers and made them accessible to the public. Although the benefits arisen from the development and operation of such platforms are many, however, several challenges exist, making more complicate the process of data exchange. Therefore, the NAPCORE project is of great importance for the ITS community, considering that it seeks to provide solutions to the above-mentioned challenges as well as to clarify the future role of NAPs in ITS ecosystem.

Regarding the emerging challenge related to the complexity of multimodal travel services, the project aims, on the one hand, to fully clarify the corresponding Delegated Regulation by concretizing the underlying multimodal data categories and, on the other hand, to aggregate in a single interface multimodal data scattered across the web space. This will not only assist the data discoverability, but also the management and coordination of the actors involved in the multimodal transport ecosystem. Another significant challenge for which NAPCORE can provide a solid answer is the low rate of data exploitation. Such a challenge is bult upon the deficiency of knowledge of most end users about the legislation, the data standards, the reference profiles, and the licensing framework for data re-use. Subsequently, much of the available data is not properly exploited. For such a purpose, the project's agenda includes training activities targeting public and/or private authorities aimed at increasing their level of understanding and familiarity with data standards, data types, and terms and conditions for their re-use. Finally, NAPCORE intends to highlight a wide range of application areas and demonstrate the development of services making use of data exchanged by NAPs and, thus, conclude to the creation of several benefits for the ITS domain.

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