BENIP and CogInfoCom related issues in transport system planning

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***Abstract* — Nowadays the different kind of engineerings are more and more connected. It is true even in transportation. This situation pushing us forward to have a common, standardized description of the transportation system. The paper gives an overview on the existing standards and guidelines. It is showing the gap between system description and full description of the system and its environment, the user. Finally, we give a suggestion for a new integrated logic to describe system and user (behaviour).**

Keywords— system description, OSM, HERE, BING, user behaviour

I. Introduction

For the successful operation of transport in terms of traffic, it is necessary to have a uniform, standardized description of data and information with the help of data standards and data models. We show in Figure 1 the simplified information relationships for transport system data groups. The grey boxes represent the participants of transportation systems.

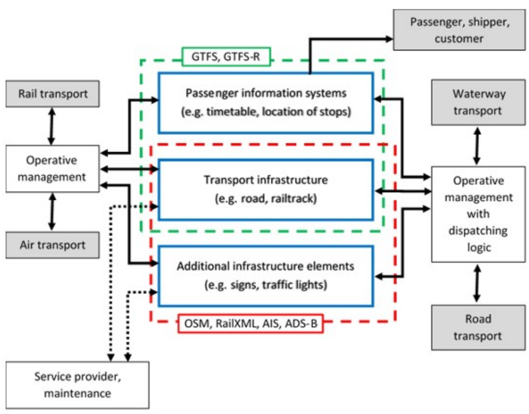

Fig. 1. Simplified information relationships between transport system data groups

The data group describing the transport infrastructure is shown in the centre of the figure. Nowadays it is almost impossible to control and locate vehicles without navigation. Navigation is, in fact, the science of orientation, which makes it possible to determine the spatial position of the elements of transport. In the 1950s and 1960s, a simple paper-based map was sufficient for a man, but self-driving vehicles require high-precision maps (HD Maps) [1].

This figure is a good addition to the BENIP logic [2] which is a comprehensive description of the full built environment. This suggested figure in this paper deals just with the part of the transportation system of the BENIP logic.

II. Role of Maps in Description of Transport Systems

TABLE I. Major Map Providers for Road Transport

Name of company	Founded	Remarks
Tele Atlas	1984	Since 2008 TomTom
Navteq	1987	Since 2011 Nokia HERE
TomTom	1991	
Mapquest	1996	Since 2019 System1
Openstreetmap	2004	
MSN Virtual Earth	2005	Since 2009 Bing
Google Maps	2005	
Waze	2008	In 2013 Google bought Waze
Bing Maps	2009	
Nokia HERE	2011	Since 2015 consortium of car makers
Here	2015	

As shown in Table 1 several companies have been involved in making road maps, however, this is a costly task depending on the level of detail. Making maps of the mainland is easier than an aeronautical chart which is a map designed to assist in the navigation of aircrafts or a nautical chart which is a graphic representation of a sea area and adjacent coastal regions.

In 2008 the EU published an Action Plan. This Action Plan aims to accelerate and coordinate the deployment of Intelligent Transport Systems (ITS) in road transport, including interfaces with other transport modes. [3] The first area - Optimal use of

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road, traffic and travel data - describes that the data are not standardized.

Nowadays, the primarily road map databases in Table 2 are widely used.

TABLE II. WIDESPREAD MAP PROVIDERS

Used name (known name)	Company or background
TomTom	TomTom N.V. co-work with some car maker
Openstreetmap	Mainly community based map
Google Maps	Google Inc.
Bing Maps	Microsoft
Here	Consortium of car maker

III. DESCRIPTION OF TRANSPORT SYSTEMS IN GENERAL

Nowadays, automation systems to support, or even to replace, human drivers have become a trend in the current Intelligent Transportation Systems research. They are called Advanced Driver Assistance Systems (ADAS) or Partially Autonomous Driving Assistance Systems (PADAS), depending on the level of automation considered. [4] In this article we deal with maps of road traffic, because in other modes of transport, regulation makes it much more possible to use machinery or autonomous systems.

The concept of a "cognitive vehicle" was proposed by Li and colleagues and defined as cognitive driving assistance systems, which – utilizing the findings of multidisciplinary engineering and cognitive science – is able to monitor and detect the errors of human drivers and correctly respond / intervene to avoid accidents. [5][6]

In 2014, 125 years after Bertha Benz completed the first overland journey in automotive history, the Mercedes Benz S-Class S 500 INTELLIGENT DRIVE followed the same route from Mannheim to Pforzheim, Germany, in a fully autonomous manner. The course taken by the autonomous vehicle had a length of 103 km and covered rural roads, 23 small villages and major cities (e.g. downtown Mannheim and Heidelberg). The route posed a large variety of difficult traffic scenarios, including intersections with and without traffic lights, roundabouts, and narrow passages with oncoming traffic. [7]

Although there were road maps, they were not detailed enough, so the preparatory work took more than half a year.

Lanelets are atomic, interconnected passable road segments which may carry additional data to describe the static environment. [6] One of the results of the project was the creation of Lanelet and later in 2018 the Lanelet2 (Figure 2).

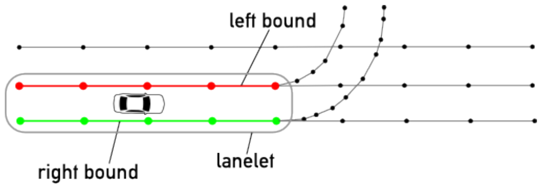

Fig. 2. Logic of Lanelet map [4]

Vehicle simulation is a special area, which also requires data. The OpenSCENARIO standard is used together with road network descriptions from ASAM OpenDRIVE and can use road surface profiles from ASAM OpenCRG. The three standards complement each other and cover the static and dynamic content of in-the-loop vehicle simulation applications.

Maritime and inland waterway transport also use standardized data groups. The automatic identification system (AIS) works by taking the ship position and movements via the vessels' GPS system or an internal sensor built into an AIS unit. That information is then collated along with programmable information from the AIS unit (e.g. Maritime Mobile Service Identity (MMSI) number, vessel name, destination, cargo type) and is transmitted in the background at regular intervals whilst also receiving other vessels AIS information. Some data provider collects this raw data and allows users to access this data. [8]

Road and waterborne transport require traffic management logic (e.g. traffic lights). There are initiatives to uniformly describe the logic, however, each firm uses its own data structures. The Open Traffic Lights project started from the need to publish the traffic lights data in the Smart Zone in Antwerp as Open Data. By using the Resource Description Framework (RDF) as a common model for representing knowledge, sensor observations are syntactically interoperable without necessarily having to support the same serialization. To enable this for traffic light observations, an ontology is needed to describe the signal phase and timing and how traffic can move over the intersection. [9][10]

On the left side of Figure 1, control logic also appears in rail and air transport, however, control personnel are also required here for normal operation. Safe driving requires the co-operation of the driving staff and the air or rail traffic controller.

In the case of rail transport, the European Train Control System (ETCS) set up by the EU provides a uniform data description. In different types of Technical Specification of Interoperability (TSI) [9] it is widely used not only in the EU but in many countries around the world. The Rail XML data model allows a uniform description of railway infrastructure and trackside elements.

Previously, there was no uniform airspace management in aviation. Nowadays, the ADS-B system provides accurate data about the vehicles, so together with the map information we can get an accurate picture of the traffic situation. This data can be partially retrieved from public databases, which manage the data in a unified structure. The OpenSky Network is a non-profit community-based receiver network, which has been continuously collecting air traffic surveillance data since 2013. Unlike other networks, OpenSky keeps the complete, unfiltered raw data and makes it accessible to academic and institutional researchers. [11]

In addition to drivers of transport modes, the fifth actor in transport is the passenger or the carrier. The General Transit Feed Specification (GTFS) describes the static timetable. [12] This standard describes only the timetable and the routes. Public transport uses another data model that describes the entire system, called TRANSMODEL. [13]

The systems described above use the data, but these data must be provided by different service providers. While only people used the data it was not so important to have a unified data structure.

Nowadays, machines are playing an increasingly important role, requiring a separate interface for each data set.

IV. Description of Human Behaviour, to Serve Human Behaviour

In the previous section we gave a detailed and historical overview on different kind of data and information descripted in transportation. We miss here one thing, the description of the human behaviour. We can have the question: Is it possible, or is it important? Yes, it is possible, and yes, it is important, as the planning and operation of the transportation system has double aims. First, it has to make possible the fast and safe moving of goods from sites via production to consumption. The other aim of the transport system to move people. To be able to serve this second aim, we have to observe and store human behaviour like mode choice, route choice or even trip generation activities.

There are already several studies dealing with this topic. It can be handled either as a general human-machine communication, like Baranyi et.al [14], [15] did, who defined the scope of human-machine interaction and the possible cooperation of related areas. Later on, Klempous et.al [16] developed further on Baranyi's definition with some applications.

In the field of transportation there were also trials on description of human behaviour in connection with general datasets. One of these is Rieser-Schüssler [17], who connected behaviour description with non-traditional data sources. Similar to this logic is Foell et.al [18] but from the viewpoint of the information service to the user, like transport information service.

If we are examining the connection of transport system and human behaviour one major point is the use of smart card's usage data, like described by Agard et.al. [19] Although his work is already 15 years old, the main statements are still valid, and usable. There is a good example by Briand et.al [20], who did a long-term examination to observe year to year changes in transportation behaviour on the basis of smart card data.

It is interesting, that the 15 years since Agard is a long time, but the theory did not become widespread as fast as it could be. A good example is Nagy et.al [21][22], who has to use "normal" passenger count information to simulate smart card data, due to the lack of smart cards.

More general and closer to our present approach is Sobral et.al [23], who did a trial to build up a time-space system to store any kind of relevant data, collected in transport system. Tibaut et.al [24] narrowing the focus from the general data description to just passenger information system, with the suggestion to define European Passenger Information System (EPIS). Alfonso et.al [25] turn to a closer look, by dealing just with urban areas in their data description model. The problem is with this latter two, that unlike Sobral [23] they omitted focusing on the description of human behaviour, they are going back to the pure description of the system. Therefore, it is a good step forward by Mnasser et.al [26], who following the way of Sobral on the ontology-based approach, to be able to include human behaviour in their model.

Although Richter et.al [27] are going a step forward with the inclusion of automated data sources, but the human behaviour is missing again. Similar to this Guerrero-Ibanez et.al [28] also dealing with the hard and really up-to-date question of integration different sources and datasets, but the human behaviour sinking again. We can see the same by Zheng et.al [29], who give a really comprehensive description of urban transport systems, but without the human behaviour.

Opposite to this is Pentland et.al [30], who described human behaviour to forecast possible reactions of drivers. This paper focuses on the human behaviour so the data and data standards are out of topic. Do we have connection between these two parts: data description and human behaviour? Malygin et.al [31] did a trial to describe human behaviour but also use standard data- and information sources.

V. Suggestion to a New System Description Logic

Based on the experiences of these papers we visualised a possible cooperation between data, datasets, standard descriptions and human behaviour, as Figure 3 shows.

The information described by several models like Zheng [29] or Guerro-Ibanez [28] or Richter [27] are the core of the service planning from the side of the infrastructure. But we have to connect it with the observed human behaviour to be able to give a service which is able to fulfil the user needs. We can image this process as two circles.

Fig. 3. Connection between standard datasets and human behaviour in transport system planning

The lower circle is the description of the infrastructure, signs, operation. At a given point this system affects the human, the user. It is enough to remember that we can drive further on freely through successive green lights, but we must stop at red light. Or we get in the bus if it is fit to us (and if we are informed on other relevant bus lines). At this point the upper circle is started. Based on the rules and/or guidelines of the "system" the human makes a decision. The planner/operator has to observe, store and analyse these decisions to fine-tune the system. This is the point, where the upper circle connects back to the lower circle. According to the result of the fine-tuning the standard description of the system has to be modified, like changing the bus schedule or the traffic light's program.

In this sense the whole process forms a closed circle of regulation.

VI. Possible directions of the future

As we could see most of the related papers and studies dealt just with the technical part of transportation systems. On the other hand, it is true that there are also several papers dealt with the human connection. The most relevant and promising direction is the cognitive info-communication. We have already some research also in this field, which results could empower our idea shown in Figure 3.

The most relevant paper in this field may be Horváth and Winkler [32], who shown the connection between pure mathematical journey planning and cognitive issues. Although Horváth [33] shown a more general approach about the same topic, it lacks the real practical usage. Similar to this is the paper of Csiszár and Földes [34], who gave a theoretical overview on cognitive characteristics in travel information services. Related to these papers is Horváth [35], who opened the focus even wider and not stuck just at the pure information services but dealt with the whole range of public transport.

These papers are good milestones to step further on. The thoughts and ideas of this research and the results of the cited papers give us a good mixture of knowledge to work further on.

VII. Conclusions

As at the evolution of any language or communication standard (like EDI, SWIFT…) if just two parties communicating with each other there is no need for special rules. But if there is a third participant, it is essential to describe the rules of communication. Due to the differences in usage and backgrounds the number of standards and guidelines in transportation are incredible. Most of them are suitable for general purposes as well.

On the other hand, we are missing the description of human behaviour in these descriptions.

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