SUPPORTING OVERALL INTEROPERABILITY IN THE TRANSPORT SECTOR BY MEANS OF A FRAMEWORK

THE CASE OF THE ITS STATION

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Abstract: The transport sector includes participation from different stakeholders, with different objectives and different responsibilities up front of each other. The information and communication technology available lays a ground for efficient collaboration by means of exchange of information between the stakeholders. Such information exchange requires interoperability at different levels. Technical interoperability is facilitated to a large extent by the information and communication technology; however, business level interoperability needs another set of means as facilitators. This paper presents some of the experiences of The Norwegian Public Roads Administration (NPRA) in achieving interoperability in its organisation, and in relationship with its external stakeholders. NPRA plays an important role in facilitating much of the transport in Norway, both acting as a public authority and as acting as the manager of the road network. To support the exchange of information between different stakeholders in the transport sector the roads administration supported the development of ARKTRANS, a framework for information exchange in the transport sector. The experience is that working only top-down is not enough to make interoperability happen. The specification of a roadside ITS station is a bottom-up approach, focusing more on the implementation of relevant standards and systems. This paper discusses how the two approaches meet, and how an overall framework after all may support interoperability at a business level.

Keywords: Transport, Traffic Management, Interoperability, Business Level, ITS Station

1. INTRODUCTION

The transport sector can be viewed as a part of the public infrastructure, a supply chain, a service provision or a business. The transport modes involved in Norway are road transport, rail transport, air transport and coastal transport. The transport sector is handling both passenger and freight transport. There have been several initiatives and activities aiming at developing frameworks and standards, supporting more efficient and reliable exchange of information in the sector. Many of these are related to one specific mode of transport or to a given activity, e.g. electronic tolling. There has been a political wish in Norway and Europe to improve the information exchange in the transport sector, across different transport modes. By doing so one hopes to be able to shift transportation of passengers and freight from road based transport to other transport modes. A better information exchange would also facilitate better utilisation of the transportation network, increased security and safety in the transport sector, and support the environmental sustainability in the sector. To be
able to improve the information exchange several means can be foreseen. The Norwegian road authorities decided to support the development of a framework for information exchange in the transport sector. ARKTRANS was specified and developed back in 2003, and has been evolving since. This paper presents ARKTRANS as a framework for information exchange (Natlivig, Westerheim, Moseng, & Vennesland, 2009). A specialized version of ARKTRANS has been developed, and named the Common Framework, it is focusing on the commercial actors’ needs for exchange of information when planning and executing logistics services (Hajdul & Cudzilo, 2011; Pedersen, 2012).

The main aim of this paper is to contribute to the research on interoperability by bringing in empirical experience from a specification case in Norway. The contribution is focusing on how an overall framework for interoperability may support the specification of an isolated system (e.g. the ITS station). The ITS station is specified based on open standards and specifications to ensure (technical) interoperability.

The research methods applied in this work are discussed in section 2 of the paper. Interoperability and interoperability frameworks, including ARKTRANS, are discussed in section 3. Section 4 presents the experiences of working both top-down and bottom-up trying to achieve interoperability. Section 5 is the conclusions.

This part introduces the Norwegian Public Roads Administration, its ITS Strategy and Action Plan, and the roadside ITS station.

1.1 ITS

The term Intelligent Transport Systems, ITS, was traditionally related to road traffic management. Jarašūniene uses the following definition: “ITS purpose is to gather information about traffic conditions and traffic flows on roads and to present it in non-distorted form for control systems (GPS, route control and creating public transport control systems, commercial transport control systems, electronic payment and tax collecting systems, etc.)” p. 62 (Jarašūniene, 2007).

The term ITS has been broadened in the latter years and has now evolved to include all types and levels of transportation, persons as well as freight, for which private industries offer a variety of extended, adapted and targeted services. The involvement of commercial stakeholders in ITS is especially the case for freight transport. (Crainic, Ricciardi, & Storchi, 2004). Terms like “Maritime ITS” and “ITS for rail” have been introduced, however ITS is still mostly related to issues in road transport.

1.2 The Norwegian Public Roads Administration (NPRA)

The Norwegian Public Roads Administration is responsible for the planning, construction and operation of the national and county road networks, vehicle inspection and requirements, driver training and licensing. On matter pertaining to national roads, the Public Road Administration is under the direction of the Ministry of Transport and Communications. On those related to county roads, the Regional Director is subordinated the county legislature.

The Public Roads Administration is under the leadership of the Directorate of Public Roads, which is an autonomous agency subordinated the Ministry of Transport and Communication. The Public Roads Administration encompasses five regional offices.

ITS is being deployed by NPRA in several ways, driven by different motivations. The existing road network is being supplemented by ITS, especially for critical legs, e.g. in tunnels and on bridges. The urban road network is also prioritised for ITS supplementation. ITS is a natural part of new road building projects.

One challenge with respect to harmonisation and interoperability of the ITS solutions is the fact that the regions have their own responsibility for planning and tendering the different projects.

### 1.3 The ITS strategy of the Norwegian Public Roads Administration

The Norwegian Public Roads Administration revised its strategy for developing, implementing and deploying ITS solutions in 2012 (Christiansen, Boag, Ruud, Trondsen, & Skjetne, 2012). The English summary includes the following statement on use of architectures and frameworks:

- NPRA will base ITS services on approved architectural principles and strategies for ICT,
- NPRA will use ARKTRANS as framework architecture,
- The agency will use open standards and specifications for ITS.

By following this strategy the roadside ITS station was to be specified so that existing standards and specifications were applied when applicable.

NPRA is participating in both national and international projects and activities with the objectives to promote and use open specifications and standards.

### 1.4 The Road Side ITS Station

The Public Roads Administration initiated a project with the objective to specify the functionality and information content of a roadside ITS station. The term “ITS”, Intelligent Transport Systems is defined by ETSI as “Intelligent Transport Systems (ITS) are systems to support transportation of goods and humans with information and communication technologies in order to efficiently and safely use the transport infrastructure and transport means (cars, trains, planes, ships)” (ETSI, 2012).

ITS may be deployed at different locations, the following ITS sub systems are most acknowledged:

<table>
<thead>
<tr>
<th>Personal ITS sub system</th>
<th>Central ITS sub system</th>
<th>Vehicle ITS sub system</th>
<th>Roadside ITS sub system</th>
</tr>
</thead>
</table>

NPRA has five road traffic management centrals in operation (TMC). These centrals use different systems and solutions for both the user interface for the road traffic operator and for the control of the equipment deployed in the road network. One main challenge in controlling the Norwegian road network is the extensive net of tunnels. These tunnels are kept under surveillance by different monitoring systems, including video cameras and sensors. NPRA has equipment from different vendors installed in different tunnels.
The motivation for initiating the work with the specification of an ITS road side station was based in the fact that the different TMCs use different systems and have different interfaces applied to different systems and different equipment. The idea was to have one set of specifications to be used when all types of roadside monitoring and control equipment were specified and purchased, and the same also for traffic management solutions and systems. The ITS station was intended to act as a “hub” where local sensors and equipment were connected, and information from these were collected before being communicated to the TMC’s systems.

Selecting the roadside ITS station specification before working with the others was motivated in the idea that NPRA needs to have a good solution in place for collecting data from the road network in the first place. Secondly, communication with the back-office solutions, the vehicles and the drivers can be addressed.

The specifications were to be based on existing standards, e.g. technical standards, where available. In addition, the specifications were to be based on the overall structure taken from ARKTRANS. The main motivation for using ARKTRANS in the work was to be able to make sure that the overall harmonisation was taken of. The project was well aware of the fact that using technical ITS, or ICT, standards is a prerequisite for achieving technical interoperability. The current organisation of the traffic management functions, in five separate traffic management centres, requires some means to be able to harmonise the functions of the centres, and between the centres. One could see many possible motivations and activities for working towards this overall harmonisation, even a separate project. Waiting for explicit activities addressing this issue, implementing means in every specification and development project that works for more harmonisation is one approach. The idea is that ARKTRANS can support this.

The specification project identified two existing standards being relevant for the roadside ITS station. OPC UA was found to be the natural standard for communication between the sensors and equipment in the road network and the ITS station. The OPC UA standard was developed for interoperability in industrial automation (Hannelius, Salmenpera, & Kuikka, 2008; Leitner & Mahnke, 2006). The standard is well suited in situations where small amounts of data need to be transferred at a high frequency, which is the case for sensor data to the ITS station. The DATEX II standard was developed as a standard for traffic data and road network data (Engel, Mobius, & Diedrich, 2013; Garrigós, Zapater, & Durá, 2011). This standard was chosen as the communication standard for information exchange between the ITS roadside stations, and between the ITS roadside station and the back office systems deployed at the traffic management centres.

2. RESEARCH METHOD

2.1 Qualitative research

The most common distinction between research methods is the distinction between quantitative research and qualitative research (Venkatesh, Brown, & Bala, 2013). The first approach origins from natural sciences and the most used methods are surveys, laboratory experiments and numerical methods, e.g. use of statistics. Many of the methods require several data points to be able to support data analysis.

The qualitative research methods origin from social sciences. The main objective was to enable the studies of social and cultural phenomena (Myers & Avison, 2002). Action research, case study research and ethnography are examples on qualitative research methods. The data sources include interviews, questionnaires and observation.

Since this study was to observe an on-going project, with a relatively few persons and meeting involved, the qualitative approach was chosen.

Action research is based on joint collaboration between the affected people in the study and the researchers. When applied to research in computer science this approach is often closely related to studies where artefacts are specified and developed with close support from the researchers. The researchers in the following study the qualities and impact of the artefacts.
Ethnography is heavily based on fieldwork, where the researcher immerses very much into the people and the phenomena to be studied. This approach can also be applied to the studies in computer science and information systems (Holtzblatt & Beyer, 1993).

Case study has been applied in this research (Flyvbjerg, 2006; Yin, 1994). The main artefact to be developed in the project was the set of overall specifications for the ITS station, and this was to be done with little involvement from the researchers. The action research method would then not be suited for the study. The short timespan of the project, where the participants only spent little of their total working hours in this particular project, made the ethnography method not suited for this study.

The main contribution from the study is on a possible support of an overall framework for interoperability into the specification of an isolated system (e.g. the ITS station) where technical interoperability was achieved by means of use of standards.

2.2 Description of the setting

The work with the specifications for the ITS station was not driven by this study. The project was initiated by the NPRA. SINTEF Technology and Society ran the project and delivered the results to NPRA as a SINTEF report. The follow-up of the specification project is a tendered research and development contract with a commercial software company. Since the researcher had access to the project’s participants during the work, and also to the documentation produced, observatory case study was selected as the best way to collect data from the work in the project. The project was organised as a small project where the NPRA representatives gave the initial requirements. NPRA has developed an ITS strategy which states that ARKTRANS should be used as a the overall framework in the development of future ITS solutions (Christiansen et al., 2012). The choice of ARKTRANS was hence given for this development project. The ITS strategy is followed by an ITS Action Plan, where more detailed guidelines for ITS development are given. This action plan advises all ITS development activities to base the work on accepted formal standards, or industrial standards, where applicable. Possible standards where identified as an initial part of the project.

2.3 Selection of participants

The project was a small project. NPRA possessed the role of project owner by having one person responsible for the functional requirements, and by having one person responsible for the technical requirements.

The project team by SINTEF Technology and Society was two persons; the project manager was a senior researcher with a functional focus on traffic and traffic management. The second team member was a researcher with deep insight into the ITS technology, and possible standards for ITS development. This included also knowledge of semantic standards for exchange of traffic and road condition data.

All these persons were subject for observation during the project work.

2.4 Data collection procedures

The researcher was present during five project meetings in total.

Notes were taken during observation of the project meetings, and short observatory reports were written. The researcher was able to discuss the work process and the preliminary results with the project’s participants. This was done without producing an interview guide in advance.

The documentation produced during the project was read, and analysed with respect to possible positive or negative influence by ARKTRANS on the work in the project, and on the final outcome of the project activities. Evernote\(^1\) was used as tool for taking notes during the project meetings and discussions.

\(^1\) http://evernote.com/evernote/
All the data in this study is empirical, and taken from a real specification project. The resulting SINTEF report was also discussed with representative from NPRA after the end of the project. These representatives were not involved in the project, but have responsibilities for the ITS strategy of NPRA, and have to a certain degree knowledge of ARKTRANS. Observation reports were written during this summary.

2.5 Data management and analysis procedures

All the data from the observations was collected by means of Evernote and kept as notes in a dedicated notebook for this study. The notebook was stored locally on the researcher’s computer, with back up to a Time Machine every day. The notes in the notebook were tagged. The tagging was done in Excel. The initial set of tag was small, including interoperability, technical interoperability, overall harmonisation, ITS standard, ARKTRANS, ARKTRANS support, functional requirement, technical requirement, technical discussion and left open. The tagging process diverted some more tags.

3. INTEROPERABILITY

3.1 Technical interoperability

The development in information and communication technology has removed many barriers in inter-organizational cooperation. The cooperation is fully possible at a technical level as stated by (Huhns & Singh, 2005) and (de Vries & van Wessel, 2013). The technical interoperability can to a large extent said to be present. The term technical interoperability needs a definition. This paper is based on the definition from IEEE, defining technical interoperability as "The ability of two or more systems or components to exchange information and to use the information that has been exchanged" (IEEE, 1990). There are two important issues in this definition. Firstly, systems or components are not being interoperable of they are not able to actually exchange information. This issue requires a definition of standardised interfaces to be deployed in the involved systems or components. Secondly, the information transferred between the different systems and components has to be put in a context where the understanding of the information is clear so that the information can be used in the right way.

3.2 Business level interoperability

Business level interoperability is defined by (Legner & Lebreton, 2007) as “The organizational and operational ability of an enterprise to cooperate with its business partners and to efficiently establish, conduct and develop IT-supported business relationships with the objective to create value”.

The business level interoperability cannot be achieved and maintained in an efficient way, with a good quality, without the present of technical interoperability. The set of interoperable and interconnected systems and solutions serves as an information infrastructure, where the physical and semantic communication of information is well working. To be able to achieve this situation there is a need to work both bottom-up and top-down. The bottom-up approach can secure the needed set of standards for communication and interconnectivity, linking the systems and solutions themselves. The top-down approach is needed to make it possible for the business to harmonise the functions and responsibility up-front of its business partners.

The business partners of the NPRA would be on one side the car drivers and the transporters, represented in the ARKTRANS reference model in the sub domain of Transport Supply, the third party service providers, represented in the ARKTRANS reference model in the sub domain of Transport Sector Support and by the different authorities involved in transport, represented in the ARKTRANS reference model in the sub domain of Transport Regulation.

The present organisation of the NPRA, and the tradition of implementing systems, have lead to a situation where the different regions, and the Directorate of public roads, can be seen as business partners to
themselves. The relationships between functions and responsibilities in the different units need ICT support to create the better value, both for internal partners, and for external stakeholders.

3.3 The role of interfaces

Interoperability in digital government can be presented at different maturity levels as reported by (Gottschalk, 2009). The discussion is judged to be valid also for the transport sector.

This paper use the following definitions for interoperability:

Semantic interoperability is defined as the extent to which information systems using different terminology are able to communicate. Organisational interoperability is defined as the extent to which organizations using different work practices are able to communicate (Gottschalk, 2009).

Both of these levels of interoperability are based on an under laying ICT infrastructure that is interoperable.

The different maturity levels defined for interoperability are:

1. Computer Interoperability
2. Process Interoperability
3. Knowledge Interoperability
4. Value Interoperability
5. Goal Interoperability

The Value Interoperability and the Goal Interoperability are defined for organisations that are able to have a continuous two-way sharing of both information and functions/processes. This will never be the case for the ITS station and the NPRA’s role up front of the drivers.

The Process Interoperability and the Knowledge Interoperability are based on exchange of information between the involved stakeholders. Such an exchange requires interfaces to be defined and implemented. The interfaces need to be aligned to internal processes, functions and documents/information structures, as described by (Legner & Lebreton, 2007):

![Diagram showing business level interoperability and interfaces](image)

**Figure 2: Business level interoperability and interfaces**

Linking globally views and interfaces as proposed by (Legner & Lebreton, 2007) is well aligned with the ideas behind the reference model in ARKRANS.
3.4 Frameworks for interoperability

Enterprise Architecture frameworks are related to the possible technical implementation of an organisation’s needs for information management. There are several frameworks available, having different stakeholder’s interests and viewpoint as main focus (Stelzer, 2010; Urbaczewski & Mrdalj, 2006). An Enterprise Architecture Framework relates the organisation’s goals and objectives to work processes and to an IT infrastructure required to execute the work processes. Some named Enterprise Architectures frameworks are the Zachman Framework for Enterprise Architecture (Zachman, 1987), the Department of Defence Architecture Framework (D. A. F. W. Group, 2003), the Federal Enterprise Architecture Framework (Ji & Xia, 2007) and the Open Group Architectural Framework (TOGAF) (T. O. Group). A specific focus on interoperability especially between cooperating organisations is not the main issue of these frameworks.

The Information Technology Infrastructure Library (ITIL) is also presented as a framework, aiming at supporting effective and efficient management of IT service from overall strategy to improvement of existing services (Gama, Silva, & Francisco, 2011; Nabiollahi, Alias, & Sahibuddin, 2010). This framework is aligned with the Enterprise Architecture approach. This framework has an indirect focus on intra-organisational interoperability, via the focus on IT services.

The changing environments of an organisation, and the need for more rapid changes in the architectures have led to the service-oriented architecture approach (SOA). Especially service composition and orchestrations are strong benefits of the SOA (Chen, 2008; Tsai et al., 2007). This is related to overall interoperability.

The European Interoperability Framework is addressing the technical, the semantic and the organisational aspects of interoperability (CompTIA, 2004). The later versions do also include the aspects of legality and policy.

The different frameworks include definitions and layering that are valid for wide sectors, like the public sector or the commercial sector in general. The adaption to a specific sector, like the health care sector or the transport sector, is missing in these frameworks.

3.5 ARKTRANS

The work with the Norwegian framework for information exchange in the transport sector started in 2000 with a feasibility study. The main development project was a three year research and development project, ending up in the framework ARKTRANS. The authorities for all transport modes gave contribution to the development of ARKTRANS. So did also the truck driver association, the state railway company, service providers and software development companies.

The working approach chosen was top-down. It was also a target to keep generic whatever could possible be generic. The content of the framework is layered:

![Diagram of ARKTRANS framework](image)

*Figure 3: The content of ARKTRANS*
The layer of overall conceptual aspects is documented by means of a reference model, and by textual descriptions of the included roles and objects. The roles and objects are linked to one, and only one, sub domain in the reference model. The roles and objects are generic ones. The idea is that different real life stakeholders will possess different roles in different settings. By using this approach is it possible to avoid overlapping functions and responsibilities, and the same set of roles and objects can be mapped to different organisation of stakeholders in the real life setting.

A more standardized notation, taken from requirements analysis and software development, documents the layer of logical aspects (Ghezzi, Jazayeri, & Mandrioli, 2002). This layer is documented by means of UML Use Case diagrams, UML class diagrams and a functional breakdown of the functions.

The technical aspects of the framework are not completely documented. The main idea has been to work on the non-technical issues related to business in the transport sector first. Both the process of developing ARKTRANS, and the use of the framework have shown that doing the conceptual and logical specifications, without taking into account the available technologies, have proven to be good.

The main purpose of the framework is to facilitate interoperability in the transport sector. The framework has been presented for a lot of stakeholders in the transport sector, and the feedback on the structure and the content has been mainly positive. The framework has been the basis for specification work in several national and international research and development projects, and the projects have partly evaluated and confirmed different parts of ARKTRANS.

One major drawback with the ARKTRANS framework as seen so far is the lack of good links between the non-technical and the technical issues when it comes to interoperability. This counts for the content, and also for the process of using ARKTRANS.

**The Reference Model**

The ARKTRANS reference model is dividing the transport sector into sub-domain, to which a set of roles, a set of functions and a set of responsibilities are assigned. There is no overlap between the sub-areas.

The sub-domains being part of the transport sector are transport demand, transport supply, transportation area management and transportation regulation. The last sub-domain is transport sector support that can be regarded as associated as the functions and responsibilities defined are not directly influencing the transport sector, e.g. the banking sector and the telecom industry.

![Figure 4: The ARKTRANS reference model](image)

The Norwegian Public Roads Administration possesses the roles in the sub domains of Transportation Infrastructure Management and Transportation Infrastructure Utilization while performing its main functions.
The functions that would be deployed in a roadside ITS station belong in the sub domain *Transportation Infrastructure Utilization*.

**The Roles and Objects**

The roles and objects defined in ARKTRANS are *generic*, with the idea behind that they should be applicable to different organisations, with different sets of stakeholders, acting in the transport sector. The roles and objects are linked to the reference model in such a way that one role or object belongs to one sub-domain in the reference model only.

**Figure 5: The set of roles in ARKTRANS**

The figure shows the set of overall roles, related to the sub-domains in the reference model. The overall set of roles is decomposed into about 80 detailed roles.

**The Logical aspects**

The layer of logical aspects in ARKTRANS includes the functions, the information models and the process models. The level of detail in this layer is so that the models can be used as examples, or templates, for a specific solution. The functions are sorted according to the reference model. The functional decomposition of the functions are depicted by means of *mind maps* and explored by a textual description. The functions are presented at a level that makes it possible for externals to understand what is performed within the responsibility of a role and sub-domain, without needing to understand the internal logic or organisation of the functional performance.

The information models are detailed so that it is possible to use them as a basis for XML-messages for use in a system or solution. The main focus is on the content of the information packages, not on the structuring of the information within them. UML class diagrams are used to document the information models.

UML activity diagrams document the processes. The roles, functions and information elements are taken from the overall level in ARKTRANS and from the functions and information model.

**The Technical aspects**

This layer is not fully documented in ARKTRANS. However, some examples are presented, based on the content of the layers above.
The main idea is that this layer should in more detail, linked to current technology (e.g. XML, HTTP, Web-services), show how the overall concepts in ARKTRANS might be implemented.

The on-going discussions on the possible use of ARKTRANS show that there are different opinions on how this layer could be documented, in a generic way, of possible at all. The work with the ITS station would hopefully give an indication on the usability of this layer.

4. FINDINGS: USE OF A FRAMEWORK ON A LOCAL SOLUTION

The specification of the ITS station was conducted as a single project. The project manager, and main responsible for the work, had good knowledge of the ARKTRANS framework.

The specifications involved assessment and choice of technical standards to be applied. The project manager had little knowledge of these issues. The project participants responsible for this part of the specifications had on the other hand little, or no, knowledge of the ARKTRANS framework.

There are standards for information exchange that can be applied to the specifications of the ITS roadside station, like the ETSI standard (ETSI, 2012) and the DATEX II standards (CEN, 2013). By using these standards one can assure technical interoperability between different implementations of the ITS station on the Norwegian road network.

In such cases, where one could choose either to specify the solution from scratch, including only the information structures, and hence the processes, needed for the solution or one could choose to apply or align, to given standards and frameworks.

By specifying the solution from scratch one would most likely get a more efficient and optimal solutions for the given solution. By applying standards and frameworks one would implement overhead and unnecessary elements and structures, not supporting the solution, but being requirements from the standard or framework.

The situation arising for NPRA is that the collection of optimal, local solutions makes difficult the total portfolio of systems and solutions needed to fulfil the responsibility NPRA holds up front of the other stakeholders in the transport sector. This will also influence on the internal communication between the different regions, the different traffic management centres and the different systems and solutions.

Even though ARKTRANS as an overall framework does not include technical specifications at the level needed by the roadside ITS station, the project felt that ARKTRANS was supporting the work. One possible danger by involving such overall frameworks in a technically oriented project is that it brings in overhead. In many projects this would be a negative influence on the project. One cannot expect that individual projects like the one reported here can take responsibility for the whole of an organisation, not at the technical level, and not at the business level.

By providing a set of technical standards and specification to the project NPRA has taken one step in the direction of having common, or even identical, local technical solutions. This will to a large extent fulfil the technical interoperability of the different implementations of a roadside ITS station in the future.

The functional interoperability, linked with clear responsibilities in the business process to take place, also the business level interoperability has been safeguarded. In this case study it was not such that this posed overhead to the project, however, this is most likely due to the knowledge of ARKTRANS involved in the project.

The overall framework did not hinder the work in the project. The participants felt that especially the functional description in the ARKTRANS framework did serve as a valuable input, as an initial set of functional requirements. This observation gave support to the idea of having an overall framework as an overall harmonisation mechanism at the business level.

The project participants did not find any direct support in the framework when trying to identify possible technical standards to be applied for the data communication needed for the ITS station. When the standards
were chosen, based on knowledge of the standards by the project partners, there was no support in the framework to judge the feasibility of the standards. However, the information structures could be helpful in the first round of identifying what type of standards that could be feasible in this case.

5. CONCLUSIONS AND FURTHER WORK

The specification and implementation of a local solution, like the roadside ITS station, would most likely benefit from not taking a total picture as provided by ARKTRANS into account. The experience from the Norwegian Public Roads Administration however shows that this benefit is short lived.

The findings in this study can be summarised in two main issues:

1. With a short-term view, focusing only on the “local” success of the single project (e.g., delivering the wanted functionality, within time and budget), a framework like ARKTRANS would likely not be helpful. Rather it might contribute to increasing the cost or development time of the project. The local benefits are achieved by adhering to a set of open standards and specifications, e.g. DATEX II and UPC/UA.

2. With a more long term view, considering the interoperability between the system delivered in the current project and other systems – some already existing and some yet to be built – the picture is different, in the favour of using a framework like ARKTRANS. Taking some extra cost up front to facilitate also business level interoperability will contribute to avoiding a much larger extra cost later, related to having systems with poor business level interoperability. Such later extra cost could either be double work (e.g., having to register information twice because lack of interoperability prevents automated sharing of the information), poor decisions because of lack of information, more costs related to interact electronically with external stakeholder, or rework to make systems more interoperable after delivery.

By having a very short time focus each individual solution would most likely benefit from being specified from the scratch. The reason for stating so is that in such case only the necessary information elements and only the necessary functions for the local solution would have been specified and implemented. This would have reduced the size of the program code and also the set of information to be stored, processed and exchanged.

5.1 Further work

When the specifications for the roadside ITS station are concluded, there will be a practical implementation based on the specifications. The time for developing and implementing a roadside ITS station should be measured. Included in this measurement there should be an estimate on possible extra efforts due to the alignment with both open standards and specifications, and with the ARKTRANS framework.

In a large organisation like the Norwegian Public Roads Administration there will never be extensive knowledge of overall frameworks like ARKTRANS in all the development and deployment projects. This is even truer when taking into account the fact that many projects are tendered, and accomplished by external companies, e.g. software development companies. These companies do often have own standards and methods to be applied during such projects. One interesting issue to do further research on is how to actually document ARKTRANS, so that both internal and external development and deployment projects can take advantages of the framework. Linked to this it would also be of interest to look at the means NPRA can apply for increasing the use of ARKTRANS.

Further research

The link between the content of an overall framework on one side, including overall sub-domains, a set of generic roles, objects, functions and information models, and more technical frameworks and standards,
should be further research. One topic of interest would be the trade-off between the overhead time and costs needed to be taken by the individual projects and the possible benefit on the organisational level.

The content of an overall framework should ideally be documented such that actual specification and development projects can adopt, and use, the concepts more or less directly. This issue is not in focus in this study, but should be further researched.

This study concentrated on the road network, and the need for standardisation in this mode of transport. The possible support of an overall framework in a *multimodal* setting should be further studied, especially the form and content of the documentation.

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