REFINEMENT AND EVALUATION OF THE ARKTRANS FRAMEWORK THROUGH USE IN TRAVEL INFORMATION SERVICES

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ABSTRACT

ARKTRANS is the national framework architecture for multimodal intelligent transportation systems (ITS) in Norway. This paper describes an action research approach where ARKTRANS is improved through practical use in a project addressing multimodal travel information services. The usability of ARKTRANS with respect to person transport, travel information service and multimodality is assessed. An overview of the content of ARKTRANS that supports the establishment of new and improved travel information services is given: The roles played by the stakeholders involved; the functionality needed by these roles; process descriptions showing interactions between the roles; information exchanged via open services; and the technical implementation of these services.

Keywords: ITS framework architecture, multimodal, travel information services, person transport, action research

INTRODUCTION

ARKTRANS is the national framework architecture for intelligent transport systems (ITS) in Norway. The framework is multimodal, i.e. common to all transport modes (sea, road, rail and air) and covers the whole transport sector, freight and person transport included. ARKTRANS was established as a joint effort of transport authorities, transport operators and transport network owners representing all transport modes. The first version of ARKTRANS was completed in 2004 as a result of a national research project. Since then, ARKTRANS has been used in national and European projects, and the content has continuously been refined. The Norwegian transport plan [1] states that ARKTRANS is to be used in ITS projects.

This paper describes an action research approach where ARKTRANS is improved through use in a project addressing multimodal travel information services, the MultiRIT project. The usability of ARKTRANS is evaluated with respect to needs identified in the MultiRIT project.

The content of ARKTRANS

As mentioned above, ARKTRANS was established in collaboration with a broad spectre of stakeholders representing all transport modes and all transport types (freight and passenger transport, private and public transport). This work also included studies and use of related work on ICT architectures in general and existing architectures for road transport like KAREN and the US National Architecture for ITS [2-4] as described in [5-7]. However, ARKTRANS differs from related work due to the multimodal specifications and the strong

focus on interoperability. As far as we know ARKTRANS is the only multimodal framework for ITS. A top-down approach is used, and the Reference Model and the Roles were defined in the beginning of the work. The logical aspects are built strictly on the definitions in the overall concepts.

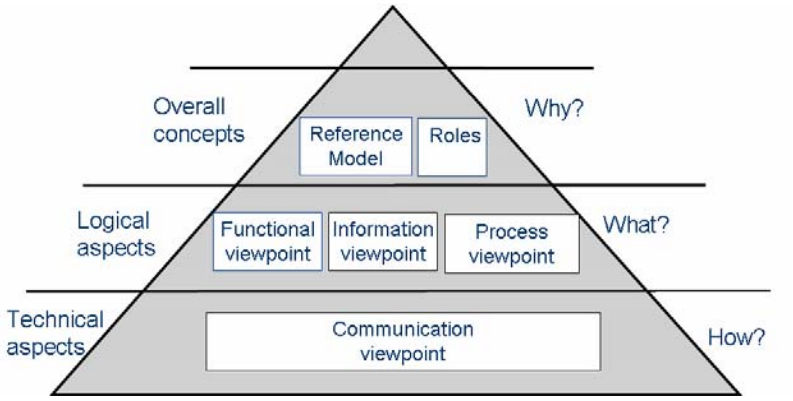

Figure 1 The content of ARKTRANS

The MultiRIT project

The MultiRIT project addresses new and improved multimodal travel information services directed towards the transport users, i.e. those who plan to travel; those who are travelling by public transport; users of the road network; and those who combine different types of transport [8]. The project aims to arrange for the implementation of travel information services by means of open and multimodal interfaces supporting information exchange. Such interfaces arrange for more efficient collection of the information needed for the composition of travel information services. By means of the open and multimodal services, third-party travel information service providers will be able to build new and improved travel information services based on information received from a wide range of travel information providers (see Figure 2). Transport companies representing all transport modes should for example provide route information and dynamic information about delays in the same way.

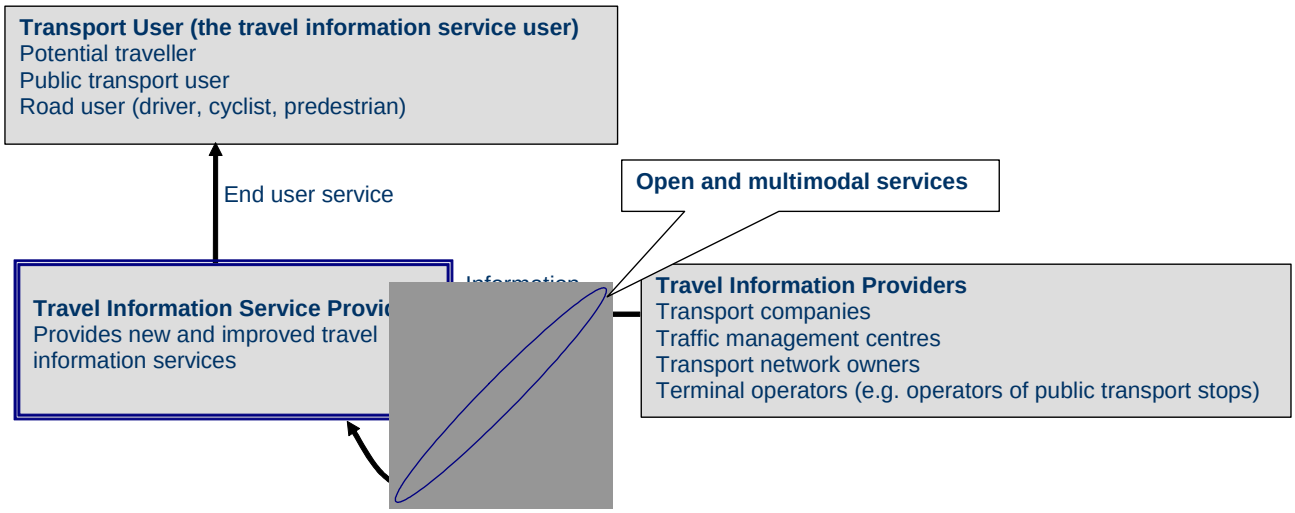

Figure 2 The MultiRIT idea – Open and multimodal services enabling new and improved travel information services

Stakeholders representing all transport modes and relevant roles (travel information service providers, transport companies, owners of public transport stops, traffic managers, end users,

etc.) participate in the MultiRIT project. ARKTRANS is used to analyse the requirements and as a starting point when specifying functionality, relationships, information and interfaces.

The motivation for this paper

The establishment of ARKTRANS was based on assumptions about the usefulness of an ITS framework that is common to all transport modes. Despite of positive feedback, there is a need to document the usability and usefulness of such a framework. This paper addresses the following questions on whether ARKTRANS supports work on:

- The person transport aspects addressed by the MultiRIT project
- The travel information service aspects addressed by the MultiRIT project
- The multimodal approach required by the MultiRIT project

This paper also describes how ARKTRANS was used in the MultiRIT project; the experiences gained during this process; and how the results and experience are transferred into generic knowledge that is used to refine the ARKTRANS framework.

METHOD

The method used to answer the questions listed above is inspired by Davidson's article on canonical action research [9]. This implied that the researchers take part in the MultiRIT project and contribute to new generic knowledge through use of a theory, in this case the ARKTRANS framework. The new knowledge gained is used to refine ARKTRANS. The main elements of the method are: a cyclical process model enabling change through action and learning through reflection; and an agreement between the participants on how to carry out the research.

The cyclic process

Figure 3 illustrates the cyclic process in action research as suggested by Davidson et al. [9] and how the work described by this paper is organised into projects. The cyclic process has 5 steps. The current situation (problems, environment and causes) is diagnosed. Based on the diagnosis, the actions are planned. The planned actions are taken to improve the solution. This may include interventions done by researchers. Experience and results are collected and evaluated in the fourth step. In the last step, the learning by reflection, the current version of ARKTRANS is updated according to the new generic knowledge gained.

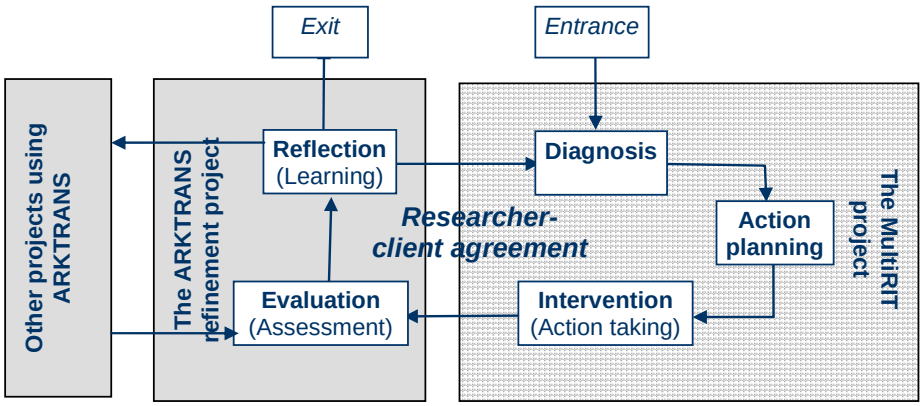

Figure 3 The action research model (based on [9]) and the project organisation

The first three steps are carried out as a part of the MultiRIT project. An ARKTRANS refinement project, managed by the researchers, is however responsible for the evaluation and

reflection. Coordination and collaboration are ensured through involvement of the same researchers in both projects. Input from other projects using ARKTRANS is also considered by the ARKTRANS refinement project, but is not described by this paper.

Agreements with participants

According to Davidson et al. [9], it is important to have formal agreements with the clients on how the action research is to be carried out to ensure the required collaboration and quality of work, and the agreement should reflect the objectives of the research.

The MultiRIT project has a project plan where the use of ARKTRANS and the contributions to the ARKTRANS refinement through a continuous and iterative cyclic process are described. This plan is accepted by all participants. There are also suggestions on how the intervention and the improvement should be carried out through the use of working groups, distribution of intermediate versions of ARKTRANS and collaboration with the ARKTRANS refinement project. In addition the ARKTRANS refinement project also has a generic plan on how to collaborate with projects that provide input to the refinement of ARKTRANS.

Progress and results are reported both from the MultiRIT and the ARKTRANS refinement project, and the results are documented in new versions of the ARKTRANS framework. After the first year of MultiRIT, version 5 of ARKTRANS [10] was established. The second year just an intermediate version was established as the updates also had to be coordinated with input from other projects. After the third and last year of MultiRIT, a new official version of ARKTRANS will be available in 2008.

Involvement of project participants

In general the MultiRIT participants are very motivated for the use of ARKTRANS and for contributing to the refinement of the ARKTRANS framework. The ARKTRANS framework is explained to them and the solutions are to a large extent specified by means of further processing and detailing of specifications extracted from ARKTRANS.

There are dynamic work groups focusing on different views (functionality, information and process) and different types of functionality (provision of dynamic travel information, public transport stop information, accessibility, etc.), and the ARKTRANS specifications are discussed and modified according to the needs in MultiRIT. The researchers are leading the work. In parallel they evaluate the outcome, extract knowledge and update ARKTRANS to reflect new generic knowledge. Inputs from similar processes in other projects are also considered as a part of this process. Some of the MultiRIT participants also voluntarily take part in the evaluation and reflection.

RESULTS

By making generic descriptions of the transport sector, as seen from different types of stakeholders, the ARKTRANS framework is intended to support the specification of ITS solutions. The functionality and services needed, the interactions between stakeholders, and partly also the information exchanged are described.

The diagnostic step in Figure 3 supports the clarification of the requirements in MultiRIT. This can to a large extent be done by means of the different aspects and views of ARKTRANS (see Figure 1). In the action/intervention step the theoretical ARKTRANS framework is imposed on the issues focused by MultiRIT, and new solutions are specified by means of amendments to the different viewpoints of ARKTRANS. The usability of ARKTRANS depends on the degree of support to this process. To improve this usability, the results are evaluated, and the content of ARKTRANS is refined according to what is learned (the evaluation and reflection steps).

Reference model, roles and functional view

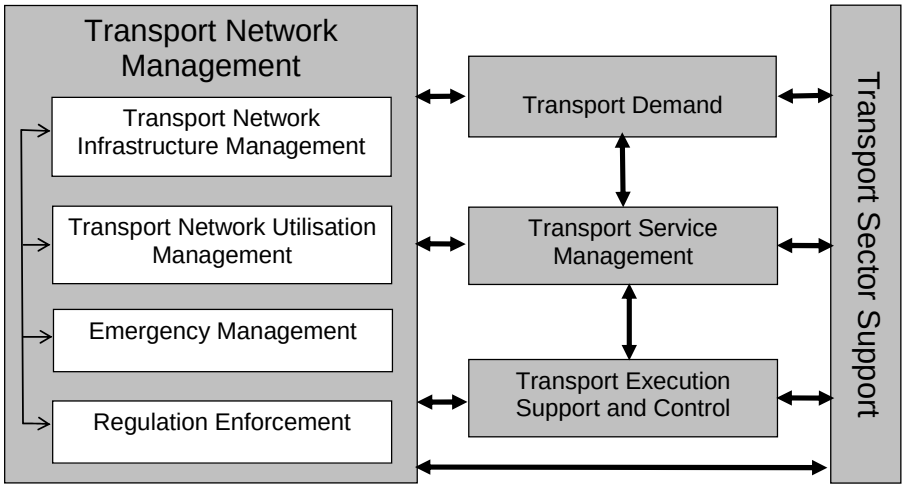

Figure 4 The ARKTRANS reference model

The ARKTRANS Reference Model in Figure 4 divides the transport sector into sub-domains. These are used to define the context for the study, and they are together with their functional decomposition (in the functional view) used in the diagnosis step to identify the functionality to be addressed. The actions and intervention step works on the relevant parts to find the best possible solutions. The results are provided to the evaluation and reflection steps. Table 1 summarise some of the results.

Table 1 Basis for diagnosis and action planning

Domain in reference model	Focus in functional view that is of relevance to MultiRIT (just a sub-set of the total functionality)	Role (generic stakeholder type)
Transport Demand	Support potential transport users (i.e. those who are going to travel) in o Finding best transport alternative with respect to route, schedule, services, stops, facilities, accessibility, etc. This includes the combination of different transport means and transport modes. o Access to status information on transport services and transport network (deviations included) that support planning/re-planning Support transport users (i.e. users of public transport, drivers of private cars, cyclists and people walking) in o Access to status information on transport services and transport network (deviations included) that support re-planning o Access to context specific (depending on location, travel plans, interests, etc.) information (next stop, tourist information, available services, etc.)	Transport User (e.g. traveller or potential traveller)
Transport Service	Provides information on public transport services, e.g.: o Routes and schedules;	Transport Service

Management	o Services and facilities available on-board o Accessibility o Deviations (delay, missing service/facility, etc.) o Prices Provides information on services provides at public transport stops: o Services provided (e.g. information services, assistance, etc.) o Deviations (with respect to the provision of services)	Provider (e.g. transport companies and terminal operators)
Transport Execution Support and Control	Supports road users (drivers and people walking/biking) in o Navigation o Adaptation to traffic conditions.	Road User o Driver o Pedestrian o Cyclist
Transport Network Management	**Transport Network Utilisation Management sub-domain :** Provides information about the traffic and routes: o Traffic flow e.g. speed and travel times (current, predictions, etc.) o Navigation guidelines o Transport network information (condition, etc.)	Traffic Manager (e.g. a traffic management centre or traffic information centre)
	Transport Network Infrastructure Management sub-domain: Provides information on the physical properties of roads, railways, fairways, etc: o Static information about properties and geography o Dynamic information (e.g. roadwork, closed roads/railways, etc.) Provides information about the condition at public transport stops, e.g. o Facilities o Accessibility o Deviations (e.g. with respect to accessibility)	Transport Network Manager (e.g. road and railway administrations, public transport terminal operators)
	Emergency Management – Not relevant in MultiRIT	
	Regulation Enforcement – Not relevant in MultiRIT	
Transport sector support	Provides travel information services : o Door-to-door travel planning o Public transport travel planning (scheduled) o Road use travel planning o Traffic information	Travel Information Service Provider

Due to the cyclic improvement process a few roles related to the sub-domains of the ARKTRANS Reference Model are refined. The original “Driver” role is for example substituted by a more generic “Road User” role that is further decomposed into the “Driver”, “Pedestrian” and “Cyclist” roles. When specifying travel information services the “Road User” role can be used in most cases. Navigations support (finding the way to specific locations) and information about traffic conditions (slippery road, congestion, etc.) may for example also be useful to cyclists and pedestrians as well as to drivers.

The functional view included already before the start of the MultiRIT project specifications of functionality needed for travel planning. However, the MultiRIT work has improved the specifications. The provision of context dependent travel information is for example added.

Process view

ARKTRANS defines scenarios or process descriptions showing how stakeholders with generic roles interact to fulfil their objectives and responsibilities. The processes are described by means of UML activity diagrams in swim lanes (one lane contains the activities of just one role) [11]. The interactions between the different roles are depicted as information flows between the activities in different swim lanes.

The ARKTRANS process descriptions are more generic and comprehensive than those needed by MultiRIT, as the ARKTRANS diagrams include activities and interactions needed in all types of transport (including freight transport). However, the diagrams provide valuable input to the work in MultiRIT. ARKTRANS has specified how the Transport User and the Transport Service Provider interact during transport preparation and planning and how the Transport User follows up an ongoing transport. Both diagrams were used in MultiRIT, but adjustments (mainly simplifications) were required. MultiRIT also decided to make separate process descriptions for urban transport and more long distance transport, as the approaches are different from the traveller's point of view. ARKTRANS does not have process descriptions for the interactions between the Travel Information Service Provider and those providing the basic travel information. Such diagrams are made in MultiRIT.

ARKTRANS shall just include generic diagrams valid for all types of transport. The MultiRIT diagrams are however focused on travel information services. It has to be considered whether the MultiRIT diagrams shall be included in ARKTRANS. The decision has to be coordinated with input from projects working on freight transport processes.

Information view

ARKTRANS includes conceptual information models defining information needed by public transport users. These models are used in the diagnosis and intervention steps to identify and specify information required in new and advanced travel information services. The completeness and usability are assessed by the MultiRIT working groups. Just minor adjustments are done in the existing models. However, some new models are added. Table 2 provides a short overview of the resulting models.

A study done in collaboration with MultiRIT and ARKTRANS showed the need for accessibility information in travel information services [12]. Initially, some preliminary services and facilities for disabled people were defined, but the 'for disabled people' classification was disliked. Accessibility is about anyone's access to services and physical facilities, as at least ten percent of the total population have problems using the public transport system [13]. It is decided that generic information about accessibility shall be attached to the service and facility information. As for services and facilities, a well defined terminology is used to provide information about accessibility.

Table 2 Conceptual information models in ARKTRANS

Information model	Description
Trip pattern (refined by MultiRIT)	The planned route patterns – the planned stops
Trip timetable (refined by MultiRIT)	The actual trips (the transport services provided) – time schedule for stops (planned and actual – showing delays); services and facilities provided; accessibility; restrictions; and deviations of any kind (cancellations, delays, changed level of service, etc.)
Terminal (refined by MultiRIT)	The public transport stops – access points; stop points; services and facilities provided; accessibility; transfer information; etc.
Services and deviations (extended - restrictions and accessibility from MultiRIT)	Services and facilities – including restrictions and accessibility to the services and facilities. A standard set of services and facilities are defined that enables the characterisation of terminals (public transport stops) and trips. Some preliminary work on a standard set of accessibility information.

Cost framework (new – provided by MultiRIT)	Costs related to a journey – transport products, usage rules, pricing rules, etc. Further refinement is required.
Preferences (new -provided by MultiRIT)	The transport user's preferences with respect to when to travel, where to travel, how to travel, needs for services, accessibility, etc.
Journey (new in MultiRIT)	The transport user's travel plan – composed of journey segments with public transport and/or road use.
Traffic (to de defined in MultiRIT)	Traffic related information – travel times (dynamic) and suggested routes to be followed by road users.

Information elements from the information models are used to specify the open services that support information exchange between the providers of travel information and those who establish and provide the travel information services to the end users (see Figure 2). Due to the involvement of the researchers in the information modelling and the specification of the open services (the intervention step) the results are generic and multimodal. So far, it has been decided that they all will be included in ARKTRANS.

Technical aspects

The specifications of the open services (in the information view) are used to generate interface specifications. In MultiRIT this is Web-service definitions supporting exchange of travel related information that can be combined and presented as travel information services.

The current version of ARKTRANS lacks such interfaces. The Web-services defined by MultiRIT are, due to the direct use of the results from the information view, generic and multimodal. Thy will probably be included in ARKTRANS as "standardised" open services for exchange of travel information.

DISCUSSION

As mentioned above, this paper addresses whether ARKTRANS supports aspects addressed by the MultiRIT project such as person transport, travel information service and multimodal solutions. An evaluation is given below as well as an assessment of the results.

Usability to person transport

The specifications in ARKTRANS are common to both freight and passenger transport. There are of course parts of the specifications that are of relevance to just one of the transport types, but in any case, the specifications are made in a neutral way. To support both transport types, some special concepts and mechanisms are used (see Table 3).

The Transport User role, related to the Transport Demand sub-domain of the Reference Model, represents someone requesting a transport service, and the Transport Service Provider (the Transport Service Management sub-domain) provides all types of transport services. A transport service may be the transport of goods or persons as well as terminal services like loading, unloading or assistance. The services have to be planned and booked (if booking is required); the execution has to be followed up – to the extent that is required; and in the case of for example deviations, the transport may also have to be re-planned during the execution. ARKTRANS specifies functionality supporting all phases of the transport process. Some amendments had to be done to clarify requirements and to include functionality needed in person transport. The adjustments are done in a neutral, transport type independent way. In

that way the functionality on provision of context dependent travel information may also be of relevance in freight transport. A research project on intelligent goods has for example identified the need for similar functionality as intelligent goods may take decisions on its own transport depending on the context.

Table 3 Concepts used to harmonize between freight and person transport

Concept	Description
Transport User	Someone requesting a transport service – may be freight transport or person transport.
Terminal	Part of the transport network infrastructure where goods or passengers may enter, leave or change transport means.
Transport Service Provider	Someone providing a transport service – may be freight or person transport services or terminal services (e.g. assistance, loading, unloading).
Transport Item	The item to be transported. May be freight (load units or goods) or passengers.
Service	Service requested by or offered to the Transport User. Standard terminology is used to categorise the services.
Facility	Physical facilities requested by or offered to the Transport User. Standard terminology is used to categorise the facilities.

The main difference between freight and passenger transport is that goods have to be transferred between transport means at terminals, whilst passengers usually find the way by themselves. However, persons may also need transfer services. Children and disabled persons may for example need assistance or transport at airports. The same is true for services and facilities provided on board the transport means. Goods may for example need a certain temperature. A passenger may need vegetarian food or the ability to get power to a laptop. There are also parallels at terminals. Goods need warehouses and customs depots. Travellers need waiting facilities and information services while they are waiting for the ferry, bus, train or plane. Thus, services and facilities are relevant to both freight and person transport.

To handle both transport types in the same way, ARKTRANS uses a concept called Transport Item to represent both freight (load units or goods) and passengers. Such a Transport Item has specific needs with respect to services and physical facilities. Thus, ARKTRANS also uses the Service and Facility concepts. A standardised set of services and facilities are defined and a specific terminology is used to identify the service and facility different types. The set of services or facilities will be quite different for freight and passenger transport, but the principles are the same. In MultiRIT this was confirmed to be a good approach. Some adjustments were done to the list of services and facilities, but the main principles were not changed. The needs of a traveller can be expressed by means of standardised service and facility terms. MultiRIT also found that information about accessibility can be attached to the service and facility information as described in [8] and [12].

In addition to public transport, ARKTRANS also support the travelling by private cars and other means. The Road User role and sub-roles (Pedestrian, Cyclist and Driver) get navigation support and traffic condition information. Process diagrams show the interactions between other roles and the Road User. MultiRIT has refined and completed the process diagrams to describe the required interactions when public transport is combined with road usage.

Usability to travel information services

The ARKTRANS framework was found to be very useful when dealing with travel information services. The roles, the functional view and the process view provided a very

good starting point for the work on finding the needs of the Transport User during all stages of the travel process, and the travel information services build on the conceptual information models in the information view of ARKTRANS.

The conceptual information models define the information needed by the Transport User. Related work like TRIDENT (Transport Intermodal Data sharing and Exchange NeTworks) [14] and TRANSMODEL [15] were consulted [8] when the information models were established, but somewhat other solutions were chosen. In ARKTRANS all transport modes are supported, and the provision of a wide spectre of information about real-time deviations and transport execution is provided (cancellations, change of transport means, change of stop points used, changed level of service, etc.). The ARKTRANS models also include the Service and Facility concepts that enable a standardised way of describing transport services and public transport stops. In MultiRIT this was considered to be very useful in travel information services, and a decision on relating the accessibility information to the services and facilities was taken to facilitate the provision of accessibility information in the travel information services.

Usability to multimodal solutions

MultiRIT aims to support the establishment of multimodal travel information services. The open services that are specified have to be the same for all transport modes.

The specifications in ARKTRANS are said to be multimodal. The terminology used is multimodal, and the logical specifications should apply to all modes. There may of course be differences. Traffic management of individual transport means is for example required in air, sea and rail transport, but not in road transport (where the flow of cars is managed). The new intelligent vehicles and intelligent infrastructure concepts may however change this and make those parts of ARKTRANS used by rail, sea and air today of relevance to road as well. It was found that the multimodal specifications in ARKTRANS supported the work in MultiRIT. Terminology and specifications could to a large extend be adopted.

Confounding factors

The researchers participating in MultiRIT have also been involved in the establishment of ARKTRANS. This may be an advantage, as they know how to use and develop ARKTRANS further, and they can easily focus the research on issues addressed by the different viewpoints in Figure 1. However, the researchers are not unbiased. They have a positive attitude towards the use and usability of ARKTRANS. On the other side, the MultiRIT working groups can be said to have a moderating effect. Through discussions, specifications and development of pilots, the participants have contributed to both the evaluation of the usability of the ARKTRANS framework and the improvement of it. The practical objective of MultiRIT, i.e. to find solutions that arrange for new and improved travel information services, also contributes to minimize the effect of the unbiased researchers. The usability of ARKTRANS is put to a trial.

The method used deviates to some extent from the guidelines provided by Davidson et al. in [9]. The MultiRIT project plan does not include questions about the ARKTRANS suitability for person transport, travel information services and multimodality. That is a focus in the ARKTRANS refinement project. The MultiRIT participants have however clearly expressed

interest in knowledge about the usability of ARKTRANS, and they support the work of the ARKTRANS refinement project and have also contributed to the evaluation and reflection.

The evaluation step is done by means of desktop studies and workshops. In addition, the MultiRIT project implements and evaluates pilots showing new and improved travel information services and interoperability through open services. These evaluations are also considered in the evaluation step. There is however no surveys or experiments proving the added value in a scientific way. On the other hand, by providing a holistic view on the transport sector (all parts of the sector, all transport modes and all transport types included), ARKTRANS is assumed to be a good tool for evaluation and learning by reflection. Dependencies and effects can be considered by means of the specifications of the different aspects and viewpoints. The multimodality in itself also contributes to the evaluation. The solutions have to be applicable to all transport modes, and stakeholders from all transport modes have contributed to the evaluation.

CONCLUSIONS

ARKTRANS is found to support the analyses and the establishment of open services that arrange for new and improved multimodal travel information services. ARKTRANS also support person transport as addressed in the MultiRIT project. The use of ARKTRANS has also influenced the work in MultiRIT in a positive way. The viewpoints addressed by ARKTRANS and their content provide good starting points for discussions and specifications, and they also contribute to a structured approach.

ARKTRANS is found to be a suitable theoretical framework for the action research. The framework supports the diagnosis, intervention, evaluation and reflection steps. The viewpoints and their content contribute to the definition of the context, the scope and the focus of the research. The ARKTRANS framework is suited for iterative improvements supported by the cyclic action research process, and the generic knowledge gained in MultiRIT has improved the quality of the framework.

It is important to notice that the ARKTRANS refinement project also evaluates and reflects upon contributions from other national and European projects using ARKTRANS. We see that the harmonization of person and freight transport opens for synergies. The European 6FP European project Freightwise is using ARKTRANS and the refinements provided by MultiRIT in co-modal freight transport. The Transport User and Transport Service Provider roles, the Transport Item and Service concepts also fit with the needs of Freightwise, and the functional descriptions and the processes can also be used. We also see that the services directed towards the road users may benefit the European 7FP project SMARTFREIGHT on assistance to the drivers of urban freight distribution vehicles.

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