A ROLE OF ITS IN ROAD WINTER MAINTENANCE

B.Jelisejevs
SJSC Latvian State Roads, Riga, Latvia
boriss.jelisejevs@lvceli.lv

ABSTRACT

Improvement of winter road maintenance is one of the most important tasks in snowy regions. Despite well structured methodology that provides clear performance criteria, as well as variety of organizational and technological measures for achieving them, there are still many controversial questions in this field. Unlike infrastructure development programmes where investment vector is clearly defined, winter road maintenance is a set of activities with the main task to ensure the usability of road network, if weather conditions affect it negatively, considering constantly growing demand of mobility of the society. Meteorological conditions and territories affected by them are dynamically variable factors and actual driving conditions depend on several factors. In this situation aspiration to ensure more qualitative road service level with limited resources becomes the drive of the field.

Intelligent Transportation Systems (ITS) provide a good platform for achieving these goals by influencing all groups of interests synergically. Network of stationary and mobile road sensors, technologies of wireless data transmission, dynamic databases, geographic information system (GIS), global navigation satellite system (GNSS) and their integrated solutions allow to develop economically feasible services that are directed to the improvement of traffic safety, simultaneously giving a chance to improve winter road maintenance. Instruments for the support of decision making, automatic registration of winter works and traffic information services are the basic directions where ITS meets winter road maintenance in Latvia. This report describes the current situation, projects and vision of future in this field in Latvia.

KEYWORDS

ITS/ RWIS / TRAFFIC INFORMATION / EXPERT SYSTEMS/

INTRODUCTION

Road routine maintenance is a set of activities performed continuously all year long and it is aimed to provide a defined mobility level in the road network, also in emergency situations, ensure the passability of road and operative liquidation of traffic dangers. In Latvia winter service (snow clearing from road, spreading with anti-skid materials) included in the routine maintenance programme covers the period from November to March. Meteorological conditions and territories affected by them are dynamically variable factors and actual driving conditions depend on several factors. Unlike other road maintenance works that have servicing or partly reconstruction character and that affect the lifecycle of road structure, winter road maintenance serves only short-term mobility needs and requires adequate performance from road maintainers.

Improvement of winter road maintenance is one of the most important tasks in snowy regions. Despite well structured methodology that provides clear performance criteria, as well as, variety of organizational and technological measures for achieving them, there are still

many controversial questions in this field. In relation to winter road maintenance there are 3 fundamental groups of interests who may not always share the same point of view:

1. target group – road users who are interested that winter conditions do to affect traffic and who want individually oriented informative support on actual traffic situation;
2. performance group – contractors who are interested in the biggest possible profit from performed works;
3. control group – road administrations that are interested in optimal use of resources by updating winter road maintenance standards and controlling their implementation.

Considering that winter road maintenance has a partly prospective and immediate character for achieving technically short-term goals, many connected aspects are diverse. That includes, for example, technical standardization of process, contract term and framework, form of payment, work registration and performance evaluation. In this situation the aspiration to ensure more qualitative road service level with limited resources becomes the drive of the field. ITS provides a good platform for achieving these goals by influencing all groups of interests synergically. Network of stationary and mobile road sensors, technologies of wireless data transmission, dynamic databases, GIS, GNSS and their integrated solutions allow to develop economically feasible services that are directed to the improvement of traffic safety, simultaneously giving a chance to improve winter road maintenance. Instruments for supporting decision making, automatic registration of works and traffic information services are the basic directions where ITS meets winter road maintenance in Latvia.

1. WINTER ROAD MAINTENANCE

The present road maintenance standard in Latvia defines the provision of certain level of service as a process of keeping road operating indicators in acceptable range with maximal terms for liquidation of discovered inadequacies and resumption of normative conditions [1]. However, the evolution of quality criteria of winter road maintenance is connected with transition from specific performance to road usability criteria because from drivers' position road maintenance quality is characterised by the provided driving conditions but not by the amount of works performed or their technical performance (Figure 1).

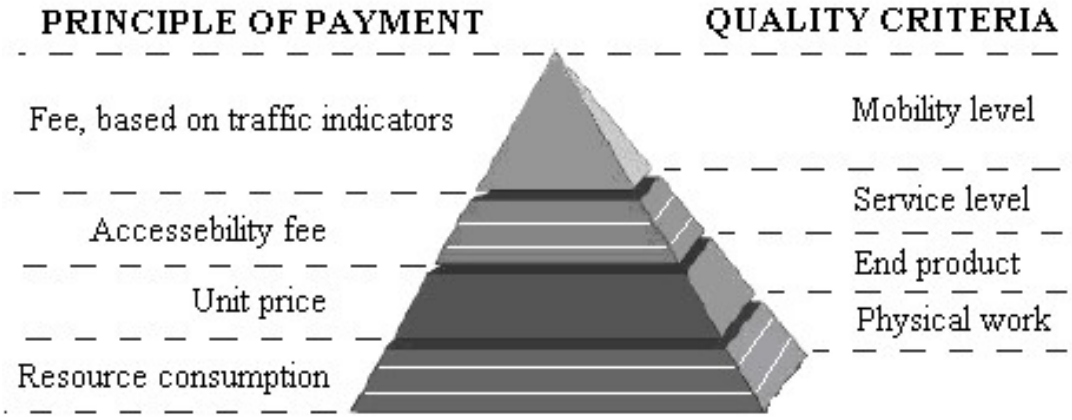

Figure 1 - Evolution of quality criteria of winter road maintenance

Requirements for work performance define the framework of technological regulations (specifications) but measurable requirements are defined for the final product. These are traditional criteria for the evaluation of performance of road works but they do not fully comply with the request to ensure constant serviceability of road. However, the implementation of road routine maintenance and PPP projects is related to active action of road workers on the

served road that is based on defining the service level. Starting from this level winter road maintenance requires more developed instruments for supporting decision making which ITS may provide from road condition monitoring to expert system applications. In the highest quality level the road works are valuated indirectly, through mobility criteria such as dynamics of number of road traffic accidents and traffic intensity. Basically they are the most objective ones since they evaluate road quality by actual traffic parametres and such work evaluation should be reached in the future (in the beginning as additional bonuses). At present the implementation of Latvian winter road maintenance takes place according to a combined model with a tendency to gradually transfer to fixed payment for ensuring service level. That would facilitate the administration of these works and encourage contractors for innovative approaches.

From technological position both strategies for skid elimination (prevalent), and strategies for skid prevention are applied in practise. Skid prevention approach means ensuring a constantly clean surface without any ice and in this context only preventive treating with chemical anti-skid materials is necessary. It is not suitable for roads with low traffic intensity, as well as, in some meteorological situations it is not possible to do without skid elimination and use of abrasive anti-skid materials. Skid prevention is especially useful in cases when preventive surface dressing is self-sufficient and other activities do not follow (black ice or white frost, for example). In general these strategies of winter road maintenance should be applied together, increasing technological diversity of processes so that in specific conditions it would be possible to choose the best solution. Potential benefit of strategy of skid prevention is increased traffic safety with more economical use of chemical agents [2]. Base of preventive anti-skid measures is proper and timely decision making that is based on accurate (probability more than 90 %) forecast of road condition for the next 2 – 8 hours. To predict slippery conditions, several information sources are being used: road weather stations, weather radars, weather satellites, sensor network of national weather service, road thermography etc.) that are integrated on the basis of digital model of road weather condition forecast to what instruments of supporting decision making of the next generation – expert systems – may be subordinated (Figure 2). In Latvia several steps are being taken in this direction although sufficient level of standardisation and implementation of skid prevention strategy on constant basis is still not reached. This direction is perspective because, when looking back at the statistics of weather conditions in Latvia, potentially it could be applied to more than half of winter road maintenance works.

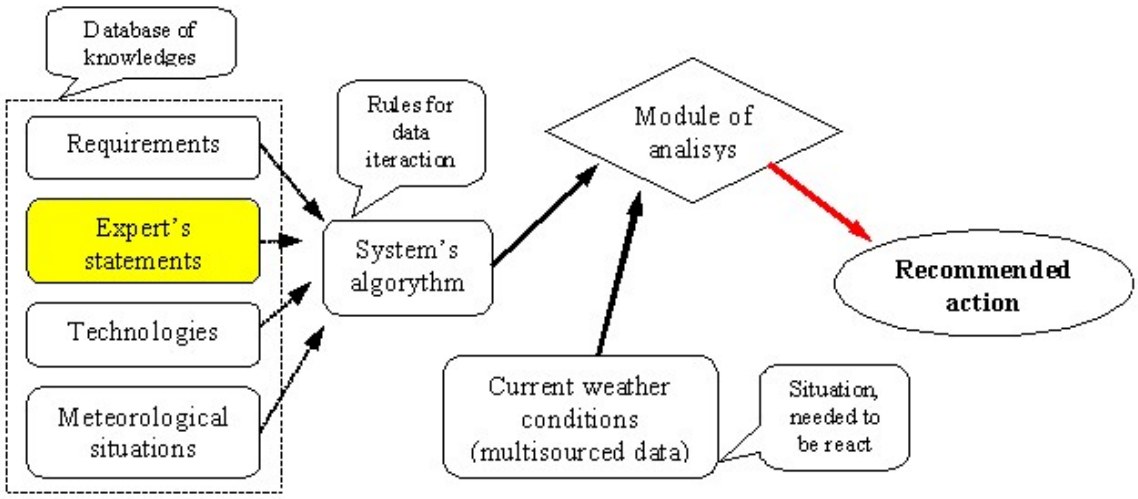

Figure 2 - Architecture of expert system prototype of winter road maintenance

Apart from administrative position of individual roads, homogeneous level of road service and related traffic information services have to be provided in the public road network ensuring even and sequentially, not rapidly, changing driving conditions for road users. It means that implementation of winter road maintenance has to be coordinated between state and municipal road administrations, as well as, between urban and rural territories. Tasks mentioned in this chapter may not be solved in autonomous mode, it is useful to link them with general development of ITS.

2. ITS OF LATVIAN STATE ROAD NETWORK

From position of road network administration there are three basic directions for improving mobility: measures of transport infrastructure (including road routine maintenance); administrative measures that direct public demand for transport and ITS. ITS refers to efforts to add information and communications technology to transport to improve safety and efficiency. When planning implementation of ITS, it has to be understood that, even though it has intermodal platform, its development has to be oriented directly to motor transport as a dominant kind of transport. Mobility in the transport system is described by factor system: traffic participant – vehicle – environment. Regardless of close interaction of these factors, traffic participant is the only logical element who, by acting according to external conditions, individually effects the mobility to the greatest extent, therefore at first ITS solutions have to ensure the awareness of traffic participants and support their adequate actions. In relation to road administration competence, various ITS products may be divided in four basic groups:

- Gathering of data related to road traffic;
- Distribution of traffic information to road users;
- Adaptive traffic management;
- Control of access to infrastructure.
-

Objective feasibility study of ITS is a complicated issue because the diversity of solutions, correlation with legislation, significant impact of individual factors of users on results and rapid development of base technologies in the sector make it difficult to do accurate calculations. However, conceptual assumptions allow to conclude that general investment and return effect of ITS is remarkable in financial terms, approximately 1 to 5 where 89 % of benefits are estimated as improvement of mobility (macro effect) and 11 % are funds saved in infrastructure management and maintenance (direct benefits of implementers) [3].
Obviously it is wrong to develop ITS solutions separately from other infrastructure management aspects. Hardware and subsystems of ITS have to be available multi-functionally as much as possible. Implementation of ITS is effective only if approached as a system by taking into account that transport is a dynamic multicomponent system and is a subject of multitudinous scenarios of development and their structural transformation in the process of implementation. In the structure of ITS three sequential inner functions may be identified: data acquisition→data processing→final services, and their mutual integration is the primary task.

In Latvia for a long time there was no clear vision of long-term development of ITS and single ITS platform did not exist, only several fragments of it, that substantially complicated compatibility raising difficulties for further development. In 2005 within “Latvian State Roads” a Traffic Information Centre (TIC) was established and ever since ITS is being developed sequentially by single functional scheme that supports current and prospective technological solutions (Figure 3). Integration level of ITS elements are largely defined by its central element – TIC – that processes and consolidates data flows from various sources in twenty-four hour regime, transforming them into services of traffic information and adaptive traffic

management, as well as, providing road authorities with operational data on works to be done immediately to eliminate traffic disturbances. Today 45 road weather stations are included in ITS monitoring systems equipped with video surveillance devices and 21 traffic counting points on state main roads; they gain on-line data for ITS service, and the statistics is also used for the needs of road network planning. When developing ITS monitoring systems, many individual considerations are taken into account that define optimal placement of road sensors and network density, users and interfaces of data application, intervals of data updates etc.

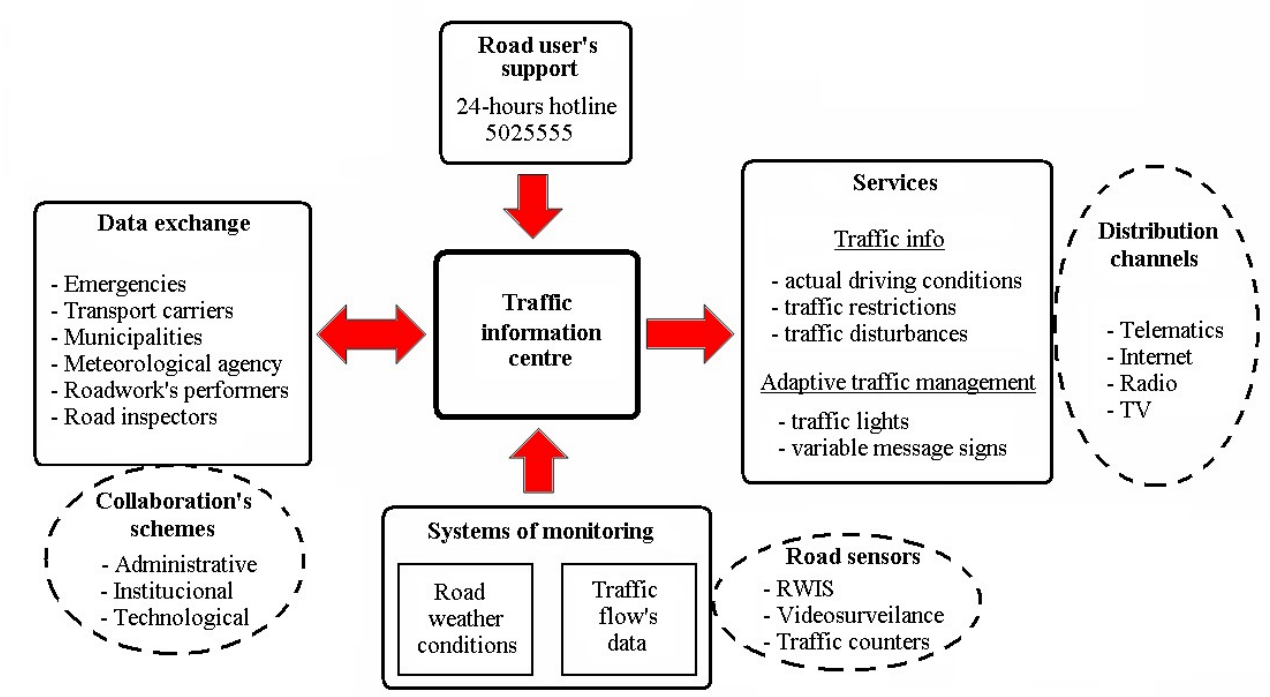

Figure 3 - Functional architecture of ITS in Latvian state road network

Primarily ITS is focused on traffic participants and used for the needs of management of transport infrastructure, though its functions meet special needs of much wider target audience, including: operators of neighbouring road networks, professional road hauliers, emergency services and other users of ITS. Road maintenance contractors should be mentioned separately, they are interested primarily in professional weather services and they can also provide valuable data contribution to ITS in general (Table 1).

Table 1 Connection between ITS and winter road maintenance

ITS data, generated in the process of winter road maintenance	**ITS specialized services, designed for the use in winter road maintenance**
Characteristics of general driving conditions	Basic services
Real-time data of activity of maintenance equipment	Road weather information system
	Road video surveillance system
Transmissions of mobile sensors attached to maintenance equipment	Car park control systems
	Combined and derivative services
Data on unusual traffic situations (accidents, dangers, obstacles, congestions etc.), traced by road workers	Complex weather resources
	Expert systems of winter road maintenance
Update of road service levels (once in season)	Automatic system of work registration

Rapid development of GIS databases, their adaptation to requirements of infrastructure management and accessibility to great amount of public geospatial information opens up new opportunities in the analysis of road winter maintenance criteria since they may be valuated by considering not only traffic, but also other data (demography, economy, land use etc.), therefore supporting the selection of the most appropriate model of winter road maintenance for specific needs.

Functions of distribution of traffic information (passive action) and adaptive traffic management (active action) in the ITS structure are quite different but interconnected. For the first quite big tolerances may be allowed and up to certain level it may be based mainly on organizational measures therefore ITS development starts with it, but the second is absolutely discreet, technically more complicated and requires high level of inner automation of the system (Figure 4). With the exception of separate signal-controlled junctions, where it would be useful to improve traffic capacity with the help of “smart” traffic lights, there are no vital needs for the implementation of solutions of adaptive traffic management in the Latvian state road network.

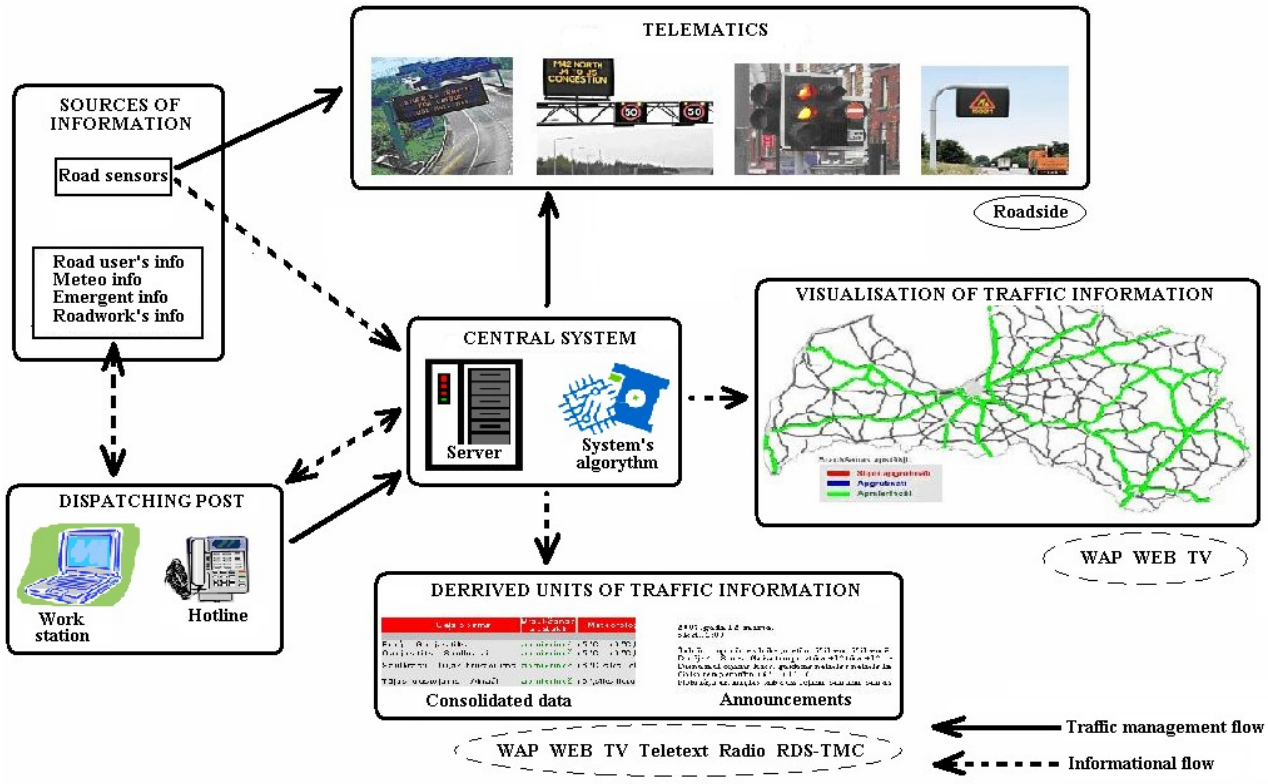

Figure 4 – Functional flow of traffic data in the ITS structure

The above mentioned ITS functionality and its structural sustainability is achievable better if its basis contains “open” (available, replaceable and updateable) IT and telecommunication solutions that are technologically based on OSI model [4].

3. TRAFFIC INFORMATION SERVICES

Traffic information contains wide range of data on current situation in road network that is available to traffic participants and specialized users (including winter road maintenance units) before trip and, what is especially important, in real-time. Today road users may receive public information on traffic situation in Latvia in the national travellers’ portal www.celugids.lv and through mass media (radio, news portals, television). One of the

problems is that coordination of traffic data between public organizations (road and emergency authorities, municipalities) is not elaborated and published information may be delayed and fragmented. In addition to that it mostly has a pre-trip character that does not allow to increase the number of potential users. Interactive traffic information is broadcast by radio stations and listeners report and receive messages about traffic problems on air. In general the level of current services of traffic information is not sufficient, also because data are often not attributive (cartographically attached) and user interfaces cannot be adjusted individually that do not allow to work only with the data of certain route. At present the work is in progress to provide limited public access to several ITS monitoring systems (road weather stations, video surveillance and traffic counting systems) but these, too, are only options and not structured final products.

Information exchange between ITS and road winter maintenance service is a two-way process. Work performers and supervisors use complex meteorological web resource as a support instrument of decision making. Work performers provide ITS informative services with characteristics of driving conditions (data on sections – main roads and maintenance technologies – regional and local roads are updated once in two hours).
In principle ITS services have to work with such cooperation schemes so that, when summarizing data from several sources, it would be possible to transmit them to vehicle navigators, devices of mobile telephony and RDS-TMC radio receivers providing live broadcast of targeted, route-oriented traffic information (Figure 5). Pre-trip information, too, should be located in united web and wap applications of organizations (digital maps with multi-source data structured in layers). Here national travellers portal could become the unified interface of traffic data publication.

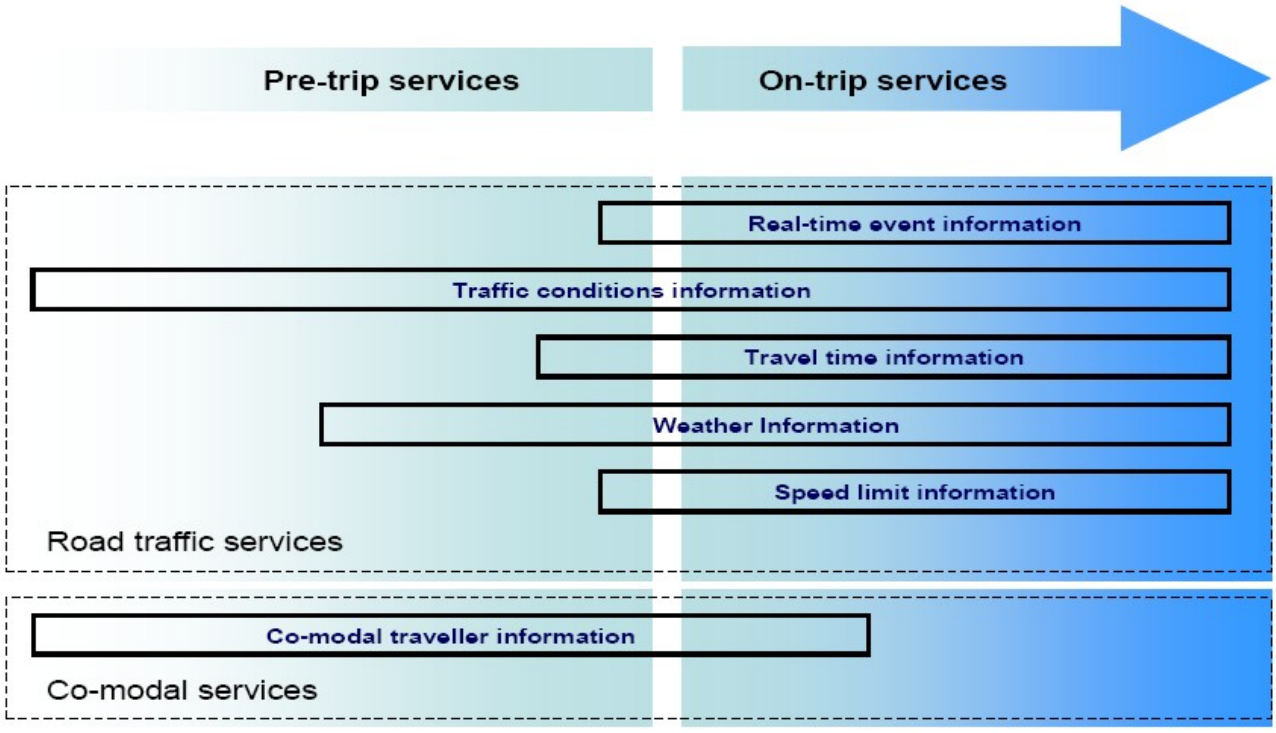

Figure 5 - Direction of development of traffic information services

Considering organizational difficulties and remarkable investments for distribution of traffic information, this function may be delegated to commercial traffic information operators. In the end of 2007 the Finnish company “Destia” came out with similar initiative, it wanted to expand its coverage of pre-trip and interactive services of traffic information in the Baltic region. In the accepted cooperation model public services give access to original traffic data to operator who processes them and creates final products. Being interested in multi-source

information, the operator on its platform integrates information on road, public transport and intermodal traffic information. First real-time services of traffic information are planned to be offered in the Latvian market in the end of 2009. Road sector is interested in involvement of the biggest possible number of operators to increase the number of final services and raise their quality in competitive conditions making them accessible to more and more users.

Now in the world indirect form of monitoring is becoming more popular, it is based on floating car data (FCD) technology. Although FCD products do not match up with the precision of measurements, it is enough for overall representation of situation in the road network and they may be used in traffic information services. Virtual service that contains vehicles equipped with GNSS receivers that serve as mobile traffic sensors is available in Latvia, too (CityGuide, for example). At present it has not gained popularity, by the middle of 2009 reaching only couple of hundreds of active participants (their number, nevertheless, is proportional to the quality of service). In the context of winter road maintenance FCD may serve as an instrument displaying active equipment of winter road maintenance in user interfaces since snow clearing and spreading machinery may slow down traffic and create bigger risk of traffic accidents due to overtaking manoeuvres, and it would be helpful if drivers could receive warnings within their selected route. By installing activity status button in the maintenance vehicle involved in the FCD (in the simplest version) or linking it to the system of automatic work registration, it is possible to provide real-time information about locations of winter road maintenance activities (Figure 6).

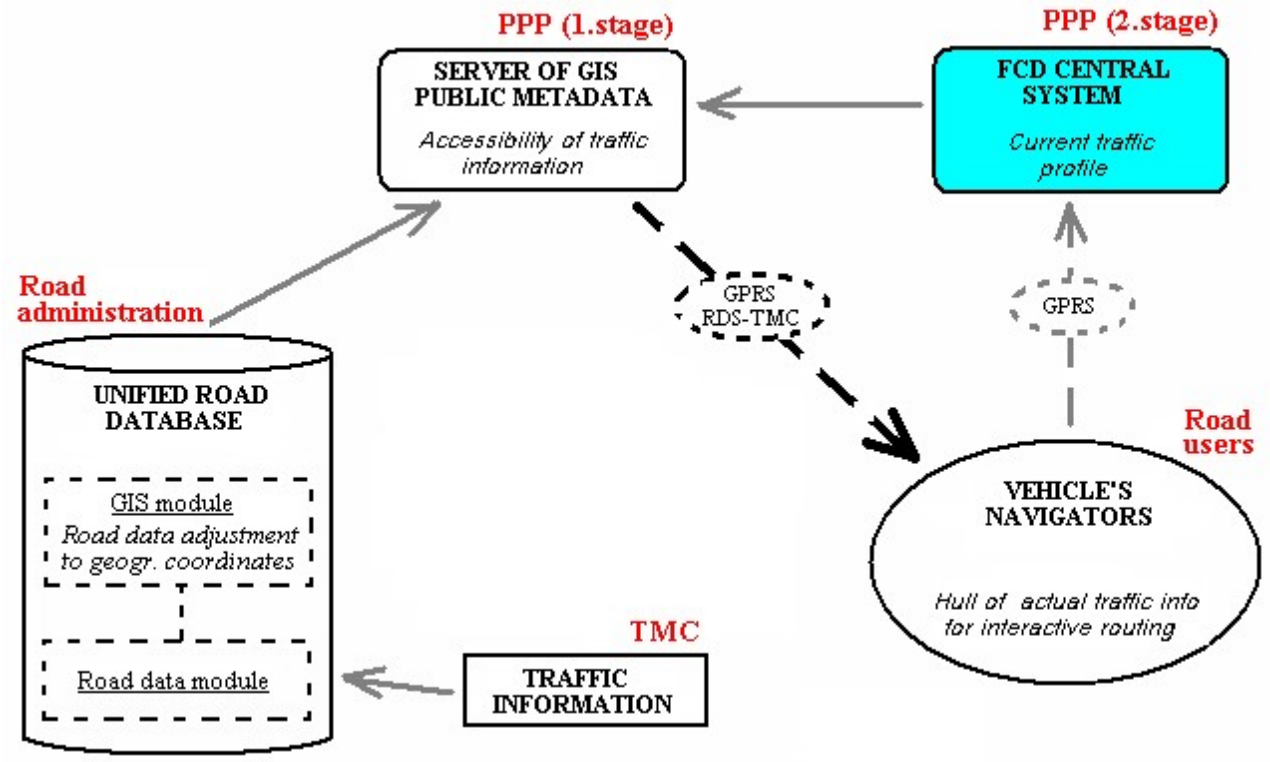

Figure 6 - Distribution scheme of interactive traffic information (concept of public service)

At present in the market there are solutions for automation of technological devices of winter road maintenance and they continue to develop to decrease the subjectivity of technical decision making (for example, selection of optimal spreading mode), control compliance of road condition and technological modes with normative requirements in the work place, as well as, to ensure automatic registration of works. Since 2007 the machinery involved in winter road maintenance of Latvian state main roads is equipped with automatic work

registration system. Considering the expensiveness of such a specific system, it would be useful to support secondary winter road maintenance service with standard car park management solutions. They do not allow to directly register work performance and cannot be integrated with expert systems because they are more suitable for inner control of car park use, however, in the context of ITS they may provide valuable real-time and archive information (number of currently active units and their locations, analysis of registered trips of these units in relation to work journal data).

4. VISION OF DEVELOPMENT

Due to global economical crisis the budget of Latvian road sector is substantially decreased and that negatively effects projects of winter road maintenance and ITS. On the other hand ITS sector in Europe developed mainly in the national level for many years is waiting for the EU directive on further ITS development in all its territory and binding strategy (probably it will come into force already in 2010). Necessity of international regulations and their form is a controversial question but there is a positive trend to support cooperative system and development of international services for further improvement of mobility (Figure 7). ITS development in the EU level means achieving defined minimal requirements that would be binding to all member states, at the same time not limiting addition of extra properties that would result from individual state factors, for example, current technological level of ITS, requirements (traffic flow, regional factors, etc.) an available resources for the development of ITS sector.

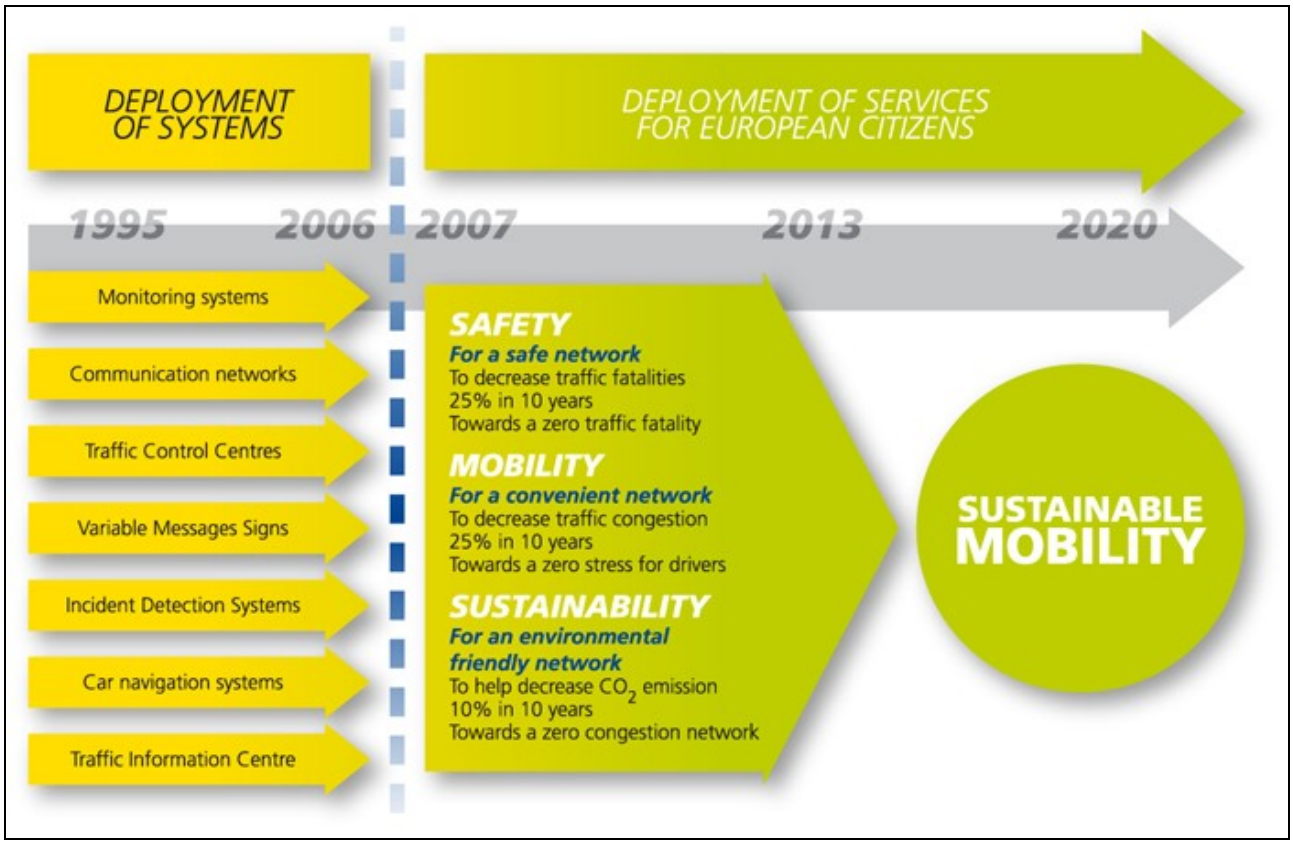

Figure 7 - Principles and planned schedule of ITS development in the EU (Easy-way vision)

Judging by drafts of these documents, initially the EU initiative will ensure only unified understanding of ITS but many technical aspects still remain unclear. Soon they should be approved in the level of standardization documentation so that they could be correctly implemented in the national level by ensuring the required compatibility. The most important

aspect is optimal use of ITS data, included in the EU ITS strategy as the primary task and achieving of other ITS goals should be based on it. Regarding this matter in the nearest future it would be useful to agree on the following aspects (Figure 8):

- Classification of ITS data;
- Defining of minimal amount of ITS data for international services;
- Institutional responsibility for providing ITS data;
- Technical aspects of providing accessibility to ITS data (data format, infrastructure of data exchange etc.).

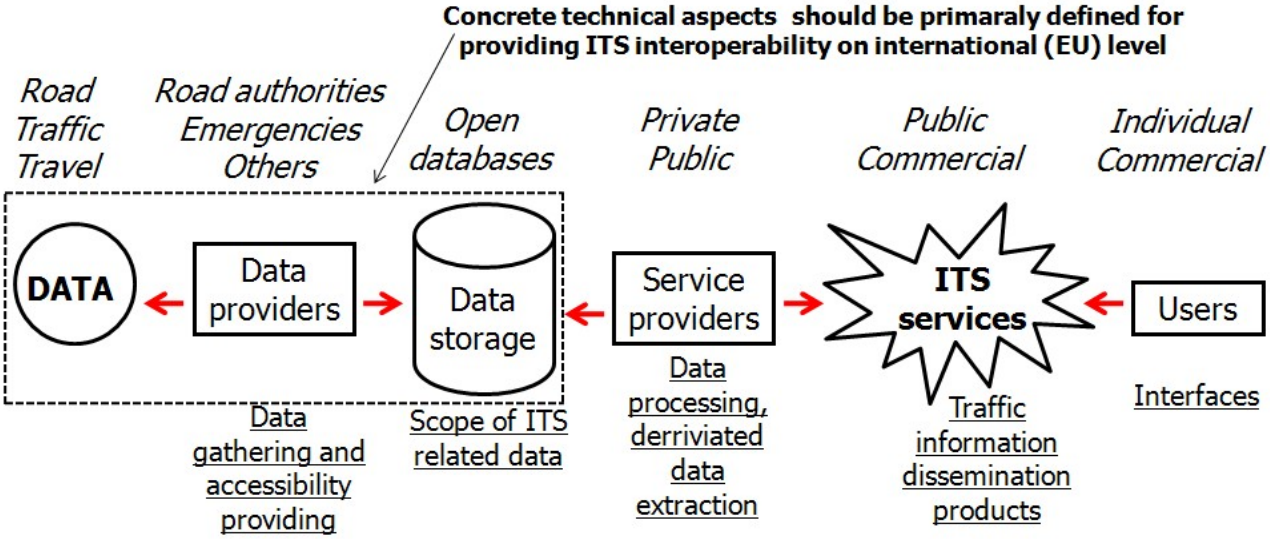

Figure 8 - ITS data flow

When developing the classification of ITS data and defining its adaptation, it could be useful to follow this logical division:

- By basic category (road, traffic and travel data);
- By activity status (static, variable and real-time);
- By necessary form (minimal amount and extra data);
- By responsibility for data provision (road units, emergency services etc.).

When discussing data, it has to be understood that it has clear hierarchy in the ITS structure (Figure 9) where: road data creates geospatial attachment of transport infrastructure parameters to e-services, traffic data reflects current situation on road but travel data is a derived product or additional information (travel time, objects of interests, interactive routing, multi-modal information etc.). As shown in the Table 1, winter road maintenance and ITS have many connections that are related to both initial data circulation and specifically oriented services.

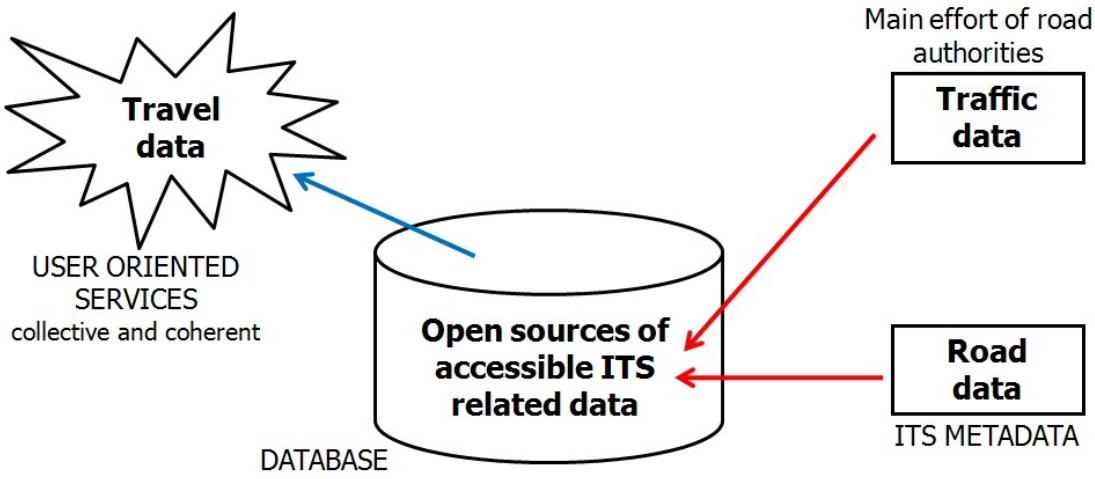

Figure 9 - Hierarchy of ITS data categories in the context of system functions

In general the balanced long-term development of ITS is not an easy task, especially in the East-European countries where its current level is not very high and this sector cannot hope for big state investments in the nearest future. In this situation operation within available possibilities becomes the leading motive. First is the maximal orientation to “light” technologies (wireless data transmission, GNSS, popular user interfaces etc.) that allows to raise ITS efficiency without investments in the infrastructure (road telematics, traffic management centres, wired communications). Second technological direction is to make ITS solutions multi-functional as much as possible with the emphasis on combined technologies of road monitoring that records initial data and provides their derivations (for example, road video surveillance has to be able to support the following functions: visual picture → traffic counting → active traffic sensor). From administrative position PPP schemes have to be supported when road administrations provide basic elements of ITS (develop road monitoring systems and ensure availability of their data, as well as, work with other services to improve data circulation) and investments in them are market concern.

5. CONCLUSIONS

As it may be seen, winter road maintenance and ITS has many connections and these sectors should develop in a harmonised manner by improving each other. Winter road maintenance authority should supply data on the situation on road as complete as possible but specialized ITS services should provide qualitative decision making support regarding both work performance, supervision and strategic aspects of road maintenance (standardization, organizational aspects etc.). In Latvia the current situation in this field may be described as settling of basic services but potential development is connected with expert systems for the implementation of skid prevention strategies and use of machinery of winter road maintenance as multi-functional, mobile road sensors.

REFERENCES

[1] Scientific proceedings of RTU (2004). B.Jelisejevs, The modified technical regulations for road routine maintenance.
[2] Papers of winter road congress in Finland (2008). B.Jelisejevs, Environmental aspects of road de-icing.
[3] FHWA (1994). ITS National Investment and Market Analysis 1996-2015.
[4] Papers of BRA regional conference (2009). B.Jelisejevs, Concept of implementation complex ITS solutions in Eastern European countries.