D1 ITS Vision

A scenario for ITS deployment on European road transport corridors accounting for regional preconditions

A report from EU EIP Activity 4.3 European ITS Deployment Road map

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Preface

This report has been developed within the EU EIP project[1] sub-activity 4.3 “European ITS Deployment Road Map”. Whereas EU EIP aims at introducing a European and transport corridor perspective on ITS deployment, it is facing a situation where ITS Deployment is mainly based on local needs and following local decisions.

The aim of this draft report is to provide a basis for the further road map development by describing the rationale behind ITS deployment as it is carried out today. The final report will be included in the concluding road map.

This report combines the following deliverables as stated in the Grant Agreement for EU EIP:

- A vision on ITS for European road transport corridors and their interfaces
- Report on regional and CEF corridor preconditions for ITS deployment (draft report)

The latter also constitute EU EIP Milestone 36.

The report has been developed by the EU EIP Sub-activity 4.3 Task Force and include the results from four workshops held 2016-2017 based on questionnaires and surveys made within the project together with findings from earlier work on ITS Deployment Road Maps.

The work has been coordinated by Arne Lindeberg, Swedish Transport Administration.

[1] Reference EU EIP; INEA/CEF/TRAN/M2014/1058323

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1. Background and methodology

1.1. Transport Systems goals and objectives- the target

To understand the rationale behind ITS deployment decisions, we need to understand the underlying goals and objectives behind use of ITS as it looks today. Even though sometimes believed to be synonyms, goals and objectives have different meanings; Goals and objectives are important to strategic planning because they turn the mission and vision into specific measurable targets. Goals and objectives are concrete and help translate the mission and vision into reality;

- Goals are the ends toward which a program or problem solution is directed. Goals are outcome statements to guide implementation of the strategy (i.e., the tactics of what is planned to be done). While goals tend to be general or broad and ambitious, they also must be clear and realistic in order to clarify the team's direction and gain support of stakeholders.
- Objectives are more detailed than goals and explain how goals will be accomplished. Objectives detail the activities that must be completed to achieve the goal.

In this report the overall goal for the transport system and the motivation for use of ITS measures has been defined as:

Creating an efficient and reliable transport system to fulfil mobility and transport requirements, while managing environmental challenges, improve economy and ensure safety and security.

With the following objectives:

1. Secure on-time delivery of passengers and goods in expected condition.
2. Satisfy increasing transportation demands within existing infrastructure capacity with a retained or decided level of service (LOS).
3. Increase throughput, time- and cost efficiency of transhipment points.
4. Optimize capacity utilization of vehicles, load units and the transport network.
5. Decrease total transport energy use and greenhouse gas emissions without curbing mobility.

In order to meet these objectives two different, but complementary, perspectives are needed as they represent different levels of decisions and in effect also the use of different ITS measures:

1.1.1. PLANNING PERSPECTIVE

ITS measures that are relevant from a planning perspective act through the policies that are implemented with support from the service. A good example is road pricing measures which, from a technical perspective, are operational in real time but their primary function is to have an impact on transport decisions. The road user charge typically changes the cost balance between transport modes. In the same way, access restrictions monitoring is operational 24/7, but impact from the service comes from the transport planners' knowledge of the access regulation (in effect, drivers that are unaware of restrictions may cause serious trouble if they too late try to correct their behaviour).

1.1.2. OPERATIONS PERSPECTIVE

The operational services are the "real tools" that are used in real time by traffic or corridor control centre staff. They are based on situational awareness, which is provided by sensors in the transport systems, and experience from the effects that will follow from the application of the ITS measures at hand. These services may have a fairly high level of automation, i.e. the system reacts without operator intervention. A good example is Dynamic Traffic Management which reacts on sensor information concerning speed, traffic load etc. It should be observed that the mix of ITS measures that are put in operation given a certain situation might be defined in a Traffic management plan. Here the traffic manager pre-defines what kind of actions shall be put in place when specific circumstances appear. Such preparatory decisions belong to the planning perspective, while the ITS tools used as part of the planned belongs to the operations perspective.

1.2. Driving forces behind ITS deployment

In addition to that they are based on one of the two perspectives described above, ITS deployment activities follow in general from four main driving forces. In most cases they act in combinations, and are not easily distinguished from each other:

Perceived transport system needs : Most important are investments that are made in response to specific perceived local needs – solving problems at critical spots; measures to increase safety, reduce environmental impact from local traffic, improve intersection and road section throughput or provide better quality of service to road users.

Transport policies put in place : ITS deployment is also made in response to policies that are not directly related to local needs; e.g. road user charging systems are put in place in order to drive modal shift on a general basis, reduce congestion or simply in order to collect money in order to finance investments.

There are also examples of ITS that are put in place in response to legislation, such ITS would not have been implemented in the same manner without legislative support. A good example is eCall which is now compulsory from 2018, and also the implementation of the Digital tachograph where a new generation will be introduced also from 2018.

Technical development : Also, technical development is in itself driving ITS deployment; new ITS are put in place simply because they have been made available, without fulfilling transport system needs or driving policies. Good examples are related to automation (e.g. self-driving vehicles), infotainment etc.

One can argue that in-vehicle safety systems (ADAS) are implemented in response to policies on safety, we will however select to include them among technology driven ITS.

They make good business: Several ITS are deployed on the basis that they generate better business for organizations, public as well as private: More efficient maintenance of roads, better load factor of lorries and passenger cars etc. Fleet management systems, ride-share opportunities etc. are examples hereof.

The strength in these driving forces are different and varies also over time. Whereas safety related measures have been in focus through history (as well in-vehicle as road side), an increased need for efficient infrastructure use is coming up as a key driver. One important reason for this being that in-vehicle safety is now perceived to be quite high. It is also important to recognize that different drivers may be present at different levels: On a national level policy related ITS measures may be in focus, while on the local level (where the real bottlenecks occur) traditional physical measures may be more relevant. Hence a key question concerning driving forces behind ITS deployment is “where is the money?”. Is the money available on a higher policy level, or is the budget linked to the physical road network as in traditional infrastructure planning?

1.3. The Work in EU EIP

The first phase of EU EIP SA 4.3 ITS Deployment Road Map covered the aspect of the perceived benefits of ITS as a means for improving road transport corridor performance, and was supported by a survey including respondents from European corridor initiatives. In combination with earlier studies in the EIP project and the plans provided by member states in response to the ITS Directive requirements, this study gave a good insight in how European stakeholders look upon ITS solution as a tool for improving network and corridor performance.

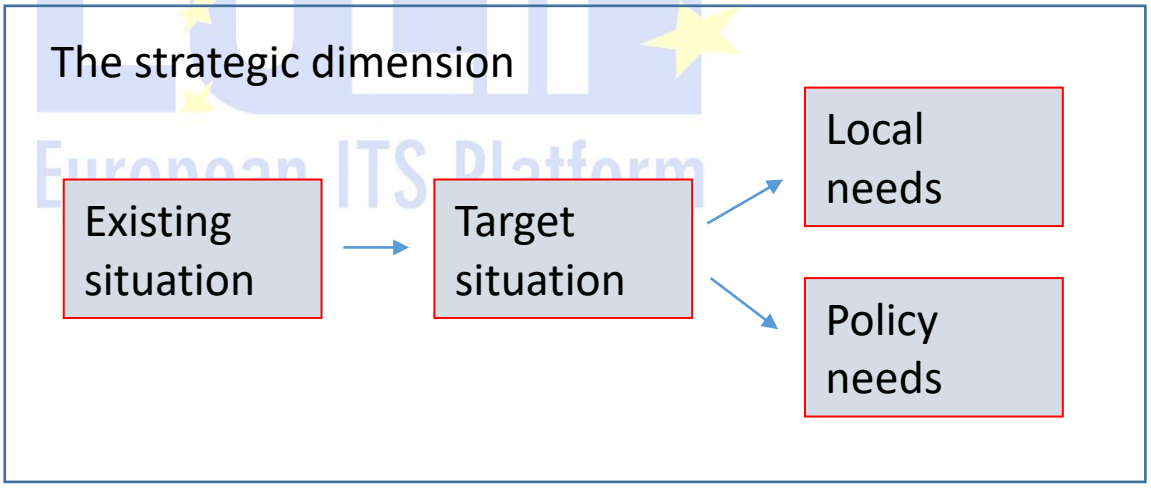
The work in the first block started in April 2016 with the planning and execution of a Europe wide survey with the title “Potential of ITS for improving CEF road transport corridor performance”. The survey built further on the two surveys carried out within the

EIP project[2] (on ITS deployment status and Status of legacy systems[3]) with the aim of finding out how ITS deployment could contribute to improved performance of transport corridors, on the basis of perceived need. The survey focused on the perceived need for ITS given the regional challenges.

Findings from the survey showed that ITS investments in general follow from local decisions based on local needs. An important question is then how a corridor perspective can be strengthened to influence local decisions? And at the same time, how can local decisions be made to take into account the needs experienced on a corridor level?

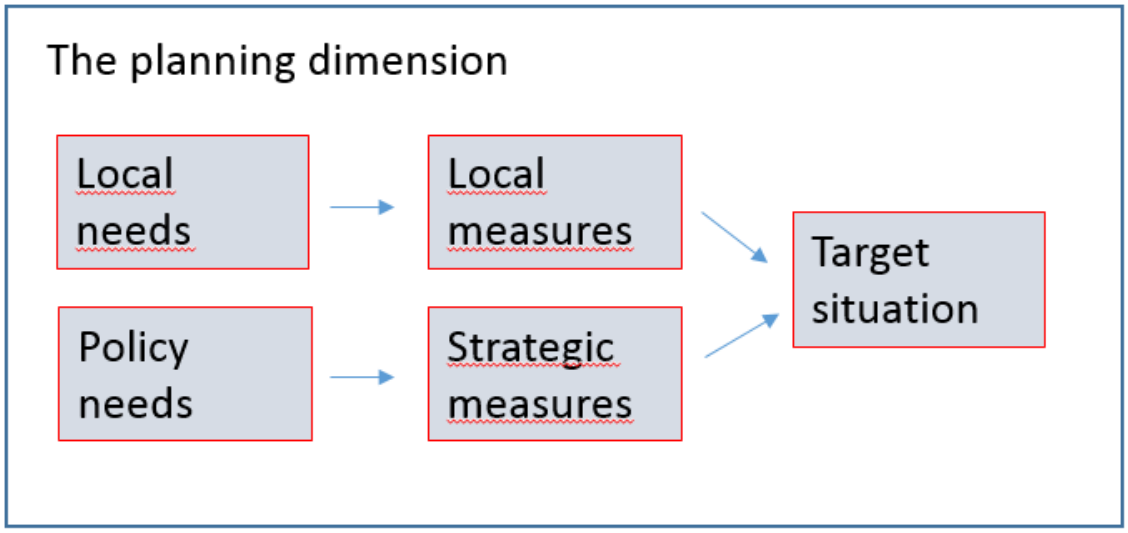
1.4. Methodology

The analysis made in this report is essentially carried out in two steps:
The first step, reflecting the strategic dimension ("where are we, and where are we going"), identifies the existing situation and puts that in relation to the target situation, the vision. The difference between the existing situation and the target situation is referred to as needs. These we define as "local" where they are expressed as solutions to what is experienced as local problems, or "policy" where they are expressed as higher level solutions (e.g. demand management through taxes). The latter will normally also have an impact on the local situation.



[2] Reference European ITS Platform (EIP) - 2012-EU-50005-S
[3] Reference EIP An update of the roadmap for European ITS Deployment Ver 1.1 2015

The second step, reflecting the ITS deployment phase, describes how the target situation (as expressed by the needs identified) shall be reached, i.e. what measures that shall be applied to fulfil the needs.



In this respect we apply measures of local character to meet local needs, and strategic measures to meet policy needs. The measures are included in an action oriented plan – an action plan - put in place to realize the vision.

In this report we will relate a series of studies to the processes described above and thereby create a foundation for an ITS deployment road map in which the appropriate combinations of measures are identified and put into a context where regional differences, financing opportunities and legal aspects are taken into account.

2. Local needs – maintaining legacy systems[4]

To draw the right conclusions regarding investments in future ITS we need to have a picture of the expected requirements from maintaining and upgrading existing ITS as this represents an important part of "fulfilment of local needs".

On the precondition that the implementation and operation of an ITS service has been found to bring value (like safety improvement, reduced congestion etc.), an investments in ITS may be classified in one of four groups:

1. It is made in order to implement new services on the network (e.g. the introduction of the first dynamic lane management system in a country or region)
2. It is made in order to extend existing services to new parts of the road network (e.g. extension of a dynamic lane management system with additional 10 km in an urban region)
3. It is made in order to replace old installations and equipment with new in order to safeguard operation (e.g. exchange of 5 years old roadside cameras or VMS panels that are dropping in reliability and facing increasing maintenance costs)
4. It is made in order to upgrade existing systems with new functionality and new technology (e.g. exchange of VMS to graphic displays and adding new message icons)

The two last categories, which we label as **reinvestments**, are difficult to distinguish from each other as improved functionality often follow from replacing equipment, which often call for new software etc. Together they deal with the issue of legacy systems, i.e. the fact that the more ITS we put into operation, the more ITS will need maintenance and replacement and upgrade in due time. Legacy systems bind resources, as the more you have, the more resources will need to be reserved for their maintenance, upgrading etc.

Presence of legacy systems also means that different functionality levels of ITS will operate in parallel which add complexity to the operation as newer systems can be expected to be designed with a higher level of harmonization.

The presence of legacy systems is both a challenge but also an asset with regards to introducing more advanced levels of functionality. On one hand, it will never be possible to upgrade all legacy systems at one specific time. On the other hand, we have an existing ITS infrastructure, technical knowhow and a financial planning for reinvestment as a basis for upgrading to more advanced services. The design of a roadmap for

[4] The full text is included in the A5 deliverable Update of the Roadmap v1.1 2015

implementation of future generations of ITS must thus be based on knowledge about what is planned to do with existing systems.

2.1. A European survey on legacy ITS systems

As a basis for the development of the roadmap, a survey[5] has been carried out with focus on questions relating to member states expectations regarding future ITS investments:

1. Expectations concerning need for re-investments in legacy systems at different time horizon
2. Expectations regarding the possibility to replace existing systems (e.g. loop detectors) with new technologies (e.g. probe vehicles)
3. Expectations concerning the balance between investments in new systems and services vs. investments in legacy systems
4. Assessment as to whether investments in legacy systems are to be considered as replacement of old equipment or upgrades to new generations of ITS
5. An assessment of to what extent parallel operation of different generations of ITS systems are considered as a problem

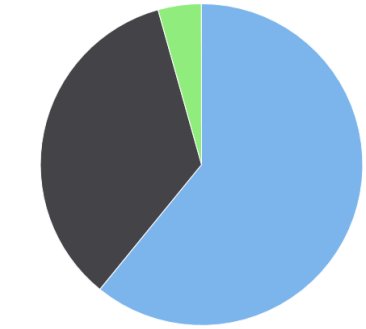
2.2. Results from the survey

2.2.1. EXPECTATIONS CONCERNING NEED FOR RE-INVESTMENTS IN LEGACY SYSTEMS

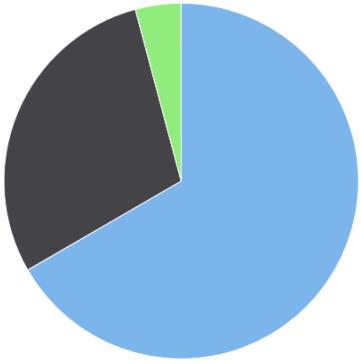
The purpose was to investigate the respondent expectations concerning how long the existing ITS infrastructure will operate without need for major reinvestments. Two questions were given reflecting expectations at different time horizons:

[5] EIP Activity 5, February 2015

Do you expect that more than 25% of your present ITS infrastructure will require reinvestments in 2-5 years time?



Do you expect that more than 50% of your present ITS infrastructure will require reinvestments in 6-10 years time?

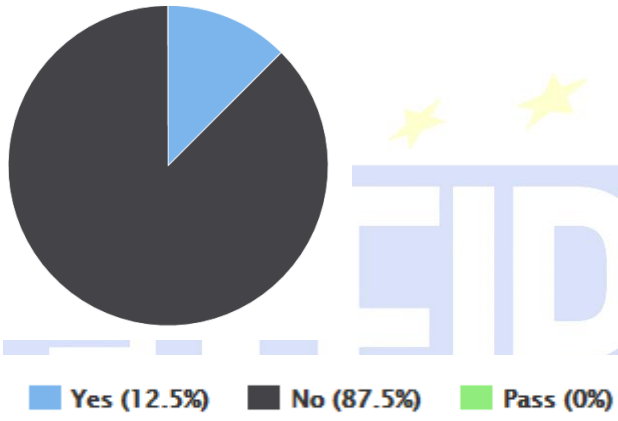


It is clear from the survey that the re-investment needs are apparent throughout the period, as well in the shorter (2-5 years) as in a longer (6-10 years) perspective. This means that re-investments will be continuously during the next decade, without any clear thresholds to be seen. This makes a major shift of ITS generation within this time complicated.

2.2.2. EXPECTATIONS CONCERNING NEW TECHNOLOGY REPLACING OLD TECHNOLOGY

Also here two questions were given reflecting two time horizons as of above. As the results from the questions were very similar only the responses to the second question is provided here:

Do you expect that more than 50% of your ITS infrastructure will be removed and not replaced in 6-10 years due to changed needs? Example: E.g. vehicle probes instead of loop detectors, in-vehicle signage replacing roadside VMS



It is very clear from the survey that there is little expectation that new technology will replace the solutions that are currently used. This may still be the case when it comes to new installations, but as we can assume that current installations have been made where the need is the highest, there will still be limited investments in “alternative solutions”.

Of particular interest is a comment from the Netherlands which states that from 2018 investments in “information giving equipment”, e.g. VMS signs, will be terminated. Investments in equipment for traffic control purposes will continue.

2.2.3. EXPECTATIONS CONCERNING THE BALANCE BETWEEN INVESTMENTS IN NEW SYSTEMS AND SERVICES AND INVESTMENTS IN LEGACY SYSTEMS

Two questions were addressing the relation between investment in legacy systems and new investments:

Considering spendings in ITS, will your main efforts be on spendings on new ITS, spendings on legacy systems or roughly equal?

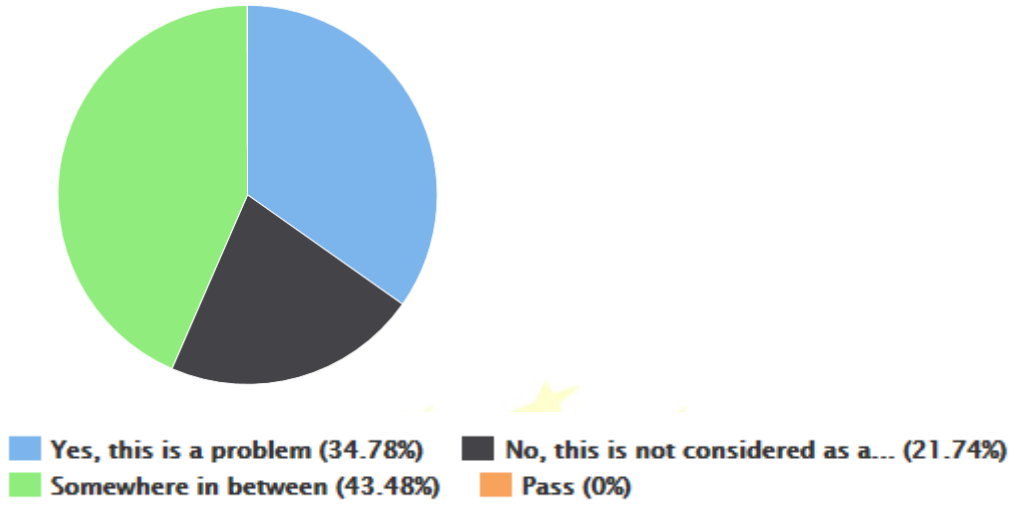
Considering your spending on legacy systems, will you characterize them as mainly replacements of old equipment, or mainly upgrades to a new generation of the system concerned?

The analysis shows two things: Approximately the same amount of investments will be made in new ITS as in legacy systems. Furthermore, investments in legacy systems will to a large extent include an upgrade of the system.

2.2.4. IS PARALLEL OPERATION OF DIFFERENT GENERATIONS OF ITS SYSTEMTS A PROBLEM ?

Finally, an important question is whether the current situation where systems of different generations are operated in parallel is considered to be problematic.

Do you consider operation of different generations of a system as a problem, in terms of keeping know-how, technical support etc.?



The figure shows that yes, there are important problems associated with this. Only a few respondents claim that this is not considered to be a problem.

2.3. Conclusions on legacy systems

From the survey the following conclusions on legacy systems can be made:

- There are low expectations on new technologies in replacement of existing solutions, e.g. probe vehicles instead of loop detectors, even in a 10 year perspective
- It is clear that a large portion of the existing ITS infrastructure (legacy systems) will need to be upgraded / replaced within a 5-10 year perspective
- Still, even if there is a large need for reinvestments in legacy systems, investments in new ITS will be of the same magnitude.
- It is considered to be a problem to operate systems of different generations in parallel.

The most important conclusion is that there is a difference between the perspective of the road operators and authorities (as reflected in the survey) and the technology forefront.

There are four main indicators for this:

1. The first is that the road authorities do not expect that new technologies will be able to replace the existing solutions within the nearest 10 years, despite that they see large needs for reinvestments which could be expected to drive evolution. There are some exceptions, but this is the general picture.
2. The second is that reinvestments in legacy systems is expected to require at least half of the resources available for ITS during the next decade
3. The third is that maintenance of existing systems also will include important elements of upgrading, maintenance means modernisation, which will bring added functionality to legacy systems.
4. The fourth is that it is not perceived to be a critical problem to operate different generations of ITS in parallel.

What does this mean? It is clear that road operator and authorities focus on reinvestments and improved functionality in existing systems and services. If they are expected to drive the development towards higher levels of functionality requiring important shift of technology, they will need additional incentives. An incentive in this sense can be access to knowledge about the benefits created through a more efficient transport system.

It is also important to understand that despite the commitment towards reinvestments, considerable resources are planned to be spent on new ITS within a relatively short time horizon which creates important opportunities but also challenges as this will bring different generation of ITS in parallel operation.

We can also see that the countries that are most at the forefront of ITS deployment also seems to be the ones that will lead the shift towards higher levels of ITS functionality. They will however be halted in their aims, as the benefits from cooperative services will usually not be released through local initiatives except for signal control related cooperative use cases provided that the vehicles are prepared. Neighbouring countries with equal development levels should join forces in the establishment of forefront deployment.

3. National plans reported by the member states

Whereas replacement and upgrade of legacy systems represents day-to-day ITS deployment and is embedded in the operations budget of the road authorities and operators, what picture on ITS deployment is given on the national policy level?

The ITS Directive requires that the member states shall provide the Commission with information on national ITS actions envisaged over the following five years period. According to the guidelines for reporting issued[6] the reporting should include, at least, the following information:

(a) the national strategy with regards to ITS, including its objectives

(b) a detailed description of ITS deployment and framework conditions

(c) the planned priority areas for actions and related measures, including an indication on how they tackle the priority areas laid down in Article 2 of Directive 2010/40/EU

(d) details on the implementation of current and planned actions as regards

– Instruments

– Resources

– Consultation and active stakeholders

– Milestones

– Monitoring

By 2015, 20 member states and Norway have submitted plans that are available to the public. What overall conclusions can be drawn from these plans from the perspective on an ITS Deployment Roadmap?

3.1. A goal oriented approach

It is clear from the plans that member states planning is goal oriented. The plans do (in general) not define what specific services shall be in focus, but points at the goals and objectives that have been set for ITS deployment (what effects they want to achieve).

[6] (Draft) Guidelines for reporting on national ITS actions Referred to in article 17 of directive 2010/40/EU

The first hand objective stated is to use ITS in order to improve or maintain the flow on the road network. Through this, also goals concerning environmental impact and safety will also be met.

3.2. The needs and plans are country specific

The plans also reflect that the activities planned follow from the particular needs of the different countries and from the current status of ITS deployment. Hence, a “one size fits all” European ITS Deployment strategy is not in line with the current situation.

Countries with a lot of through traffic have a clear focus on Heavy Goods Vehicles, including as well services to drivers as control measures like Weight In Motion. These countries also points at the need for solutions for uniform measuring of carriages (length, width, height etc.).

3.3. Traffic Centre Upgrade is in focus

Many countries have experienced that new systems and services have been brought into the Traffic Management Centres during the last years without changing the overall architecture of the systems controlling the centre. This has resulted in a situation where centre operators have to handle different systems through different interfaces without internal coordination. This means that important information from one system is not used for decision support in other systems bringing unneccesary costs and loss of potential.

Many countries now plan to renew their TMC´s in order to better organize the operator interfaces and enable interaction between systems (e.g. for data collection).

3.4. DATEX II is an important tool

It is also clear that there is no perceived alternative to DATEX II in terms of providing a solution for exchange of traffic information. Several countries plan to upgrade or invest in DATEX II during the period.

3.5. Data quality and supply are important

Several countries see the need to open databases and release traffic data for third party service providers. Besides real time data from the traffic network, also data about the network is requested by service providers and other external actors: Road network data, speed limit information etc. There is an obvious pressure from commercial actors in this

area. The member states also point at the need to develop knowledge and practises for securing data quality as the need for data grows.

3.6. EasyWay / EU EIP is in the centre for cross-border cooperation

Many countries point at the EasyWay community, e.g. through the EU EIP initiative, as the primary tool for cross-border cooperation and harmonization. No alternative to EasyWay is discussed.

4. Perceived need for (new) ITS investments

There can be many reasons to why decisions are made to implement ITS. However, the key to any decision is that there is a need to solve a problem (or several problems), and that ITS is expected to contribute to mitigating this problem. In case of upgrading or replacing legacy systems the original rationale for the ITS investment made earlier is always scrutinized: Do we need to replace or upgrade this equipment? Does the underlying problem remain or can we remove the system without replacement? Is there a better way to solve the problem following from recent technical development?

Hence there is a need to create an understanding of the current situation on European road transport corridors in terms of identifying and valuing problems, and then to identify ITS[7] deployment measures that could be undertaken in order to improve the performance of these road corridors through fighting these deficiencies. In addition, challenges to the required ITS deployment (resources, legislation etc.) must be identified together with activities that can be carried out to meet these challenges.

As a first step in this process the EU EIP project launched a survey with focus on the perceived needs for ITS measures with the objective to get a better understanding of the general driving forces behind ITS deployment: Are they needed to increase capacity or to improve road safety? Or is the primary goal to ensure that road users are well informed, which will support both these aims?

The scope of the survey was to get a better understanding of the general driving forces behind ITS deployment, and it was made complementary to previous studies that have been carried out in order to map the current situation and assess the impact of legacy ITS systems on the European road network[8].

The survey took its starting point from the overall goal for road network operations:

Creating an efficient and reliable transport system to fulfil mobility requirements while manage environmental challenges, improve economy and ensure safety and security.

From this, the survey focused on three aspects of managing traffic through ITS:

- To ensure high quality network performance regarding availability and reliability
- To provide enough capacity on high-occupancy road links
- To ensure a high level of safety

[7] Intelligent Transport Systems – ICT within road transport

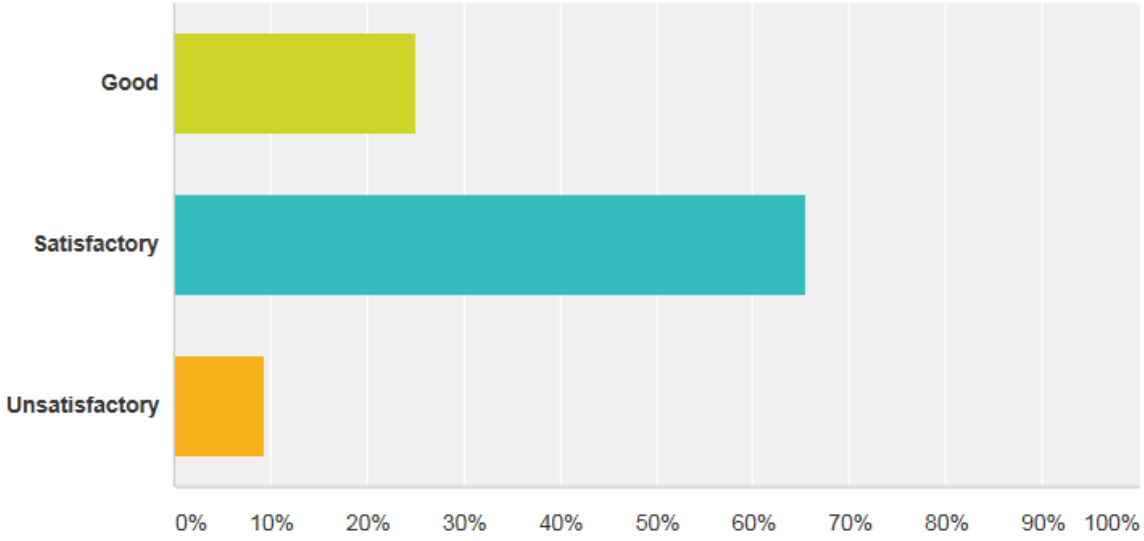
[8] These studies were made in the EIP project 2013-2015

4.1. The respondents

Respondents to this survey were found as well inside the road ITS community, notably partners in EU EIP and in the ITS Corridor projects ongoing under the CEF program[9], as well by stakeholders in the European Core Network Corridors (CEF corridors). No specific expertise in road ITS were required to respond to the questionnaire, but the responses indicated a very high understanding of ITS amongst the respondents.

4.2. Statements on network performance

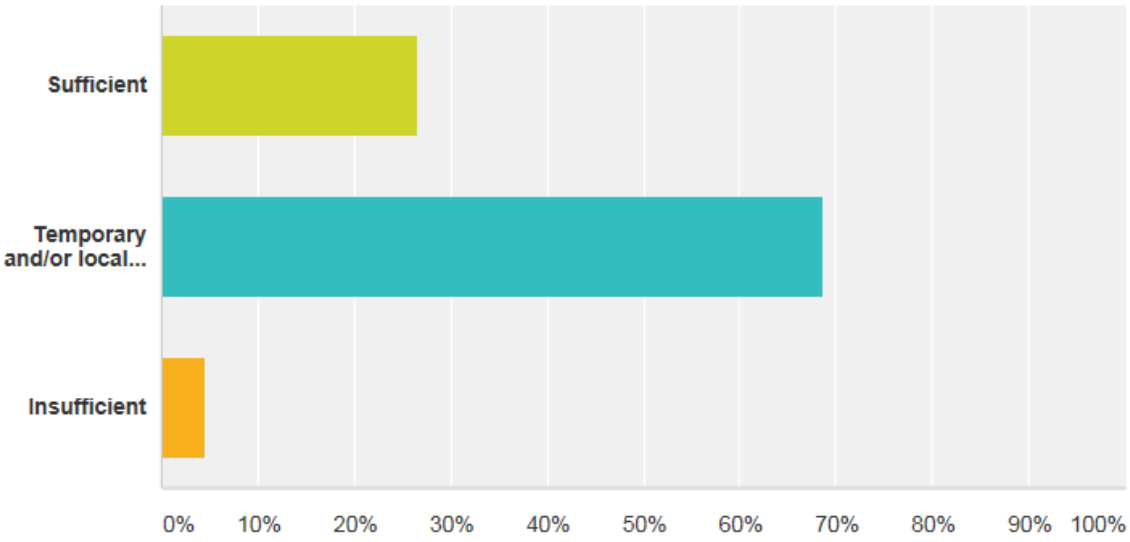
As a starting point, the survey asked for the perceived overall performance of the road corridor sections concerned, in terms of reliability and accessibility.



As shown in the graph, around 9% of the respondents considered the current performance of "their" network to be unsatisfactory. Or more important, above 90% of the respondents are satisfied with the performance of the network under their operation, albeit only 25% report the performance as good.

[9] MedTIS, Arc Atlantique, UrsaMajor, NEXT-ITS, Crocodile (www.its-platform.eu)

A follow up question to this aimed at finding as to whether unsufficient capacity could be the cause for this situation.



Summarizing the responses to these questions, the following conclusions can be drawn:

- The corridors function fairly well and have enough capacity
- But there are bottlenecks / local shortcomings causing disturbances

4.3. The utility of traffic management

Following this result, the question is to what extent traffic management is expected to provide solutions to the problems perceived.

The question given was “Classify on a scale 1 (very much) to 5 (hardly at all) your view on the utility of traffic management on the road corridor sections concerned in relation to the following situations”. The following answers were received:

	1. Very high	2	3	4	5 Very limited, not motivated
(Local) congestion	56,60% 30	28,30% 15	11,32% 6	1,89% 1	1,89% 1
Variation in vehicle speeds	14,81% 8	42,59% 23	29,63% 16	11,11% 6	1,85% 1
Adverse road weather conditions	21,15% 11	26,92% 14	40,38% 21	11,54% 6	0,00% 0
Stop and go situations	30,19% 16	35,85% 19	22,64% 12	7,55% 4	3,77% 2
Roadworks	25,93% 14	35,19% 19	22,22% 12	14,81% 8	1,85% 1
Deficiencies in road quality / pavement	7,41% 4	11,11% 6	31,48% 17	31,48% 17	18,52% 10
Events	33,33% 18	22,22% 12	18,52% 10	16,67% 9	9,26% 5
Lorries blocking all lanes	25,93% 14	25,93% 14	16,67% 9	20,37% 11	11,11% 6
Road accidents and incidents	53,70% 29	24,07% 13	11,11% 6	9,26% 5	1,85% 1

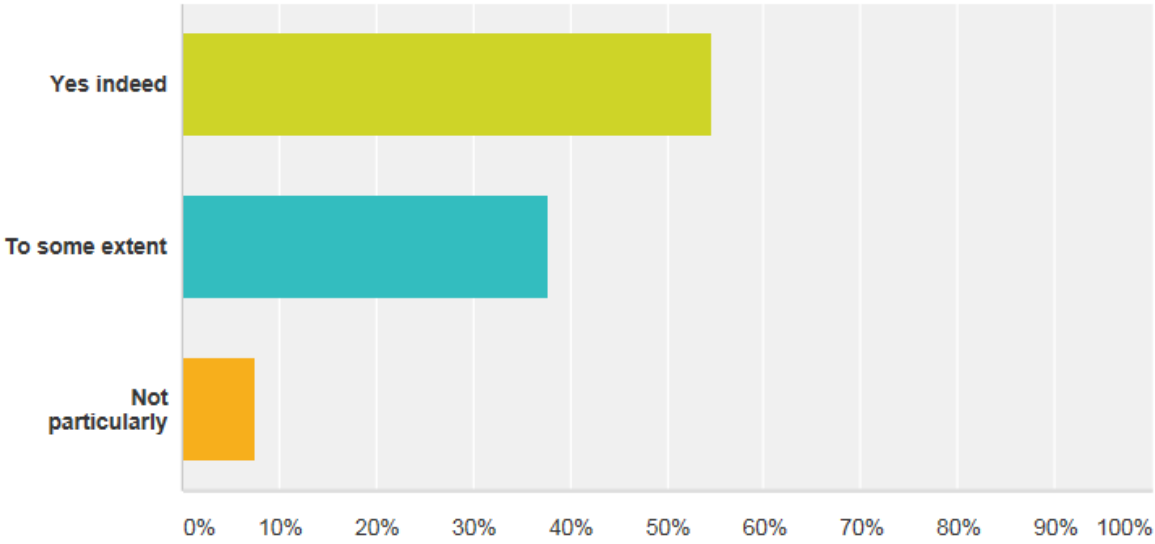
Table : Traffic management Usability indicators

From the responses given it is evident that there is a general view that traffic management find its use in response to local problems: Bottlenecks, accidents, roadworks etc.

4.4. Services to road users?

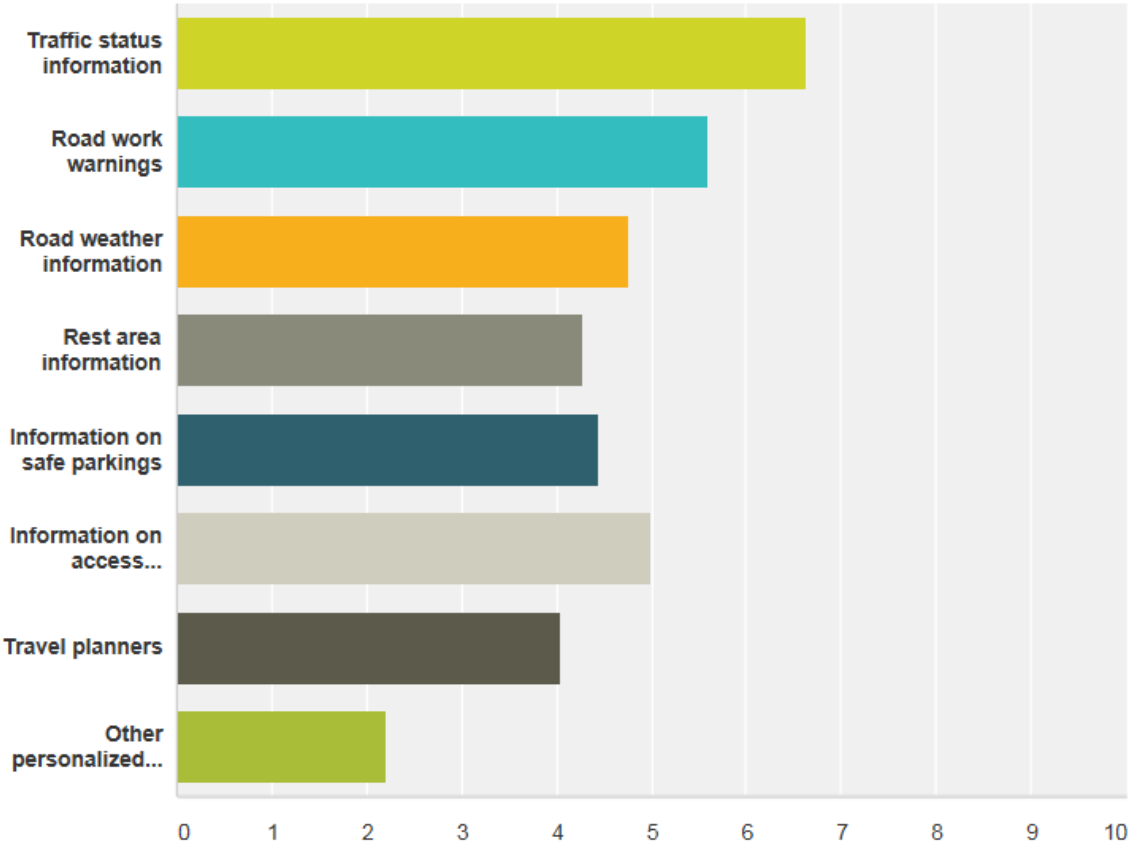
If we distinguish between traffic management measures which to their nature are steering (speed limits, lane control etc.) traffic information and other services can be provided also with the purpose of having an impact on the driver behaviour. The basic idea is that a well informed driver makes better decisions and more easily adapt to the situation on the road.

While considering the problems identified above, the question given was “Is provision of user services on the road corridor sections concerned considered as a priority issue?”



The response given gave a clear message that service provision is considered to be a priority measure in addition to providing traffic management.

A follow up question targeted the perceived value of different kinds of traffic information, and below you will find the ranked importance of answers to the question “Please rank the importance of quality information services towards professional drivers (HGV, Taxi, ...)”:



The top ranked information services included (generic) traffic status information, followed by information on road work warnings, information on access restrictions and road weather information. These services have in common that they provide situational warnings, i.e. warnings and information regarding situations which the driver should be aware of in good time to be able to change route to avoid delays or to slow down to reduce risk of accident. Services, guided towards more general planning, were ranked lower.

4.5. Conclusions on ITS priorities

Road operators rank safety measures and flow continuity as keys to corridor performance. More general information services to road users (parking info, travel planners) are considered as less important for this purpose. Road Works information shows an ambiguous pattern. It is considered to be of high importance, but the available

methods to provide this information (information and traffic management) seems to be inadequate. Here we can see a clear room for improvement and technical development.

Conclusions:

- Solving local bottlenecks is considered as most important as well from a local perspective as from a corridor perspective
- This means doing physical installations of traffic management equipment (lane/line control, variable speed limits etc.) at particular spots and stretches in the network.
- Road Works is identified as important, but not accounted for in current practices, eventually due to lack of good solutions. The great interest shown in Road Works Warning use case within C-ITS development reflect this.

5. Applicability of ITS solutions in different Operating Environments

5.1. Methodology

Complementary to the study reported in the previous chapter, a specific study was carried out within EU EIP activity 4.3 during spring 2017 with the aim of identifying the ITS that is considered most relevant for different Operating Environments[10] and to what extent this is dependent on the regional preconditions.

The scope of the work is to create knowledge about regional differences in preconditions and expectations for ITS deployment, and to create a foundation for synchronized ITS deployment by developing Core Service packages for different environments.

For different parts of the road network and corridors, expressed as Operating Environments, we have described which problems should be addressed, and which ITS measures would then be relevant for deployment.

5.1.1. WORK CONTENT AND METHODOLOGY

In the study the respondents has looked upon the corridor from a “road manager” perspective answering the question; Which problems do we need to solve within the next 5-10 years? The answer is given for each Operating Environment as experienced in the respondent specific network domain, where each respondent selected which Toolbox priorities (Actions) were considered to be most relevant in order to mitigate the needs, and in turn which ITS measures this would bring to deployment.

[10] Operating Environments. EasyWay Supporting Guideline ICT-DG01. November 2012.

Operating Environment	Toolbox priorities (Actions)	ITS measures considered (multiple tools per action possible)	Comments
C1 Critical spot	Change distribution of demand in time	Pricing services	Not available until 2025
		Access control services	New legislation needed?
	Manage access to critical road section	Traffic control (Ramp metering)	Possible by 2019
T3 Motorway	----		

Table: Example chart

5.1.2. TABLE OF TOOLBOX PRIORITIES

There is a range of ITS measures available in the road manager toolbox. These measures can be applied either as part of strategy implementation (i.e. creating the foundation for decisions on transport strategies) or as part of operational traffic management. We can also identify ITS measures that are enablers rather than services in themselves.

Some services appear as both strategic and operational. Here the strategic dimension means defining the rules and policies that control the operations, while the operational dimension is to operate the systems accordingly.

Measures for improved safety and efficiency	**Strategic relevance**	**Operations relevance**
a) Change the distribution in time of transport in order to achieve a more even allocation, avoiding peaks (access restrictions, fees)	Yes	
b) Change the distribution of transport in space in order to achieve a more even distribution on the network, and prevent "wrong vehicles on wrong places" (traffic control, traffic management, traffic information, access restrictions)	Yes	

c) Change the composition of vehicles on a certain piece of infrastructure (access restrictions, fees)	Yes	
d) Manage the flow on a given road section in order to reduce speed variation and thus improve the capacity and reduce the risk of incidents (MCS, ISA, Speed Cameras)		Yes
e) Manage access to a given road section in order to prevent disturbances and reduce the risk of incidents (Ramp metering)	Yes	Yes
f) Increase the speed on the link and thus increase capacity (throughput)	Yes	Yes
g) Reduce the risk of incidents and traffic disruptions through better informed infrastructure users (traffic and traveller information)		Yes
h) Reduce the consequences from disruptions through fast countermeasures (incident response time)		Yes
i) Reduce traffic volumes through redistributing transport between transport modes	Yes	

Table : Toolbox priorities

Most of the possible actions can be seen as relevant from either a strategic or operations perspective. Only (effectively) Ramp Metering offers relevance from both perspectives whereas different control strategies will be used in relation to the different perspectives.

5.1.3. ITS MEASURES IN THE TOOLBOX

In the following, the available ITS measures are presented briefly.

5.1.3.1. STRATEGIC (PLANNING) PERSPECTIVE

ITS measures that are relevant from a strategic perspective act through the policies that are implemented through the service. A good example is road pricing measures which, from a technical perspective, are operational in real time but their primary function is to have an impact on transport decisions. The road user charge typically changes the cost balance between transport modes. In the same way, access restrictions monitoring is operational 24/7, but impact from the service comes from the transport planners' knowledge of the access regulation.

Hence the following ITS measures are considered for strategic use:

ITS strategic measure		**Description**
1.	Priority allocation service	The possibility to give specific priorities to specific vehicles (conditional) on network elements
2.	Access control services	The possibility to regulate access to network (corridor) resources
3.	Pricing services	The application of user charges to regulate demand
4.	Reservation services	The possibility (for a certain vehicle) to make advance reservations for access to network resources
5.	Information of regulations and restrictions	Easily accessible information for facilitating transport planning
6.	Traffic management plans	Prepared combinations of traffic management measures in response to specific conditions on the corridor / network

Table : Strategic ITS measures

5.1.3.2. OPERATIONS PERSPECTIVE

The operational services are the “real tools” that are used in real time by traffic or corridor control centre staff. They are based on situational awareness, which is provided by sensors in the transport systems, and experience from the effects that will follow from the application of the ITS measures at hand. These services may have a fairly high level of automation, i.e. the system reacts without operator intervention. A good example is Dynamic Traffic Management which reacts on sensor information concerning speed, traffic load etc. It should be observed that the mix of ITS measures that are put in operation given a certain situation might be defined in a Traffic management plan. Here the traffic manager pre-defines what kind of actions that shall be put in place when specific circumstances appear. These decisions are defined as strategic measures (above).

The ITS measures available for real time corridor operation are:

ITS operational measure		Description
7.	Dynamic road and traffic information	The provision of real time information to users of the corridor / network (pre- and on-trip)
8.	Dynamic traffic management (including MCS)	The real-time control of the traffic flow on the corridor
9.	Vehicle specific traffic management and information	Information and control messages directed towards individual vehicles (transport id´s) during transport operation
10.	Urban gateway	The operation of an entry/exit point between a corridor and an urban node
11.	Platooning	The operators control of enabling (HGV) platooning of vehicles on a section of a corridor
12.	Variable Speed limits	The operator possibility to change speed limit settings on a corridor section in order to optimize flow
13.	Green wave	The operator possibility to set a series of traffic control equipment to Green wave mode
14.	Traffic Control (including ramp metering)	The operator capacity to regulate traffic on a road, and on its approach ramps, through traffic control devices
15.	Incident response and management	The capacity of the operator to detect road incidents and activate resources for effects mitigation
16.	Check in/out	The registration of a vehicle on the interface between elements of the network or corridor (leaving/entering)
17.	Tracking and tracing	The capacity of the network operator to track a

		vehicle and follow its way through the network
18.	CAM message collection through cellular or DSRC communication	E.g. Probe vehicle data, data collection for network / section performance measurement
19.	DENM message distribution through cellular or DSRC communication	E.g. Dynamic Road Works Warning or other Day 1 or Day 1,5 C-ITS service

Table: Operational ITS measures

5.1.3.3. C-ITS DEPLOYMENT PERSPECTIVE

Some of the services indicated above will require "connected vehicles" (e.g. 9, 10, 16, 19). As these services can be provided through "smartphone technology" we distinguish them from services requiring communication in-between vehicles as required for e.g. Platooning, and between vehicles and dedicated roadside stations (e.g. by ETSI C-ITS G5 communication).

As we can expect C-ITS infrastructure deployment to start up within the next 10 years, we need to also consider deployment of C-ITS road stations. We add an operational measure reflecting collection of CAM data through DSRC roadside stations or through cellular communication, and a measure for provision of DENM messages through cellular or DSRC roadside stations for certain day 1 and possibly day 1,5 C-ITS services (18, 19).

5.1.3.4. OPERATING ENVIRONMENTS

Operating Environments find their use in different ways. They are used in the EasyWay Deployment Guidelines to describe the feasibility of different services in relation to the different environments on the European road network, and they are also used in the European ITS Deployment Road Map process as the basis for describing network extension and service level development.

By using the Operating Environments as the basis for the Road Map, rather than the physical road network, stakeholders in road ITS can discuss deployment priorities in relation to an abstract network model, and then bring this information back into their national planning process to be applied in the national network.

The following list of Operating Environments of relevance for corridor analysis has been used[11]:

Operating Environment	Road topology	Traffic characteristic
P1	Peri-urban motorway or road interfacing urban environment	Possibly safety concerns
C1	Critical spots	Local flow-related traffic impact and/or potential safety concerns
S1	Motorway corridor or network	At most seasonal flow-related impact, possibly safety concerns
S2	Motorway corridor or network	Daily flow-related traffic impact, possibly safety concerns
T1	Motorway (link)	No flow-related traffic impact and no major safety concerns
T2	Motorway (link	No flow-related traffic impact, potential safety concerns
T3	Motorway (link)	Seasonal or daily flow-related traffic impact, no major safety concerns
T4	Motorway (link	Seasonal or daily flow-related traffic impact, potential safety concerns

Table : Operating Environments used in the study

[11] Extract from ICT-DG01 version 02-02-00, December 2015

5.2. Results

The table below shows the perceived relevance of different ITS measures (a to i in table above) in relation to Operating Environments.

Particularly frequent relations are marked with bold in the table.

OE	a	b	c	d	e	f	g	h	i	
P1	**x**	**x**	x	x	**x**		**x**	x	x	(S/F)
C1		x		x	x		**x**	**x**		S/F
S1							**x**	**x**		(S/F)
S2							**x**	**x**		(S)/F
T1							**x**	**x**		No
T2							x	x		Safety
T3	x	x	x	**x**				x	x	Flow
T4				x			x	x		S+F

Table : Relevance of Actions for different Operating Environments

The analysis shows that Strategic measures are applicable to critical spots and urban environments with heavy traffic load. While operational measures find their use on the entire network with two clear objectives:

i) Reduce the risk of incidents and disturbance through well informed road users

ii) If something happens, detect disturbances fast and apply countermeasures rapidly to mitigate damage (efficient incidents response)

Ramp metering is considered as well a strategic as an operations tool, which finds its use in urban and peri-urban motorway systems.

The conclusion is that the main driving force behind ITS deployment is to maintain the flow on the network (which will reduce risk of accidents and mitigate effects if they happen). If we put this objective in relation to upcoming “innovations” we can see that primarily C-ITS services provided with this objective will have relevance for the road operator in this respect.

6. Observations on regional prerequisites

6.1. Strategies for ITS deployment

The development and implementation of Traffic Management (i.e. use of ITS) follows from three different deployment strategies:

1. Existing (old) roads[12] are retrofitted with ITS and subject to management measures

All countries have extensive road networks that were built before ITS was introduced. Following an order of priority given by the status of the roads concerned, these roads are successively equipped with ITS (including cabling etc.) and made subject to traffic management and potentially introduced into overarching control strategies (TMPs etc.).

A key characteristic to this strategy is that the road operator (authority) needs to develop and implement the specifications required for the ITS systems in use.

2. New roads are developed and operated with "embedded ITS"

Road administrations that do not operate overarching traffic management systems (e.g. on a national or regional basis) may select to include Traffic management and relevant ITS systems in procurement for developing new road sections. E.g. "20 km motorway including systems for monitoring and control and their operation". This strategy is common also for specific road sections that are subject to tolling and operated by concessionaires (bridges, tunnels etc.) where the operator is keen on providing a high service level.

A key characteristic to this strategy is that the infrastructure provider needs to develop specifications etc. for the ITS systems concerned and to have the competence and organization for continued operation. We can also see that the "local operator" is more interested in ITS that will reduce operational costs (e.g. WIM, speed control) than optimizing network performance on a regional/national level.

This means that the road section and the management of the road comes together, causing a situation where different parts of the network are controlled by different (regional) traffic management centres and services. This is not a good situation, but to separate the investments in ITS and the physical road would require access to very detailed specifications to secure interoperability. This level of specifications is not

[12] Here the term Road is used as a generic term for a part of a network

available and it is considered quite difficult to establish them. In their absence we can conclude that the current legislation related to procurement to some extent drives this situation as it is too complicated to procure independent ITS.

3. New roads are designed to fit into existing systems

This strategy is applicable where the road operator has a national / regional system in operation and all new road sections will include ITS that is required to be integrated in this system.

This strategy will require quite detailed specifications to ensure that the delivery (road and ITS) can plug into an existing traffic management system.

Looking at these three strategies we can see that the requirement for competence with the road operators are highest for strategies 1 and 3, and supplier competence will be required primarily in strategy 2.

6.2. Adopting corridor management strategies

An important aspect is that linking infrastructure and ITS development increase the risk of local solutions and creation of a vendor lock-in situation. Luckily time has shown that there has been an interesting evolution from local (spot) to regional and finally national traffic management centres as systems became more mature and faced the need for maintenance and upgrade. The adoption and evolution into a corridor management strategy will be an additional step in a process that is ongoing.

It is clear there will be a need for further incentives and motivation for road operators to include a corridor perspective in the network operations. This will be particularly important in countries which still are developing their ITS systems and where there is no centralized traffic management, but responsibilities are distributed and related to specific segments with limited interaction and cooperation.

7. Conclusions

With the purpose of designing a road map for establishing and operating ITS that aim at optimizing network/corridor performance we can see that three important prerequisites need to be fulfilled:

- There is a need for harmonization (architecture and specifications)
- Incentives will be required
- Stakeholder responsibilities need to be developed

7.1. The need for a common architecture and common specifications

European transport corridors include in general several cross-border sections, and even more when considering administrative borders of different kinds. There will be a vast number of possible interrelations between vehicles, road operators and service providers.

The EasyWay project developed and implemented a number of Deployment guidelines with the purpose of streamlining ITS deployment in order to achieve service harmonization (continuous and interoperable services) on European road corridors. These Deployment Guidelines are currently being reviewed through the EU EIP project. This approach is correct, but the current set of Deployment Guidelines (initially developed in 2010) does not cover next generation road transport with V2V and V2I communication and information exchange (C-ITS). Furthermore, the Deployment Guidelines approach the services per se. What is needed is a top down strategy on how to ensure seamless communication between vehicles and infrastructure related to European transport corridors. The C-Roads project may provide a solution to this, if it will include all relevant communication technologies for C-ITS.

In addition, we have found that several road operators across Europe do not have the capacity to procure interoperable non-vendor specific ITS solutions due to the lack of good specifications. Instead they are forced to consider ITS as a part of the infrastructure, whereas the ITS implemented will be dependent on the infrastructure supplier (contractor) rather than corridor needs.

7.2. Drivers will be required

As shown in the studies presented in this report, road operators primarily focus on solving local needs through local measures. To establish and operate ITS that optimize network/corridor performance various drivers will be needed to ensure that stakeholders also value the corridor perspective.

Such drivers may include:

- Incentives like financial support, to projects supporting the development of corridor strategies
- Legal measures supporting and facilitating innovations in investments.
- Knowledge on corridor performance and its impact on local traffic, with particular attention to the impact from freight transport
- New traffic management tools connecting local and corridor perspectives
- Support in planning and design for transport system balancing local and corridor needs
- Stakeholder cooperation for identifying potential benefits from integration of systems and services

These aspects will be further developed in the continued work of this project.

7.3. The role of stakeholders in the road transport system

7.3.1. THE ROLE OF THE ROAD OPERATOR

The studies carried out and reported here show the same pattern: The road operator / road authority sees as its priority task to maintain the flow on the road network, and to react quickly if something happens to mitigate the effects from the disturbance.

It is also clear that this view is supported by the national ministries as they have expressed their plans in their reporting to the EC: The primary objective stated is to **use ITS to improve or maintain the flow on the road network**. Through this, also goals concerning environmental impact and safety will be met.

For this purpose, the road operator will use the tools that are available on the market. Furthermore, a large, and likely increasing, portion of the available budget will be spent on maintenance and renewal of legacy systems, and in doing this the operators do not

foresee that important technology shifts will happen in the foreseeable future (next 10 years).

If we look on road network operations of today, we can see that road operators way of managing traffic is reactive: Traffic is monitored, and actions are based on the monitoring results. Everyone that has studied the interior of a Traffic management centre can verify this. It should however be said, that many of the systems in operation, from intersection control, ramp metering, lane control systems, dynamic speed etc. are developed to maintain flow and reduce the risk of incidents and accidents.

One important aspect is also that vehicles are so far not individuals (except in some bus priority systems in intersections) in relation to the road operator. Vehicles are in general not known, and treated as a mass.

The technical development now taking place will change this. Connected vehicles will allow for a new generation of systems and services where individual vehicles and / or transport can be handled. A parallel can be drawn to development in rail and air transport.

The road operators basic mission will not change, it will remain to organize the traffic in an optimum way. But the development will allow for new ways of achieving this goal. Also these new opportunities will be further discussed and developed in the project.

7.3.2. THE ROLE OF THE VEHICLE INDUSTRY

The role of the vehicle industry is changing faster than the role of the road operator. From being an organization selling cars (lorries) to their future owners, the vehicle industry has adopted the idea of a long term relationship with the user of the vehicle. Hence, the industry is also providing a range of optional solutions to accessing their cars. Ownership is only one (and mostly applicable to older cars). The vehicle industry knows that provision of services, maintenance, upgrades, insurance etc. in the longer term is more profitable than selling the vehicles. Nowadays a vehicle is followed by a range of services offered by the selected OEM, which ensure a steady cash flow from the vehicle to the OEM.

This means that every vehicle is (will soon be) considered as an individual in relation to the OEM that has produced it, and furthermore, this OEM has complete information about the vehicles operations and can also remotely control many of its functions.

This puts the OEM in a much stronger position than the road operator when it comes to control of individual vehicles, but traffic management should remain the responsibility of the road operator. A clear view on how actors and their relations will develop is needed for continued road map development.

8. References

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- Proceedings from workshop: European ITS Deployment road map development process and ITS deployment challenges, Glasgow 8 June 2016
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