TECHNICAL SESSION B2

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ROAD NETWORK OPERATION

INTRODUCTORY REPORT

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EXECUTIVE SUMMARY

The Road Network Operations technical committee's (TC B2) work falls under Strategic Theme B: Improving Provision of Services. This theme's overarching goal is to encourage the improvement of transportation services through enhanced operation of the road system, integration with other transportation modes, good governance, and a customer oriented approach.

In this context, "network operations" means operation in the widest sense, including the integration of these activities:

- across geographical boundaries between road operators and road administrations
- allowing travellers and freight forwarders the optimised use of all modes of transport
- facilitating inter-modal transfer and smooth access to ferry-terminals, ports, airports, road-rail transfer points, etc.

The institutional issues of network operation are significant because of the number of stakeholders involved. The provision of accurate and timely information to all the interested parties has a central role.

Network Parameters

The PIARC committee on Management of Network Operations recommends that the following test is applied when trying to determine the reach of wide-area "Integrated" network operations:

- A transport network that has its geographical limits defined according to the road users' needs…
- that may be multi-modal, multi-jurisdictional, multi-national (local, regional, national authorities and concession-holders)…
- using possibly different levels of infrastructure (rural, local or national roads hierarchy)…
- that involves interaction and inter-agency cooperation on traffic management and traffic information

As part of this the Road Network Operations TC B2 looks at strategies to reduce congestion and/or mitigating its effects, the use of intelligent transportation systems (ITS), and overall management of road corridors. Given that congestion in its various forms is the primary challenge facing road corridor managers, many of the tools related to corridor management are the same as those for management of congested areas. The TC B2 therefore decided to combine analysis of congested area management and corridor management. It studied the increasing use of technology by governmental jurisdictions to deliver efficient, targeted services to road users in terms of delivering information and operating the network to make best use of the available road space.

The multinational group gathered case studies, examined on-going efforts around the world, and the development of references and tools. This was disseminated through a seminar, compilation and indexing of the case studies, exploring the future development of

vehicle infrastructure communication services and revising the World Road Association ITS Handbook.

This report is consequently organised in 3 parts:

- the congested areas and corridor management strategies and tools
- the exploration of the new opportunities offered by the future “connected vehicle”
- the capitalisation on ITS know-how with the updating and implementation on-line of the ITS handbook

The B2 committee plans to dedicate most of the Technical Committee session at the Mexico World congress to the first part of this report.

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1. MANAGEMENT OF CONGESTED AREAS AND ROAD CORRIDORS

1.1. Approach

The first difficulty is to define what a congested area is and what is meant by road corridors.

Usually, we understand congestion as a situation where the demand for road space exceeds supply. But this excess may vary in time, in duration and can be perceived differently according the offered level of service and users’ expectations. We can say at the end that the congested areas are parts of the road network where this imbalance is found between the road network performance expected by users and how the road network actually works.

PIARC defines “road traffic corridor” as: “A set of essentially parallel roads connecting two points.” For the purposes of this report, however, we will qualify this definition in several ways. First, many road corridors, particularly in rural areas, may only have a single road for part or all of their length. Second, many corridors connect more than two points. Third, while corridors tend to be linear, some are not, instead branching to connect several points. Given so many various possible configurations, a simple working definition of *road corridor* might be “a road(s) of some importance connecting two or more points.” Beyond

this, it is difficult to generalize, given that each corridor has unique characteristics and conditions.

Corridors present also diversity in terms of traffic volume, type of traffic. A complication for road corridor management is the degree of interface with other modes. The more points at which a road corridor intersects with other passenger and freight modes, and the variety of those modes, the more challenging this task becomes. A further complication is that corridors generally go across different jurisdictions, even international borders.

Congestion is in any case an issue for corridors. The US Federal Highway Administration describes and ranks the sources of congestion[*] as follows:

- **Bottlenecks**—points where the roadway narrows or regular traffic demands cause traffic to backup–are the largest source of congestion.
- **Traffic incidents**—crashes, stalled vehicles, debris on the road–cause about 1/4 of congestion problems.
- **Work zones**—for new road building and maintenance activities (like filling potholes)–are caused by necessary activities, but the amount of congestion caused by these actions can be reduced by a variety of strategies.
- **Bad weather** cannot be controlled, but travellers can be notified of the potential for increased congestion.
- **Poor traffic signal timing**—the faulty operation of traffic signals or green/red lights where the time allocation for a road does not match the volume on that road–are a source of congestion on major and minor streets.
- **Special events** cause "spikes" in traffic volumes and changes in traffic patterns. These irregularities either cause delay on days, times or locations where there usually is none, or add to regular congestion problems.

All these sources also interact. Other elements help to take the measure of congestion: level of service, speed, travel time and delay. But, for travellers, the most important criterion is the reliability of the highway system, particularly of the predicted travel time. People can accept a longer travel time for a trip during the peak period, so long as this predicted travel time is reliable.

Anyway, everybody agrees on the fact that congestion has a significant impact on environment, on energy consumption, on the public's well being and more generally on economy. In most countries, building new infrastructure is unsustainable, impracticable, and financially unaffordable, even inefficient.

Making the best use of the existing infrastructure, particularly in a corridor is needed and this requires a system approach that incorporates high level transport strategies, including alternative transportation modes.

Many countries have come to realize this approach in combination with new technologies and capabilities that can provide cost effective solutions to the growing congestion

[*] http://www.fhwa.dot.gov/congestion/describing_problem.htm

problem. Although much is still in the pilot or experimental stages, there are many examples of best practices throughout the world which have matured.

Thanks to a wide survey among the PIARC country members, TC B2 has identified case studies from which lessons have been drawn for future implementation of management strategies and tools for congested areas and road corridor management.

It should be noted that although one of the strategies may have prominence within a case study, several others strategies provide a supporting role. As an example a managed lane strategy using existing shoulders as a part time thru lane might employ road pricing in this new capacity, improved transit service by the revenue generated, real time traveller information to determine the operating time, and traffic incident management techniques to mitigate the lose of the safety shoulder. Where information gaps were identified the authors performed a literature search and interviews with transportation officials to provide a full picture of potential strategies for combating congestion. A distinction has been made between non-recurring congestion and recurring congestion management strategies and tools.

1.2. Non-recurring congestion:

Non-recurring congestion management includes the development and deployment of strategies designed to mitigate traffic congestion due to irregular or non-recurring causes, such as crashes, disabled vehicles, work zones, adverse weather events, and planned special events. About half of congestion is caused by temporary disruptions that take away part of the roadway from use.

One major aspect of non-recurring congestion is the ability to anticipate the situation (planned events) or to detect as quickly as possible the unplanned events. Traffic information plays an important role in that case, either by warning users of the planned event, either by informing them as quickly as possible in case of non planed event. Therefore, management strategies include the following:

- Traffic incident management
- Planned special events traffic management
- Work zone traffic management

and in addition to these, real-time traffic information.

The following recommendations have been proposed for non-recurring congestion management strategies:

Traffic Incident Management

- Develop and adopt a unified goal for incident response.
- Develop comprehensive guidance on incident response performance measures that local and/or regional stakeholders can use to assess incident response programs.
- Provide comprehensive “first responder” training which includes traffic incident response practices that takes into account the unique environment of the roadway. This includes procedures to assure the safety of the responder and road user, limits the traffic flow impacts associated with the response, and provides a quick clearance of the scene.

Planned Special Events

- Develop cross jurisdictional/agency traffic management plan

- Manage travel for a planned special event so that economic and tourism benefits are captured for the hosting community.
- "Showcase" a successful planned special event; this could lead to increased future tourism.

Work-Zone Management

- Shorten the contract time; particularly phases that impinge on traffic.
- Improve communication with motorists
- Adopt a coordinated policy, planning, and programming approach to work zone planning and operations
- Design for future maintenance

Real Time Information

- Incorporate the principle of traveller information into agency and corporate mission(s).
- Increase the delivery of travel/journey time information systems. Deployment might need to be phased depending on research and technologies.

1.3. Recurring congestion

Recurring congestion occurs during peak travel periods when the number of vehicles trying to use the highway system exceeds the available capacity. Peak travel periods can be daily (commuters), weekly (rushes for week-ends) or seasonally (holidays or some celebrating days during the year). Daily congestion affects mostly urban areas, while seasonally congestions may affect large networks leading to holiday resorts. Weekly congestion can affect both.
Effectively managing demand during peak periods involves first convincing travellers to make their trip at a less congested time, on a different mode (mass transit), on a less congested route or through a means other than travel on the highway system (telecommuting). For more localised and specific congestion areas, it can require effectively managing driver behaviour (speed harmonization), actively managing existing infrastructure (hard shoulder running), Incentives for modifying drivers' behaviour can also be based on pricing.

The following recommendations have been adopted for recurring congestion management strategies:

Congestion Pricing

- Variable rates are best for congestion reduction; fixed rates are perceived as pure tolling or revenue generation only.
- Tie revenue to roadway improvement or alternative transportation mode
- Provide extensive public outreach prior implementation
- Use technology to minimize back office overhead, collection, and enforcement costs

Arterial Management & Traffic Signal Timing

- Provide cross-jurisdictional management/signal coordination
- Investigate the use of adaptive control systems
- Establish a well defined procurement process for equipment

Real Time Traveller Information

- Establish data standards
- Design serviceability into display signs
- Sign spacing is critical in providing sufficient time for users to react yet being economical to deploy
- Travel time information is particularly useful when there are multiple routes/mode choices available to users

Planning and Implementing Physical Capacity Expansion

- Tie budget and project selection processes to roadway performance indicators
- Implement bottleneck reduction program
- Explore non-physical capacity expansion (operational) strategies concurrently with physical capacity expansion options.
- Design for future maintenance

The above recommendations for reducing recurring and non-recurring congestion are applicable to road corridor management. However, the particular challenge facing road corridor managers is to implement and coordinate these recommendations as appropriate along the length of a corridor that may have many diverse segments and different jurisdictions.

1.4. Inter-Agency Working

As revealed during the survey, the technological tools are increasingly available to better manage congestion and road corridors. The greater challenge is certainly how to encourage stakeholders to work together to optimize their networks.

Transport systems are generally managed by multiple agencies focussing on, for example, specific modes of transport, depending upon the preferred approach of individual countries. With road networks crossing international boarders, local authorities managing local road networks, and private companies becoming more prevalent in implementing and managing specific sections of motorway networks around the world (e.g. BOOT schemes), achieving systemic urban congestion reduction outcomes from the entire road network requires effective cooperation between agencies and private operators.

In much the same way as complimentary measures can enhance the success of addressing urban congestion; cooperative agencies can ensure that more global outcomes are achieved along entire road corridors, despite jurisdictional boundaries.

1.5. User and customer relationship

One recurring theme that has been identified in the case studies is the need to reach out to the public either to inform them as to why a particular scheme or strategy was being considered or as drivers provide them with the necessary road condition/performance information to allow them to make better trip decisions. And even, when they cannot make another trip choice, informing drivers alleviates their perception of the congestion. This element is essential in moving roadway management and use from a “passive” activity to

an active operations paradigm which maximizes the efficiency and effectiveness of the infrastructure. Future development of vehicle to infrastructure communication will reinforce this approach: the driver becomes an actor in the road system.

Exactly when, how and where the services based on vehicle to infrastructure communication will be widely developed is an issue on which the various stakeholders have not yet found an answer. For that reason B2 has been exploring the challenges and obstacles for deployment.

2. THE CONNECTED VEHICLE

Much of the technology for Intelligent Transport Systems (ITS) was originally developed for controlling traffic signals in urban areas. Through continued development ITS applications now cover the entire road network as well as the whole range of transportation systems, including public transport, tolling and charging systems (ETC). Today ITS provides a toolkit for transport network managers to use for increasing efficiency; improving safety; encouraging alternative modes and assisting with the management of roadway maintenance and construction.

The introduction of more intelligent, connected vehicles and the relationship between these vehicles and an intelligent infrastructure opens new opportunities for improving the road network management. Working with FISITA (The International Federation of Automotive Engineering Societies) TC B2 established a joint task force (JTF) to take this initiative forward. It identified a demand for guidance to advise road operators around the world how to plan their investment to make the most of the opportunities for greater safety and efficiency. It also identified a demand from the automotive industry to understand the role of the road operator and the benefits of working more closely with road operators. The following sections highlight the main issues concerning the “connected vehicle”. Results of this work will be presented in Special Session 12 at the Congress.

2.1. Policy Issues

Whilst all agree that commercial wireless telecommunications networks provide a platform for the development and deployment of information and infotainment based applications opinions are divided whether forthcoming 4G services can provide the performance necessary to enable safety applications to operate to best effect. If 4G cannot deliver sufficient performance vehicle based DSRC services are required with infrastructure support.

Regardless of the technology there is a general consensus that public authorities have a major role to play in the deployment of connected systems. However, depending on the existing legal and economic environment in each country, this role could be limited to one of leadership, research, and setting up the legal framework in order that automotive and telecom industry is able to develop the services. Conversely, there could be the need for public investment in the basic infrastructure because the business case for a DSRC infrastructure is not compelling

In any event the automotive industry is asking for some common rules and standards among countries: cars, basically the same are sold all over the world and cars travel across borders. Moreover, the safety aspects are crucial and this is clearly the role of public authorities to set up the rules in this area.

2.2. Standards

A uniform approach to world standards for communications and connected vehicle applications in the automotive sector would be ideal but it has to be accepted that regional differences make this unlikely, so it follows that car makers will have to adapt their products for each region. Architecture and interface standards are very important to achieving economies of scale and making services profitable. They are most likely to emerge from the industry, with input from government providing structure and guidance for standards regarding the unique requirements of public safety and similar services.

Generally there is an assumption that safety applications will require dedicated short range communication (DSRC) whilst information and infotainment services can use a commercial 3G/4G network. But the apparition of 4G and future broadband air communications may be sufficiently robust to support safety applications. This needs to be explored.

It has been noted that the electric car industry has important and specific needs for standards and the development of electric interfaces may force new agreements and open new opportunities for standardisation.

2.3. Business Case

There is general acceptance that the roadside infrastructure for DSRC needs to be provided by government, the road authority or the road infrastructure operator in case of concession. Up to now, no business model has been identified which would encourage a private company to provide a dedicated network. None of the research or pilot projects have seriously addressed the business issues associated with the connected vehicle.

However the business case is a critical issue. Governments require a strong, evidence based case before they will invest in a communication infrastructure. Businesses require customers, but consumers have shown reluctance to invest in systems which have a cost or subscription overhead, even if this enhances safety. People expect to purchase a vehicle which is safe and can be operated safely without the need to purchase additional equipment or to pay service charges. It is necessary to add something extra-ordinary in terms of service products to make additional safety features attractive. Safety must be packaged with other attractive applications.

2.4. The wireless connection – dedicated short range communication or commercial cellular network?

DSRC presents major advantages for safety applications: it has a broadcast mode; it provides accurate localisation of the vehicle. Roadside and vehicle equipment are not expensive if they benefit from mass-market production. In addition DSRC beacons are being deployed for free flow tolling and charging applications. DSRC is preferred by many in the automotive industry because it is a known, developed and understood technology.

In spite of these advantages, there remain some issues:

- The DSRC operating frequencies are not universal throughout the world
- Security and vulnerability issues have to be addressed.
- There is a lack of understanding of the behaviour of DSRC under heavy use congested situations and tight geographic areas.
- Co-existence of DSRC for tolling and DSRC for other applications may cause some problems.

Looking to the future, it appears that next generation of 4G/ LTE data systems would be sufficiently responsive and reliable to enable even safety applications, which will never be the case for the existing 3G services.

The next generation of cellular 4G systems:

- promises latency and reliability which rivals DSRC
- has a strong business case and competitive environment based on other commercial applications
- are subject to ongoing development and will, year by year, become faster and have greater bandwidth – and lower costs and more appropriate for machine to machine applications

Regardless of government or automotive industry policy the 3G/4G network will be expanded and deployed. It is likely that applications will be developed by the free market based on either aftermarket automotive devices or Smartphone type equipment.

2.5. Issues for countries in transition

In each country we have to consider the individual cultural approach to driving and pedestrian behaviour and how this differs from other countries. Outside the big cities some countries will need to invest in the basic infrastructure and improved safety habits before investing in co-operative systems.

Some countries may have a strong investment in 3G/4G communications and smart devices with low cost telecommunications. This provides a strong base for the development of services, when basic data collection and traffic monitoring systems are not yet in place: equipped vehicles can provide data on speed, weather, incidents and journey times, all of which have value for journey planning and network monitoring.

2.6. Security

Systems which rely on spatial and temporal information are reliant on high integrity data. Development of short range systems should proceed using the assumption that the system will be subject to malicious interference.

To assure the quality of co-operative systems it is suggested that a certification system is put in place.

Confidence is critical: interference and a failure in security either during trials or pilot schemes or during the early phases of roll out would seriously damage commercial prospects. Security solutions have to be built in to the system architecture, requiring firewalls in the vehicle and in roadside devices.

2.7. Privacy

Privacy issues are not considered in the same way in each country. There is also a difference in the opinions of different sectors of the population. The younger generation has developed a relaxed attitude to privacy (Facebook, etc) but this is a trend that could change. Most mobile telephone users and credit card users have already surrendered much of their privacy in order to take advantage of telephone services. Connected vehicle users may follow suit if there are perceived advantages.

2.8. Roads and Maps

The current generations of maps are sufficiently accurate for the current generation of navigation systems but have not sufficient information or accuracy for more advanced applications involving safety, efficiency or vehicle control. Further work is required to determine the mapping requirement, standardised methods for updating maps and develop protocols.

Map ownership is another issue. Network detail is changed often by the road operator and changed at short notice. There has to be an effective system of updating this detail on the maps. However, public sector owned maps are unlikely to be an answer. It is not likely that the public sector would be motivated or able to keep maps sufficiently up to date or accurate. There may be a need for an independent map and data supplier organisation?

One can imagine that roads should be designed to be sensor friendly. Driver assistance systems such as lane tracking systems or sign reading algorithms may take advantage of standardised design. Adding a beacon signal from signs would simplify the process.

2.9. Conclusions

There is universal agreement that standards for cooperative systems particularly at the application layer are crucial. The automotive industry would prefer a standardised approach throughout the world, but accepts the reality that it will have to manage different approaches in different regions. Standardisation at application level would be a bonus.

DSRC is seen to be important for safety related applications. Despite rapidly maturing technology none could provide a practical path to the widespread deployment of DSRC. There is a growing body of opinion suggesting that future generations of mobile telecommunications will be able to a service good enough to support most applications including safety. Aftermarket applications on Smart phones and navigation systems could drive the market.

The industry is cautious about putting multiple communications technologies into the vehicle, increasing the cost and complexity. However, the industry will provide equipment to suit either legislative requirement or customer demand. They believe that the government/road operator is the only organisation suited to managing a network providing safety applications but they need strong evidence or guarantees that a government infrastructure before they will enter production.

Any deployment has to be secure and robust. An early security failure would be a disaster.

3. CAPITALIZING ON ITS

TC B2 was also in charge of preparing the way for exploitation and dissemination of the work of the current committee and its predecessors. This has been achieved by making available on line the PIARC Intelligent Transport Systems Handbook, drawing on the technical committee members' experiences of ITS deployment from around the world.

The *ITS handbook* investigates how ITS investments for road network operations are evaluated and advocates policy related performance indicators in order to evaluate the

success of ITS strategies of different countries. It identifies success factors for ITS strategies and precautions to take against failure. Recommendations on how road authorities should assess and evaluate ITS schemes are elaborated.

The *ITS Handbook* is now used as a reference text by some universities and as the basis for training seminars and professional development in a number of countries, including to students and professionals in countries with economies in transition. It presents a catalogue of solutions, with practical examples illustrating through case studies how ITS can be implemented. However, B2 committee has been made aware of two significant issues with the handbook:

1. There is a need to keep the handbook current and up-to-date by drawing on continuing experience of ITS deployment, for example some of the case studies reported in this report
2. The high cost of purchasing printed copies of the handbook or subscribing to the on-line version is a barrier to its use for training purposes, especially for undergraduate courses and professionals in developing countries.

B2 committee has responded by taking advantage of the expiry of the marketing agreement made in 2004 with the publishers of the English-language version. The committee resolved to take on the task of making the *ITS Handbook* freely available on-line over the Internet, without subscription of charge so that the material can be accessed and downloaded by anybody, anywhere.

Through a contract let by the US Department of Transportation behalf of B2 Committee the full text of the *ITS Handbook* is being imported into the Road Network Operations website and organised in a way that will permit easy down-loading and local printing by the user. The on-line content is organised around various practical questions:

- What are Intelligent Transport Systems?
- How do Intelligent Transport Systems work?
- What about ITS architecture and standards?
- What are the benefits of ITS?
- How do I plan and finance ITS?
- How do I launch ITS?
- What about ITS in transitional and developing countries?
- What about ITS in the long-run?

Each chapter has an on-line table of contents showing the topics covered in that chapter with options to view and download the complete chapter or a selected section of a chapter. The ITS Handbook will sit alongside the companion *Road Network Operations Handbook* published by PIARC in 2003 which is also available on-line for free download from the Network Operations web site. Together, they provide resource material related to traffic management, incident management, and traffic operations and for providing safe and efficient services to all road users. The handbooks also provide guidelines on the implementation of ITS technologies and services for congestion management and corridor management in an integrated transportation system.

The outcome of this project will be an updated and expanded PIARC Road Network Operations website in English and French that will allow interested parties to access, download, or print the *ITS Handbook* and the *Road Network Operations Handbook* by individual section or by subsections. Please visit the Network Operations web site at:

http://road-network-operations.piarc.org/

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DRAFT CONCLUSIONS

The road network operation cannot be considered today as a service limited to roads. Strategies for road network operation have to consider the overall mobility of people and goods across the various modes. Of course road authorities or road operators are not in a position to determine transport policy. A coherent shared view of network operations has to be developed among the operating partners in order to propose to governments an overall approach. Co-operation includes exchange of information in order that travellers can access to coherent data allowing them to make their choice. More than that, different operators should cooperate for daily operation to be able to implement their own strategies in a coherent manner. From the survey undertaken by Technical Committee B2, most of the identified case studies have a multimodal dimension. Future work of the succeeding committee should emphasise this dimension.

Cooperation in the future will extend to the vehicle itself: the driver will contribute more and more to the transport system, thanks to real-time communication between vehicle and infrastructure. But this will happen really if some basic conditions are fulfilled. Vehicle to infrastructure communication necessitates investments. No satisfactory business model has been found up to know that will allow the private sector only to invest. In addition, there are likely to be significant social benefits in terms of safety, energy saving that call for public investment, but so far there is no hard evidence of such benefits, and authorities are reluctant to make the first step. Co-operation between road authorities and automotive industry should be pursued, certainly extended to road industry (road design and equipment) and telecom operators/OEM industry.

PIARC has made an important step forward in the capitalisation and dissemination of knowledge concerning ITS and network operation, by publishing on line both the ITS handbook and the Network Operations handbook. B2 Committee expresses the wish that this service is maintained and that the content is regularly updated in future. This is not possible by relying only on a technical committee workforce working on a voluntary basis: a way has to be found to support a permanent editorial resource to achieve this.