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IRF was founded in 1948 to encourage better road and transportation systems worldwide. IRF is a non-profit, non-political service organisation which helps in the application of technology and management practices to produce the maximum economical and social return from national road investments.Some 500 governments, companies and associations around the world are members of IRF and provide financial support to the three offices in Geneva, Brussels and Washington DC. National and regional road associations around the world make up the Federation. IRF is an accredited transportation consultant to the United Nations, the Council of Europe, and the Organisation of American States, and works closely with other international institutions in the transportation field.

# Safe infrastructure today...

The best road infrastructure embraces the world's best practices. But those practices do not just arrive fully formed. The IRF looks at the changed world of tunnels and one city's award-winning approach to master plans

**"The European Union was not initially concerned with tunnel safety: this fell to the Member States under the principle of subsidiarity"**

**Didier Lacroix**

Europe's road tunnel fires of 1999-2001 forced fundamental safety improvements.

While road tunnels were considered rather safe parts of the road system, with accident rates often lower than in the open, a dramatic fire occurred in 1999 in the Mont Blanc Tunnel between France and Italy that caused 39 fatalities. It was followed a few weeks later by another fire in the Tauern Tunnel (Austria) with 12 fatalities.

These two catastrophes have radically changed the perception of road tunnels. Whereas tunnel safety was previously seen as a matter for specialists, it has now become a matter of public concern, prompting politicians to take an interest. Two years later the fire in the Gotthard Tunnel, Switzerland, which resulted in 11 fatalities, reinforced this change of mindset. A number of catastrophic fires have also occurred in rail tunnels, including the Channel Tunnel (France-United Kingdom, no victims but considerable damage in 1996); the Kaprun Funicular (Austria, 155 fatalities in 2001); and the Daegu Subway (South Korea, 200 fatalities in 2003).

It goes without saying that underground safety had been widely studied and taken into account long before these fires, resulting in an extensive knowledge base as well as good practices, recommendations and regulations. This background proved insufficient however, and further work was initiated in various countries as well as at European and international levels.

In order to harmonise the numerous national initiatives, the United Nations Economic Commission for Europe (UN ECE), a body based in Geneva, Switzerland, which covers 56 countries, set up a multidisciplinary group of experts on road tunnel safety. Its final report, completed in 2001, highlighted that tunnel safety must be considered in a systematic approach and made recommendations on all aspects: road users; operation; infrastructure; and vehicles.

The European Union was not initially concerned with tunnel safety: this fell to the Member States under the principle of subsidiarity. However, after the Mont Blanc and Tauern fires, the heads of State asked the European Commission to address the matter. The Commission's first step was to include safety in tunnels as a subject in their calls for research tenders. On the whole, they have funded six research projects which ran from 2000 to 2008, covering a wide scope.

One of these, the DARTS (Durable and Reliable Tunnel Structures) project, considers costs during the whole tunnel life (www.dartsproject.net), while another is the SafeTunnel study on vehicle-infrastructure communication (www.crfproject-eu.org). The Sirtaki project looks at operational management of emergencies (www.sirtakiproject.com). Meanwhile, the VirtualFires project is a simulation project for emergency services training (www.virtualfires.org) and on a related note, the UPTUN project was the largest with an €12 million (US$18.6 million) budget. It investigated upgrades to fire safety for existing tunnels (www.uptun.net). Lastly, the L-Surf project researched full-scale underground testing to (www.l-surf.org), while there were also two thematic networks on fire safety (www.etnfit.net), as well as the SafeT recommendations on all aspects of tunnel safety (www.safetunnel.net).

The European Commission subsequently decided to prepare a legislative instrument in the form of a directive, which was approved on 29 April, 2004. This directive has relied on previous work from

the UN ECE and the World Road Association, as well as new national regulations. At the international level, before the 1999 fires, most of the work to produce syntheses and recommendations was indeed conducted by the World Road Association (PIARC). Since 1957, its technical committee on road tunnel operation has been dealing with road tunnel geometry, equipment, safety, operation and environmental impacts. It produced some 25 reports in the past 15 years, all available from PIARC.

Tunnel construction and civil engineering aspects, on the other hand, are the domain of the International Tunnelling and Underground Space Association (ITA). As a number of partners in the aforementioned European projects and networks wished to continue their action after the end of their contracts with the European Union, they have launched a new Committee on Operational Safety of Underground Facilities (COSUF), under the auspices of ITA. This committee, which is also supported by PIARC, aims to develop a world-wide network to exchange knowledge and experience, facilitate cooperation, foster research and promote underground safety. It is open to all corporate bodies interested in underground safety.

Entrance to a shelter in the Mont Blanc tunnel

## Progress

The new regulations as well as research and development activities have led to improvements in all fields of tunnel safety. The European directive 2004/54/EC on minimum safety requirements for tunnels in the Trans-European Road Network has now been transposed in all 27 EU countries and is used as a reference worldwide. In the USA, NFPA 502 has become a standard and takes into account the latest developments, such as from PIARC, in its 2008 edition.

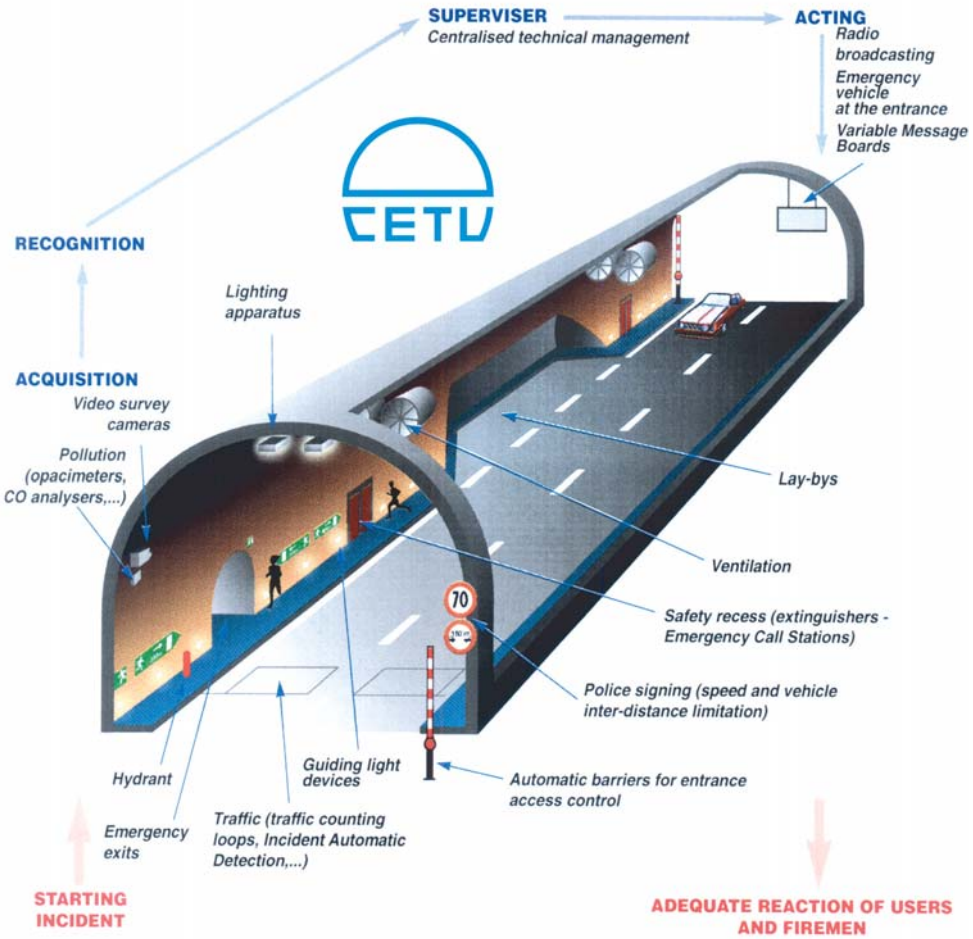
The EU directive clarifies the responsibilities of all players in tunnel safety and sets a number of procedures to check safety at design, commissioning and operational stage. These procedures are based on a very important tool, the safety documentation, which is compiled by the tunnel manager. It gathers all relevant information and is used for communication between all parties. The administrative authority must examine this documentation before construction starts and give an authorisation before a tunnel is opened. Existing tunnels must meet the directive's requirements within 10-15 years. Exercises and data collection from incidents as well as periodic inspections are compulsory.

The definition of the safety measures to be implemented in a tunnel is based on a combination of three concepts: a system approach (inspired by UN ECE) of all components of safety, minimum requirements and risk analysis. The directive prescribes minimum measures for the infrastructure and operation. An important role is given to risk analysis, such as to justify alternative measures, take account of any special characteristics or decide on authorisation of dangerous goods.

To apply and in some cases go beyond regulations, important technical progress has been achieved ranging from incident and fire detection, SCADA or ventilation to fire protection and communication with the users. Decisive advances have been made regarding fire resistance of tunnel structures: design fires have been defined, insulating layers for structure protection are now widely used, and new possibilities are offered by fire-resistant concretes, generally including polypropylene fibres. The capabilities of fixed fire-fighting systems based on water mist or foam have been demonstrated to reduce temperatures in case of a fire, and are currently assessed regarding users' protection.

Another essential aspect has been brought to the fore by the 1999-2001 tunnel disasters: the importance of human behaviour on the part of users, operators and ▶

The safety chain for incidents in road tunnels



emergency teams. Extensive work on behavioural and organisational aspects has been performed through several aforementioned European and international initiatives. Training and exercising of the operational and emergency staff is now a well-established practice for many tunnels. The most difficult issue remains the information and education of tunnel users, as well as real-time communication with them in case of an emergency. The aim is to make sure that users will indeed use the emergency exits and other dedicated facilities when necessary.

However, while impressive progress has been achieved on road tunnel safety, additional efforts are still necessary. New tunnels are built in compliance with today's safety requirements, but a number of existing tunnels still have to be refurbished. Traditional solutions may prove very expensive: innovations are necessary to ensure cost-effective improvements.

New technical developments are expected to further improve a number of usual safety facilities and get more insight into the appropriate use of new technologies such as fixed fire-fighting systems. However, today's most difficult challenges are probably the implementation of a real safety management system at all stages of tunnel life and the appropriate education and real-time management of tunnel users. International associations such as PIARC and ITA COSUF are working to foster new initiatives and disseminate results available worldwide ■

● *Didier Lacroix, Centre d'Etudes des Tunnels (CETU), France, is vice-chairman, ITA COSUF*

# Tshwane wins 2007 IRF Road Safety Award

## Road safety master plans: an inclusive approach from South Africa

**The City of Tshwane wins the 2007 IRF Road Safety Award. Pictured at the presentation are (from left) Sibylle Rupprecht, Director General IRF Geneva; Jean Lalo, Chairman of IRF Road Safety Working Group; Hilton Vorster, Acting Executive Director Roads & Storm Water Division, Public Works & Infrastructure Development Department, City of Tshwane, Republic of South Africa, and Dr. Ndivho Lukhwareni, Strategy Executive Director, Public Works City of Tshwane**

Low income communities suffer disproportionately from the effects of road accidents. And, formal information on accidents and their location in these communities often does not exist. So, how do authorities go about improving road safety in low-income communities where the relevant information is not available in the right format?

The City of Tshwane, a metropolitan municipality in South Africa, addressed this problem and achieved great success.

Tshwane is a city in transition and has a mix of established and historically disadvantaged areas. The disadvantaged areas are mainly situated to the north of the city. Since road safety in these areas was severely neglected in the past, the new municipality that came into being in 2000 was faced with a tremendous challenge to improve road safety and provide infrastructure there. Fatality rates were high and the communities were discontented about the road safety situation. They even cordoned off and damaged roads after serious accidents to prevent further accidents and demonstrate their discontent.

The City of Tshwane acknowledged the problem and developed road safety master plans in collaboration with stakeholders and the community.

The master plans mainly focused on the provision of engineering measures such as pedestrian bridges, walkways, raised pedestrian crossings, speed humps and loading facilities at schools, but also attended to education, awareness raising, law enforcement and evaluation. In addition, the master plans were used to establish partnerships with other spheres of government as well as other non-government road safety organisations.

During the 2006/07 financial year, all the road safety master plans were updated and refined on the basis of knowledge gained from the process over a few years. Measurable key performance indicators (KPIs) for the provision of engineering measures were included in the Roads and Stormwater Division's scorecard. Implementation was monitored accordingly. All targets set were met, leading to significant reductions in traffic accidents, injuries and fatalities. The process has been found to be sustainable and replicable, using the knowledge of communities and empowers them to be part of the solution.

Tshwane used a scorecard for determining key performance areas (KPAs) and KPIs. These were

| Accidents | | | | | | Casualties | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Fatal | Serious | Slight | Damage | Total | Fatal | Serious | Slight | No injury | Total |
| 2006 | 271 | 2,300 | 8,462 | 50,046 | 61,079 | 300 | 2,955 | 11,650 | 75,177 | 90,082 |
| 2007 | 214 | 2,235 | 8,208 | 53,142 | 63,799 | 236 | 2,921 | 11,189 | 73,609 | 87,955 |

used to measure the performance of the Municipality and individuals. In line with Tshwane's objective to fight poverty and build clean, healthy, safe and sustainable communities, a target was set for the reduction of fatalities. The initial target was to reduce fatal accidents per 10,000 registered vehicles by 5% a year. The city achieved a significantly higher reduction, of 12.5%.

Reduction in fatal accidents and fatalities: Tshwane used the Trafman system to capture accident data and produce management reports on road traffic accidents.

Following this process, Tshwane achieved a 21% reduction in fatal accidents and a similar reduction in fatalities. Serious and slight accidents and injuries were also reduced. Although the total number of accidents increased slightly, the total number of persons injured declined.

During 2007 the City of Tshwane managed to reduce accidents and fatalities caused by road accidents significantly. Road Safety Master Plans were instrumental in developing a comprehensive approach that included engineering, enforcement and education. Those plans played a major role in achieving the reduction. As part of the implementation, law enforcement plans were set up and education and awareness campaigns were run. The tested 4E approach of engineering, education, enforcement and evaluation was followed, yielding very good results. The dedicated educational campaigns targeted at vulnerable groups also proved to be successful in reducing fatalities and serious injuries. Tshwane is a worthy winner of the IRF 2007 Road Safety Award ■

Westlink M7 Australia project

# Maunsell/AECOM win IRF ward

## Maunsell/AECOM wins IRF 2007 Global Road Achievement Award in the Design category for the Westlink M7, Australia project

The Westlink M7 is a motorway link from the existing M5 at Prestons to the existing M2 at West Baulkham Hills and includes a major interchange where it crosses the M4 at Eastern Creek. It provides 40km of dual carriageway in each direction and has been designed for a future public transport system in the wide central median.

The motorway takes in excess of 60,000 vehicles per day off roads in western Sydney and nearly 10,000 of these are heavy goods vehicles. Motorists travelling the full length of the motorway will avoid 56 sets of traffic lights and save up to an hour of traveling time.

The Maunsell-SMEC joint venture was lead consultant for the engineering design of the Westlink M7. The project was a Build Own Operate and Transfer contract between the Roads and Traffic Authority of New South Wales and Westlink Motorway Limited, who contracted the Abigroup/Leighton joint venture as the construction joint venture for the design and construction of the link.

The project is large in geographical span and in the quantity of materials and resources required. It includes 17 interchanges, 20km of local road upgrades, 47km of shared pedestrian/cycle pathways, 60km of noise walls, 144 bridges and 7million $m^3$ of excavation.

"Working over one of Australia's busiest sections of motorway to deliver the project presented all those major challenges," said Richard Jackson, Maunsell's CEO. "The exciting part about the project was its impact. What we were building would contribute significantly to Sydney's growing transportation needs by providing a 40km section of motorway that connected existing motorways to ease congestion and improve traffic flow."

The Westlink M7 is a major project carried out in an urban environment and great importance was placed on the aesthetics of the design, achieved through the selection of appropriate forms for bridges and integrated development of subsequent design details. Column shapes and abutment treatments were selected to achieve a consistent family of bridges that are readily identifiable as belonging to the Westlink M7. The slender box girders with long cantilevers enhanced the appearance of the bridges, particularly the highly visible overbridges and ramp bridges at the major interchanges.

Noise walls varied from area to area to reflect the various urban design themes, and large precast units were used in the majority of locations to enable rapid erection to meet the project program. The throw screens on bridges were detailed to integrate with the structural forms of the bridges.

The shared pedestrian/cycle path, which travels the full length of the project, presented challenges in minimising the effects on the riparian zones, and an innovative design was developed using precast concrete sections with transverse slot to allow light and water to penetrate, while at the same time satisfying the ride criteria for cyclists.

The necessity of construction over existing motorways led to the development of designs using precast segmental box girders. Span by span box girder designs incorporating dry joints and external tendons were adopted for the motorway viaducts and overbridges. Balanced cantilever segmental boxes incorporating epoxy joints and internal tendons were designed for the longer span bridges at the major motorway interchanges and major road crossings.

Construction was carried out at night, without the necessity for road closures or major traffic diversions. The early completion of the project - eight months ahead of schedule - indicated the success of this design strategy. A design development, used for the first time in the world, was to tie the continuously reinforced road concrete pavements into the decks for many of the bridges. This eliminated the need for anchor beams leading to savings in construction cost and time. Most importantly, this also eliminated the joints at the ends of bridges, giving a smooth ride for the public and drastically reducing maintenance costs.

"We have received many industry honours for our work on Sydney's Westlink M7, but winning the IRF Design Award has special significance for us because it puts this project and the efforts of our roads team firmly on the world's stage," said Jackson. "We are honoured to accept this award with our project partner SMEC and acknowledge the support of the Abigroup-Leighton joint venture for construction, and our clients, the Roads and Traffic Authority of New South Wales and Westlink Motorway."