

Operating tasks in road tunnel

Tareas básicas de la operación de túneles viales

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Abstract

All the tunnels are different from one to another, and tunnel management depends on national practices and in some countries also on local conditions. Furthermore, the persons who are in charge of operating them do not belong to the same bodies according to countries (for example, in some countries the Police manages the traffic, in others this work is made by the administration of roads and in some cases this task is entrusted to a private company. However the actions to be achieved are the same: traffic management, technical management and first rescue.

Following a general presentation of operating tasks the paper goes on the means to do them: staff, equipments and rules. It defines the management of tunnel equipments taking into the account the facilities and the surroundings: national requirements, operating procedures, staff, etc.

Resumen

Todos los túneles son diferentes unos a otros, y la gestión de túneles depende de las prácticas habituales en cada país, y en algunos casos incluso difieren a nivel local o regional. Asimismo, las personas a cargo de tareas operacionales en túneles no forman parte de la misma organización, dependiendo del país que se considere. Por ejemplo, en algunos países la policía es quien debe realizar la gestión de tránsito, en tanto que en otros casos esta tarea queda a cargo de empresas privadas. Sin embargo, las tareas son siempre las mismas: gestión del tránsito, gestión de aspectos técnicos, y tareas de rescate.

Este artículo realiza una presentación general de las tareas operacionales y las formas de llevarlas a cabo, en lo referente al personal, equipamiento y reglas a seguir. La gestión del equipamiento del túnel queda definida en función de las características de la infraestructura y de su entorno (normativas nacionales, procedimientos de operación, personal a cargo, etc.).

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Operating a road tunnel depends on national practices, even in some countries on local conditions and usage.

However, in a rather simplified way, it is possible to define precisely which objectives and tasks a tunnel operator is faced with and to identify the various means available to fulfil his missions.

This text resumes elements set up by the Working Group No.1 of PIARC Committee C3.3, to be published in a next future in the "Guide for organising, recruiting, and training tunnel operating staff".

### 1) The operator's tasks

The operator has to guarantee to those users passing through the tunnel he is in charge with a service quality and safety level in strict observance with the valid regulatory requirements.

As a general rule the tunnel operator must manage traffic within the tunnel (or on the route including the structure), and principally ensure safety within the tunnel for the users passing through it or people likely to work in the structure (operating personnel, subcontractors, etc.),

Therefore the operator ensures :

#### œ Traffic management

Regarding the important structures (in terms of length, traffic density or complex structure) the traffic management occurs most often from a command control centre (PCC) or traffic management centre. Very often means of remote surveillance are available there (television circuit, automatic incident detection) and it is possible to act on the command of some equipment (ventilation, signalling, tunnel closure, etc.). In some cases the operator has also available patrols which, passing regularly through the tunnel, ensure a direct surveillance to the users; such patrols can act rapidly if required.

#### œ The management of the civil engineering parts (perenniality of the structure and annex facilities)

The question is to ensure a permanent surveillance of the civil engineering structure of the tunnel by conducting frequent examinations and periodic inspections; it is also necessary to ensure the maintenance of the drainage facilities, gutters and all annex facilities (premises inside the tunnel, technical premises, etc.)

#### œ The management of the equipment

For the important structures the operator has available a great number of equipment he has to control-command. To this purpose he has available systems for data supervision, control and collection (SCADA systems)

allowing a remote surveillance of the condition of all equipment, also their command. The operator must also ensure the maintenance of all devices installed in the structure; to this purpose also data processing means are available to assist the operator's work.

- ☞ The management of crisis situations  
Whatever the nature of the incident may be, either a problem related to traffic (accident, accidents in chain, fire, etc.) or related to equipment (loss of the power supply, failure of the data transmission network, etc.) the operator has to act.
- ☞ The administrative management  
In addition to the tasks directly related to the users' and traffic safety, the operator must ensure the management of his personnel. He must also set up the investment and operation budgets required for the proper operation of the structure; lastly, he has to look after the achievement of his objectives and set up at intervals the operation balance of the tunnel (financial elements, traffic elements, etc.)

Very schematically the tunnel operation can be represented as a plan with "events affecting traffic" in abscissa and "human means and equipment" in ordinate. Three zones are defined on each axis: normal, incident and emergency. They partition the plan into three cells. Under terms of operation the outer cell requires the total closure of the tunnel, the intermediate cell involves control measures and/or traffic limitations; the inner one corresponds to the most frequent range of normal operation.

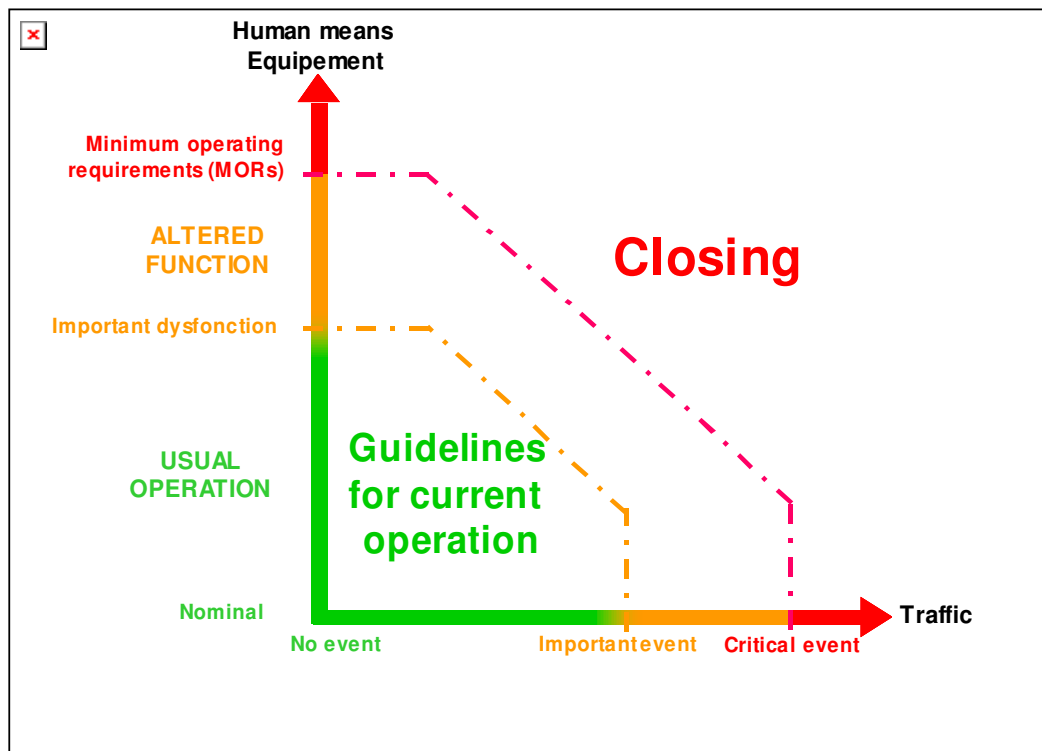
- Within a range of acceptable 'normal' operating conditions, events may occur that do not really affect the traffic flow; also, equipment may also show minor malfunctions. Such minor events or malfunctions (in the green zone of the scheme below ) lead to simple internal operational actions occurring frequently; they do not require any recourse to external support.
- The tunnel operation may be disturbed either by an incident affecting traffic or by the loss of physical and/or human functions. Thus the operator has to call on one or several external services: traffic police, rescue services, breakdown service, sub-contractor etc.

Two severity thresholds are defined:

**Beyond the first threshold**, the events affecting traffic or environmental or the technical dysfunctions (in the orange zone of the scheme below) have **consequences** on the traffic flow or safe operation of tunnels. They require the operator and traffic police to introduce compensatory measures or traffic limitations. The road operation is affected but not the users' safety. The tunnel is operated under controlled degraded mode.

**Beyond the second threshold**, the events or malfunctions (in the red zone of the scheme below) are safety **critical** or major and lead to the tunnel closure.

Under appropriate conditions, the tunnel authority will initiate the specialised emergency response and rescue plan.



## 2) The operator's environment

### 2.1) The other actors

The operator acts in a field where many other actors are also acting :

- œ the users: their safety must be ensured within the structure,
- œ the other operators upstream or downstream the route: they must be informed of a possible closure of the tunnel or of restricted traffic conditions,
- œ the national and local administrative authorities: they must be reported to in observance of the regulatory requirements,
- œ the Owner (when not the same as the tunnel operator): the Owner must also be reported to,
- œ the services in charge with actions (firemen, traffic police, medical services): they act according to the nature of incidents and they cooperate in setting up coordinate acting plans,
- œ the possible subcontractors (cleaning, maintenance, breakdown services for users, etc.).

## **2.2) The regulation**

Two types of texts can be applied to the operator :

∞ the general documents

These are texts of general significance: laws, government decrees, national and international recommendations (eg PIARC), national and international standards, circulars regarding road traffic or transport Safety, etc.

∞ texts specific to the structure the operator has to manage

These texts are different for some structure or the other. They often present the various plans set up by the operator (action plan of the operator's personnel, action plan of the rescue services), the by-laws defining the conditions the personnel is submitted to, the operator's guidelines content, the traffic rules defining the traffic conditions for the tunnel users, etc.

## **3) The operating modes**

### **3.1) Definitions**

#### **Non Monitored Tunnel**

As a minimum, the emergency telephone calls and any automatic alarms will be received by some facility offering round-the-clock attendance. This facility may be separate from the operator and alert the latter and the emergency services in the event of need. Although constant human supervision of the tunnel is not necessary, action requiring human initiative must be taken in the tunnel in the event of an alarm. This for example might constitute ensuring that alarm systems and any automatic protection/response have been activated correctly or of proactively starting up the smoke extraction system or activating traffic signs which depends on the circumstances of the event occurring in the structure.

#### **Monitored Tunnel**

The amount of traffic or the characteristics of the tunnel may make it desirable for there to be constant human supervision. By human supervision is meant at least the active presence in a monitoring/control station of a person equipped with the means for displaying the interior of the tunnel and its surroundings, for receiving alarms and for initiating the application of appropriate actions to deal with any abnormal situation.

This supervision may be remote and common to several infrastructure units or an entire route.

#### **Local Control Centre**

The local Control Centre is dedicated to one tunnel (or to a small group of tunnels very close to each other). It is located very close to the tunnel(s). It contains all the necessary equipment to operate the tunnel and all the people working in this Control Centre are involved in the tunnel operation. For very long tunnels or for toll urban tunnels and high traffic tunnels this Control Centre could be extensive and complex.

### **Remote Operation Centre**

In some cases tunnels can be located on major motorways or on urban network, when the whole route or network is controlled by a Control Centre. Very often this sort of control centre is located close to one tunnel but if the route comprises many tunnels others may be distant. It contains all the necessary equipment to operate the network and the tunnels. This type of arrangement can be very useful on a motorway network or for a group of urban tunnels.

### **3.2) The various possibilities**

#### Monitored or non-monitored

Small tunnels or tunnels with low traffic are, in most cases, not monitored. On the other hand, many tunnels are controlled twenty-four hours a day. Typically, tunnels are the object of permanent (human) monitoring if they are relatively long, are relatively complex and/or if the traffic intensity is high.

#### Local (dedicated) Control Centre or remote Control Centre

If the tunnel is monitored, in some cases only one tunnel itself is monitored or a small number of tunnels located very near to one another. In this case a specific Control Centre could be dedicated to the tunnels and located close to them. This is called a local (dedicated) Control Centre. On the other hand a tunnel can be situated on an extensive route or a road network, the whole of which is the object of a permanent surveillance and for which one Control Centre exists. The Control Centre is not necessarily close to the tunnels. This type of Control Centre is referred to as a remote Control Centre. In rare cases a remote Control Centre is dedicated to a (sometimes large) number of facilities over an extended area.

#### The number and complexity of technical installations present in the tunnel

In tunnels with high traffic and/or great length, there is more commonly a large quantity and variety of technical equipment which has to be monitored in addition to the traffic itself.

It will be recognised that rapid evolution of communication and information technologies will lead to much greater flexibility in the location and use of Control Centres. However the location and speed of deployment of physical resources particularly those required for response to emergencies will still be very important.

### 3.3 ) Task distribution

| <i>Field</i>                        | <i>Task</i>     | <i>Actor(s)</i>            |
|-------------------------------------|-----------------|----------------------------|
| <b>Traffic management</b>           | Supervision     | Operator                   |
|                                     | Patrols         | Operator or subcontractor  |
| <b>Civil engineering management</b> | Surveillance    | Operator                   |
|                                     | Maintenance     | Operator or subcontractor  |
| <b>Equipment management</b>         | Control-command | Operator                   |
|                                     | Surveillance    | Operator                   |
|                                     | Maintenance     | Operator or subcontractor  |
| <b>Administrative management</b>    |                 | Operator                   |
| <b>Crisis management</b>            |                 | Operator/external services |



## 4) Facilities used by the operator

### 4.1) Traffic surveillance

All tasks concerning traffic surveillance are conducted by the operator often with the assistance of sophisticated monitoring and alarm technology, some of which can also generate automatic pre-programmed responses. The type, the number and the performances of these facilities are normally strongly linked to the characteristics of the tunnel and to the traffic level.

For a high equipped tunnel with monitoring from a modern control centre an operator can have at his disposal the following facilities :

- œ Fixed and cyclic monitors of the CCTV Surveillance network,
- œ Automatic camera selection, enhancement and digital detection of abnormalities,
- œ Recorders, digital or analogue for picture, voice data
- œ Central emergency call station, direct links to emergency services,
- œ Integrated supervision desks,
- œ Automatic incident detection (AID) systems,
- Communication services (radio broadcast, audible and visual alarm systems, variable message sign, road signs, public address system, intercom in aid station etc.

Some particular tools can help in case of a big incident :

- œ Pre-recorded announcements and instructions either global or zonal (this way the operator merely has to press a button to broadcast and/or display messages in the tunnel e.g. "there is an emergency in the tunnel; leave your car and go to the nearest exit").
- œ Grouped commands (calamity button)
- Automated response (in case of combined incident detection from different detection systems, activate some emergency systems such as escape route, start/stop ventilation start/stop pumps, increase lighting etc. Normally these automated actions can be overridden by the operator).

A standby incident response management room (crisis room) can help the tunnel manager, particularly in a network situation so that an emergency response in one location can be separated from the extra traffic diversion

demands elsewhere. Such a facility can also be very useful for staff training and familiarisation in parallel with normal tunnel operations.

Integrated supervision desks especially provide the following information to the operative :

- o3 Warnings from the operating system given by protected facilities (opening of safety recess gates, removed extinguishers etc.) ;
- o3 Pollution sensors ;
- o3 Fire sensors ;
- o3 Traffic sensors (average daily traffic, traffic density rate, speed, stationary vehicles)
- o3 Technical alarm (equipment malfunction or failure) ;
- o3 Traffic management status signs.

#### **4.2) Technical Surveillance**

In the case of a well-equipped tunnel with a Technical Control Centre, the facilities have to be monitored by the operator in the Control Centre, having at his disposal a wide range of technical data and monitoring equipment.

The Technical Control Centre will provide some or all of the following functions and information :

- o3 tunnel environment monitoring (air quality, external light levels, weather conditions, etc.) ;
- o3 main power supplies monitoring and control ;
- o3 emergency power supplies availability with automatic and manual override control ;
- o3 equipment monitoring – functionality, availability, condition, performance (ventilation, pumping, lighting, communications, sensors, alarms etc.) usually automatic with manual override ;
- o3 safety systems functionality, availability ;
- o3 alarm systems ;
- o3 communication and recording systems (picture, voice, data) ;

- ∞ supervisory SCADA<sup>1</sup> system (computer driven data collection, processing and automatic control system).

The main purpose of the operator is the total overview of the equipment to ensure its correct function and to respond correctly with manual intervention in case of malfunction or of extreme or emergency operating conditions.

Also the operator can be concerned with the management of the maintenance response in case of equipment fault or breakdown. He can be responsible for analysing the technical malfunctions (problems in power supply, communication networks, facility breakdowns), assessing the safety margins in terms of technical operation with deficient equipment and managing the actions on these facilities.

To fulfil the maintenance tasks, the operatives have to :

- ∞ Analyse any malfunction to possibly diagnose the cause, evaluate the operating safety margins of the facilities and warn the maintenance agents of the technical problem ;
- ∞ Attempt remote curative action and observe and interpret the results, then inform the maintenance agents ;
- ∞ Inform the maintenance agents about the remaining curative maintenance needs, and arrange the relevant actions ;
- ∞ Participate in the follow-up of the actions, check on the control screens that the failure has been removed and that the function is fully restored and normal service resumed ;
- ∞ Throughout all of the above, liaise with the traffic control centre officer so that appropriate traffic control arrangements can be put in place to compensate for reduced safety margins and if necessary provide safe access and work areas to carry out repairs, or in extreme cases to arrange to totally close the tunnel.

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<sup>1</sup> Supervisory Control and Data Acquisition

## 5) Legal Requirements, Procedures and Plans

### 5.1) Legal Requirements

A legal framework exists in all countries. This framework can be at a national level and at international level. Some requirements are compulsory others are only recommendations. Very often regulations are general texts and they only define the principles (national regulations in accordance with European Directive, National texts). The recommendations (PIARC, IESNA<sup>2</sup>, etc.) are in accordance with the regulations and can define how to interpret and/or enforce the laws.

In European Union, tunnel managers of Trans European Road Network shall, with the prior approval of the Administrative authority, nominate a safety officer who shall coordinate all preventive and safeguards measures to ensure safety of users and operational staff. This safety officer shall perform the following tasks :

- ☞ coordination with emergency services,
- ☞ taking part in the planning, implementation and evaluation of emergency operations,
- ☞ taking part in the definition of safety schemes and the specification of the structure, equipment and operation.

Most countries have decided that the safety officer will be assigned by the tunnel manager (not the rescue services). The independence of the safety officer will be attained by placing him not hierarchically beneath the tunnel operator.

In many countries, tunnel managers are required to prepare and work to a emergency response plan. This plan is based on the local legislation and must include procedures and instructions for at least the control staff and incident response staff. Procedures for incident response must also be co-ordinated with the procedures of rescue services.

Instead of a general emergency response plan, some tunnels can have more detailed documents. These documents may describe all tunnel installations related to safety, define the risks of abnormal events, classified by type and if possible include Risk Assessment in terms of frequency and consequences. These documents also define the relative roles and responsibilities of internal and external parties in the event of an emergency. External parties are fire brigade, civil authorities and so on. (As an example "Safe Operational Procedures Plan, Technical Incident Plan" etc.)

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<sup>2</sup> Illuminating Engineering Society of North America

A more comprehensive plan could also contain risk assessments, procedures and safe systems of work for all maintenance tasks.

The content of this manual is defined by national instruction or guidelines usually specific for each country. It defines the scenarios covered in the safety plan and "Safe Operator Procedures".

## **5.2) Procedures and Instructions for Operation**

For each tunnel there should be a documented framework defining the tunnel operations objectives/principles; it should cover all conditions, both normal and abnormal or emergency.

These operating guidelines define a series of elementary actions on the site with procedures and constraining provisions according to normal, abnormal or emergency conditions. The operating guidelines are exclusively aimed at the operating and surveillance personnel, plus communication procedure and protocols.

Finally, all major tunnels should have an "Operations Manual" that explains :

- traffic operations → safe operating procedures,
- maintenance operations → safe systems of work,
- organisation, roles and responsibilities,
- functions done by the different bodies, both internal and external, agreed/shared procedures for normal and abnormal or emergency situations.

## **5.3) Plan for Emergency Situations**

An emergency response plan has to be prepared by the tunnel manager :

- either jointly with external emergency services ,
- or with input and support from the external emergency services.

This safety plan must in particular lay down :

- ∞ the management organisation commanding and co-ordinating the tunnel operator's facilities, distinguishing different levels of responsibility ;
- ∞ the external emergency services command and co-ordinating structure ;

- ∞ agreed initial communications, rendezvous arrangements and, if appropriate, command handover procedures ;
- ∞ agreed arrangements for the deployment of emergency response teams and use of tunnels ;
- safety equipment (e.g. emergency ventilation) ;
- safe underground access routes and way finding information ;
- internal and external monitoring, communications and warning facilities (display of instructions, method of transmission, accident definition code etc.) ;
- general response instructions, distinguishing between normal and ordinary operations and those requiring action by parties other than the operator ;
- the nature of the resources to be committed in each case ;
- the steps which are to be taken with regard to the control of traffic within the structure and access ways and clearing the approach routes ;
- the ordinary facilities designed to keep track of events, decisions and actions occurring in the course of operation ;
- the responsibility and arrangements for public and media information.

**The responsibility in term of co-ordination between Firemen, Police and Tunnel Operator has to be defined very precisely in the emergency response plan.**

## **6) Lifetime of the structure**

### **6.1) Maintenance**

All along the structure lifetime the operator has to ensure the maintenance of the civil engineering facilities and maintenance of the tunnel equipment. The maintenance actions can be divided into two groups :

∞ the preventive actions conducted at intervals defined in advance and aimed at preserving the good operating condition of the equipment.

The preventive maintenance shows the advantage to prevent most of the unforeseen failures and to be easy to plan. However, it may lead to high expenses if such actions are too frequent: therefore it requires to be extremely optimised.

∞ The corrective actions conducted when a system or part of it is broken down. The corrective maintenance has the advantage to operate a system at its maximum lifetime; however the inconvenience is that it cannot be planned, and therefore leads to conduct actions in urgency with high over-costs.

It is recommended to utilize preventive maintenance as often as possible; it allows a task planning and causes to have equipment in good condition of operation. It should be noticed that even with a quite properly conducted preventive maintenance the operator will not have the possibility to prevent some actions of corrective type.

The operator carries out scarcely the whole maintenance of the equipment; subcontractors are called for. In terms of subcontracting, several choices are possible :

∞ To subcontract only the maintenance actions of a defined technical level; thus the operator can subcontract actions not very complex technically (cleaning, washing,...) or inversely very complex tasks (supervision system, radio re-broadcasting equipment).

∞ To subcontract all tasks regarding one or several equipment groups (the whole ventilation system, the whole remote surveillance facility, etc.);

## **6.2) Exercises**

The operator must test at intervals the efficiency of the personnel and defined procedures. Thus he can be sure that all agents are well accustomed with the various tunnel equipment, also he can possibly detect defaults in the performance of certain tasks.

In addition to the internal exercises, the operator has to organise (or initiate) rescue exercises with the cooperation of traffic police and fire fighting services.

The results of each exercise must be analysed. If the knowledge drawn from an exercises emphasises defects, the action strategies must be revised.

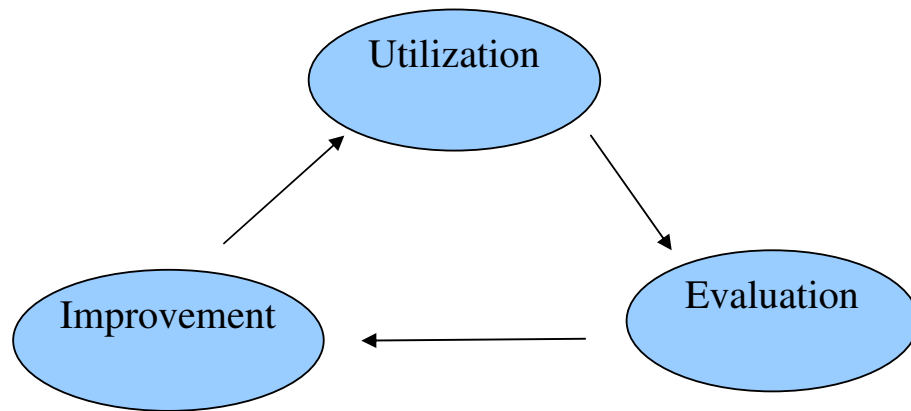
## **6.3) Feedback on experience**

The feedback on experience provides the possibility to analyse :

∞ the operation of the various systems utilised in the tunnel .

∞ the pertinence of the utilised operating procedures.

The operator will find it beneficial to determine a dynamic approach resulting from the established operation, assessing the obtained performances and – if required – defining improvements to introduce.



## 7) Conclusions

The operator of a road tunnel has two major fields of activity: the traffic management and safety concerns within the tunnel. To accomplish these various missions, he has available human and technical means managed by well prepared procedures. The global mission of the operator is quite extended in time since its acts on :

- ∞ the past (feedback on experience, data base of traffic incidents, data base of technical failures),
- ∞ the "usual" present (daily management of the minor events),
- ∞ the "factual" present (accident, fire),
- ∞ the future (planning of actions, proposed improvements).

Very numerous tasks depend more or less directly from the operator: these may be the maintenance and performances of the equipment installed within the tunnel, the action procedures or the acting method of the whole operating personnel.

The service level and quality offered to a road tunnel user therefore depend largely on the operating level, i.e. the operator's performances. Lastly, it should be outlined that the performances must be evaluated constantly, in view to improve permanently the service offered to the user.