UPgrading of existing TUNnels

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Task 1.3:
Existing Detection and Monitoring Systems
Final Report

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Summary

The objective of the task was to list existing detection and monitoring techniques and to investigate reliability of those systems. Further to that the partners tried to identify existing detection and monitoring equipment installed outside tunnelling, which are potential suitable for installation in a tunnel environment as well.

As an aftermath of September 11th 2001 events, acquiring information about technology installed in tunnels and much more about technology installed outside tunnel has become a rather problematic issue as operators of large-scale structures are highly cautious in giving details about any respective structure and the installed technology. Related to already installed equipment this was especially to reliability data.

Therefore, the investigation on currently installed detection and monitoring equipment in tunnels was not as successful as expected.

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1 Introduction

The simplest way of reducing fires in tunnels is to prevent them from occurring in the first place. This is impossible to achieve. However there must be ways to minimise the effects that a fire will have in a tunnel. This can be achieved by ensuring that early detection of an incident and a fire is made.

It is believed that the Channel Tunnel fire started on a lorry outside the tunnel and the fire was actually taken into the tunnel. We therefore aim to investigate external detection of fires to ensure that a vehicle on fire is prevented from entering a tunnel. Additionally, it is imperative that early detection of a fire incident inside the tunnel is necessary to increase the chance to successfully suppress the fire and safely evacuate the tunnel.

At present, tunnel operators and the fire brigade lack accurate, real time information about the location, the growth and the potential fire load inside tunnels. This information is really needed to ensure someone's own safety and to be able to attack the fire in a proper way.

A wide range of detection and monitoring devices are currently installed in tunnels all over Europe. However, data on reliability of existing detection and monitoring systems in tunnel application is scarce. This report tries to list the currently installed detection and monitoring equipment and make a reliability assessment.

Detection and monitoring systems are being used however in a large field of application. This report makes a first assessment of those equipment and assesses whether some existing techniques might perform adequately also in a tunnel environment.

For the purposes defined in this task, information about monitoring and detection systems could be retrieved from Czech Republic, Germany, Greece, Slovakia, Spain and the United Kingdom.

As an aftermath of September 11th 2001 events, acquiring information about technology installed in tunnels and much more about technology installed outside tunnel has become a rather problematic issue as operators of large-scale structures are highly cautious in giving details about any respective structure and the installed technology.

2 Objective of the task

The objective of the task was to list existing detection and monitoring techniques and to investigate reliability of those systems. Further to that the partners tried to identify existing detection and monitoring equipment installed outside tunnelling, which are potential suitable for installation in a tunnel environment as well.

Details of actual detection and monitoring systems installed will be recorded, their reliability will be evaluated, providing failure rates, false alarms, etc. The data collected from tunnel owner/operators will be used to determine the best type of technology to use for future recommendations into fire detection, incident detection, fire suppression and will also provide a guide into the types of technology to be investigated for innovative ideas.

An investigation into monitoring and detection devices and techniques used in other industries will be made. This may provide a simple means of technology transfer from an existing industry to the tunnels industry. Industries that may be considered could include petrochemical, chemical, and industries that have a combustible by-product.

A discussion will be conducted on whether to obtain data on existing detection systems that may be used in tunnels outside Europe. Some UPTUN Partners have international contacts with tunnels where devices that may not be used in Europe but may be used elsewhere.

3 Limitations

The data provided for the purpose of this task were quite limited due to the partnership in the task. Therefore, for the purposes defined in this task, information about monitoring and detection systems could only be retrieved from Czech Republic, Germany, Greece, Slovakia, Spain and the United Kingdom.

As an aftermath of September 11th 2001 events, acquiring information about technology installed in tunnels and much more about technology installed outside tunnel has become a rather problematic issue as operators of large-scale structures are highly cautious in giving details about any respective structure and the installed technology.

Taking into account the points raised it is obvious that the results provided by this investigation is limited to the countries and the type of equipment retrieved. The recommendations given at the end of this report can therefore not be generalised. However they can be understood as an entry point to more detailed investigations.

4 General classification of detection and monitoring equipment

The equipment installed in tunnels is so extensive, that it seems to be impossible to produce a complete list of the different equipment types and the various manufacturers of those. Therefore we relate to a general classification of equipment currently installed in tunnels in Europe. This classification, which bases on the database on equipment produced in the FIT project[1] but has been adapted to the purpose of the exercise described, considers mainly the mostly installed types of equipment. The list is as follows:

1. Communication Equipment
    - SOS devices
    - Loudspeakers
    - Sounders
    - Fixed signals
    - Variable signals (accidents, rain, mist, traffic jam, etc.)
    - Radio communication
    - Closing barriers
    - CCTV
    - Automatic detection of incidents
    - Control Centre
2. Detection equipment
    - CO detection
    - Opacimeters
    - Ice/snow detection
    - Anemometers
    - Rain / smog detection
3. Fire fighting equipment
    - Emergency push-buttons
    - Automatic detection of fire (smoke, image, temperature)
    - Manual extinguishers
    - Hydrants network
    - Smoke extraction
    - Safety cable
    - Liquid drainage
    - Shelters

[1] FIT: European Thematic Network on Fire in Tunnels (EU Contract No G1RT-CT-2001-05017). The databases produced can be found under http://www.etnfit.net

4. Lighting
    - Emergency lighting
    - Emergency power generators
    - Uninterrupted power supply (UPS)
5. Ventilation

The list shows a more or less complete overview of the different types of safety equipment installed in tunnel environment. However, the task was to investigate the detection and monitoring equipment. Therefore the partners concentrated on those. But evening these two categories the partner of the task described in this report were not able to investigate each of the sub-categories mentioned for the detection and monitoring fields.

5 Equipment currently installed in tunnels

5.1 Video detection

Video-surveillance systems applied in tunnels are typically recognised as regular video-surveillance devices (without video-detection function) and video-surveillance devices including video-detection.

The reader will find video detection systems including information about manufacturers in the annex to this report.

Video-detection currently applied in tunnels is mainly intended to enable traffic measurements, vehicle stoppage detection or detection of traffic congestions in tunnels. The video-surveillance system is usually integrated as an AID (Automatic Incident Detection) system in a tunnel control system. The information about detected traffic events and other traffic-related data is transferred to this control system. The video-surveillance system has usually binary I/O interface, serial interface, optionally network adapter (ETHERNET), etc. Graphical signals in analogue format are transferred either via optical fibres or some other convenient mode. Graphical messages in digital format are transferred over the network via TCP/IP protocol.

The automatic detection system which identifies a stationary vehicle or traffic congestion on a traffic lane inside the tunnel notifies the operator about the exceptional event in the tunnel. Traffic measurements (number of vehicles, vehicle type, speed) are processed in the traffic sequence of the control system and are not used for the activation of any automatic reactions in the control system.

The video detection process affords an „alarm monitor“ function which displays the image of the camera that is monitoring the area with a reported incident:

- Traffic problem
- Vehicle stoppage
- Opened SOS box
- Other

Based on the information obtained from the video-surveillance system (and from additional information sources if used) the traffic/technology operator makes decisions about subsequent action, i.e. calling in rescue parties and activating exceptional modes in the control system to induce appropriate control system responses to the unusual situation in the tunnel. Video-surveillance does not fully automatically control the activation of the control system reactions.

The mechanism of the control system and operator’s reaction to an exceptional event is such that the control system responds to the incident by passing an alert message to the operator, and the operator can either confirm the incident entry in the control system or cancel the event as a false or unwanted alert. In case the operator does not take any action to the alert message, a certain time (often about 20 seconds, e.g. standard for tunnels in the Czech Republic) after the alert message (notification) the control system activates the automated response to the reported incident by calling up the relevant exceptional mode in the control system.

5.2 Measurements of CO concentration, opacity, temperature, air velocity

Measurements of variables which yield results for CO concentration levels, opacity, temperature, air velocity, are taken in tunnels at several positions.

The measurements are taken in tunnels at the points located approximately 100 m from the entry point, and halfway through the tunnel length. With long-scale tunnels, measurements of CO concentrations, opacity, temperature, air velocity can be performed repeatedly (approx. after every 1000 m) between the determined terminal measurement points (i.e. entry points).

Among the most commonly used measurement systems are systems with stationary sensors that are resistant to an aggressive environment. Measured data, instructions and messages yielded with help of measurement devices are transferred to the control system via a serial communication line, network (TCP/IP protocol), etc. Low-end measurement devices use converters with standardised output; incoming signals are transmitted directly to the control system analog inputs. The diagnosis of the actual status of a measurement device is performed via signals conveyed to the control system binary inputs. Data, messages and instructions are stored in the control system archive.

Increased values of the above indicated physical variables are commonly used in the automatic mode of the technology control system in order to enable staged control of air conditioning devices. Provided that the technology control system is switched to manual mode, the operator can use the measured physical variables as referential values for setting up the air conditioning technology.

If the interval of admissible values is exceeded, the control system will notify the operator. When critical values are reached the control system automatic mode uses these values to identify exceptional events in the tunnel and selects the appropriate response of the control system (technology control – air conditioning equipment, traffic segment, etc.).

For the purpose of detecting an exceptional situation in the tunnel [„increased CO (NO_x) concentrations and opacity“, „exceeded air limits“] the control system uses the measured values for opacity and CO concentration; these reported results are averaged within sequences of the measured locations. The condition for calling up an exceptional event in the control system is the overrun of threshold values (for admissible increase) for a defined period. The end of an exceptional event is conditioned by the reduction of monitored variables under the threshold values (for required decrease) for a defined time interval.

The mechanism of the control system and operator’s reaction to an exceptional event is such that the control system responds to the incident by passing an alert message to the operator, and the operator can either confirm the incident entry in the control system, or cancel the event as a false alert. In the situation when the operator does not take any action to the alert message, a certain time (often about 20 seconds) after the alert message (notification) the control system activates the automated response to the reported exceptional event by calling up the relevant exceptional mode in the control system.

The reported exceptional situation „increased CO (NO_x) concentration and opacity“ is the impulse for increasing the intensity of ventilation, limiting vehicle access to the tunnel, and extending the interval between vehicles departing from the tunnel.

The reported exceptional situation „exceeded air limits“ is the usual impulse for increasing the intensity of ventilation to the maximum, and for limiting vehicle access to the tunnel as

much as possible. Vehicle departure from the tunnel is preferred. If such provisions prove to be insufficient the control system or the operator activate the „engine shutoff“ traffic signs. These signs remain lighted for a necessary time unless the concentrations of measured emissions or the opacity in the tunnel drop below threshold levels during a defined period.

Most devices work on the following principles:

- CO
  the absorption rate of infrared radiation between the transmitter and receiver depends on CO concentration in the air
- opacity
  the passage of a light beam between the transmitter and receiver depends on air transparency
- NO_x
  transmission (UV spectroscopy) or as a gas analyser

One of the main prerequisites for faultless function is to keep the sensors clean and to follow the diagnostics for maintaining accurate function of sensors.

Measuring of air velocity often works on the basis of measuring the time spread for the ultrasonic signal. However, also anemometers are used.

5.3 Traffic measurements, traffic alerts

5.3.1 Implementation of traffic measurements and resulting evaluations

Traffic measurements (vehicle type, number, occupancy, speed, etc.) can be carried out with use of different measurement devices that work on different principles. Depending on the applied device and the length of the tunnel, the measurements are taken at several points inside the tunnel. To comply with the requirement for applying traffic measurements for the purpose of traffic problem detection (congestion, vehicle stoppage, etc.) it is recommended to locate detectors within shorter distances.

Measured data, instructions and messages yielded by measurement (evaluation) devices are transferred to the control system through a serial communication line, network (TCP/IP protocol), etc. All resulting data, messages and instructions are stored in the control system archive.

If the interval of admissible values is exceeded, the operator is notified by the control system. When critical values are reached the control system automatic mode uses these values to identify exceptional events in the tunnel and it selects the appropriate response of the control system (technology control – air conditioning devices, traffic segment, etc.).

Incident detection in tunnels from the aspect of traffic situation, i.e. congestion, stopped stream, stream regression etc., is supported by special evaluation devices that are part of the measurement system. Analysed signals reflecting exceptional events are transferred by these devices to the control system. Apart from this method, collected traffic data can be forwarded directly to the control system for subsequent evaluation.

The mechanism of the exceptional event response called up by the control system and operator is similar to the response activated by video detection. The control system responds to the incident by passing an alert message to the operator, and the operator either confirms the incident entry in the control system, or cancels the event as a false alert.

Traffic measurements use the following detection methods:

- Video detection
- Evaluation of signals from induction loops
- Microwave sensors
- Radars

5.3.2 Excess vehicle entry

To prevent the entry of an oversized vehicle into the tunnel space, some tunnels use systems for detecting exceeded admissible vehicle height. Once activated, the excess height detection system transfers the information to the control system which responds by displaying traffic signals restricting vehicle access.

The detection system usually works with the following tools:

- Two subsequent light barriers positioned in the traffic direction (excess vehicle height indication is evoked by alert signals received concurrently from both barriers)
- Light barrier and induction loop (excess vehicle height indication called up by the engaged loop and the alert message passed from the barrier)

5.4 Safety system

The road user who enters the SOS box becomes an active element of the system. The person detects an incident and forwards the information to the tunnel control desk. The operator at the control desk decides about the activation of a suitable control system response to the reported incident and calls in the rescue service if needed.

Following the entry of a person using verbal communication, SOS boxes can serve to detect exceptional events of all kinds – assumed as well as spontaneous. In the case only the emergency press-buttons are activated (police, rescue parties, towage service), the SOS boxes can serve to detect an assumed exceptional event. The tunnel electro-fire signalisation system (EFS) becomes activated in response to the activated fire alarm signalling box. Messages from SOS boxes are transferred to the control system. As a general rule, the press-buttons are marked with icons (symbols) indicating their function clearly recognisable to road users of all nations.

SOS boxes are part of the standard equipment required especially in road tunnels and their use is regulated by national standards. The activation of SOS boxes (opening, entry of a person) activates an orange-coloured flashing light fixed on the „telephone“ traffic sign located next to the SOS box; this orange light indicator informs other road users about imminent risk. The

video-surveillance system usually displays the area surrounding the SOS box on the alarm monitor.

SOS boxes are fed from a regular power supply system with a stand-by source.

Normally the traffic operator has the priority to communicate with a person calling from the SOS box, while the technology operator listens to the communication in parallel and monitors the incoming SOS messages. If the situation requires, the traffic operator can delegate responsibilities to the technology operator who can communicate with the person in the SOS box and process the signals received from activated emergency press-buttons as needed.

The traffic/technology operator makes decisions for further actions based on the information obtained from SOS box, i.e. calling for rescue teams and activating emergency modes in the control system to evoke required responses of the control system to handle a reported incident in the tunnel space. SOS boxes can also be used by members of emergency teams for communication with the control centre, i.e. requests for necessary technology settings, confirmations of actions in resolving the situation, and other.

In the case that other detection systems with automatic links are activated in addition to SOS boxes, the information passed from SOS boxes serves as supplementary information in the decision process for the activation of control system automatic response or for calling off the situation as a false alert.

SOS box standard accessories (in addition to a phone, emergency press-buttons, fire alarm signalling box activated by press-button) usually are:

- Medical kit
- Fire extinguisher(s), hand extinguisher – 6 kg
- Salvage tools:
    - Salvage pickaxe
    - Salvage steel heaver

Telephone communication with the traffic/technology operator is activated automatically upon picking up the receiver from the cradle, or upon entering the SOS box with a speaker phone. Generally any manipulation with the dial-plate or any other instrument to establish contact is disallowed. The dialogues are automatically recorded.

5.5 Fire safety system

The fire system consists of electro-fire signalisation (EFS) control panels, press-button fire signalling boxes, automatic fire signalling boxes, and fire linear signalling boxes frequently used in tunnel tubes, as these signalling devices react to air temperature growth in relation to a defined time interval, or to absolute values of air temperature, or to both factors respectively.

5.5.1 Electro-fire signalisation (EFS) control panel

The electro-fire signalisation control panel is an electronic device used for continuous space monitoring to prevent fire incidence and to activate a fire emergency in the case of fire. The EFS control panel can take care of controlling subsequent functions (emergency devices activation, activation of the stationary extinguishing system, closing of fire-proof doors, unblocking escape ways, ventilation of escape ways, activation of remote data transmission, etc.). In road tunnels the fire system is typically interconnected with the tunnel control system which ensures operation and monitoring of integrated subsystems.

The monitored spaces are divided into fire sections and fire incidence detection is handled by fire signalling boxes located in the monitored spaces. Fire signalling boxes identify accompanying features of a developing fire – smoke or heat. Fire signalling boxes are interconnected with the EFS control panel.

Communication between EFS and the tunnel control system usually runs along a serial line or via binary inputs and outputs. The fire safety system is supplied from a power supply system with a stand-by source.

The electro-fire signalisation system serves to detect symptoms of a developing fire and activate all linked devices that cooperate in the fire prevention scheme. The EFS system consists of a control panel and fire signalling boxes installed in structured fire sections.

The EFS system responds to the activation of a fire signalling box. In the case of a fire alert in a defined fire section, the information about time, place, locality, and fire signalling box is recorded in the EFS system. A fire alert is called up by acoustic signalling.

5.5.2 Press-button fire signalling box

The press-button fire signalling box is typically located in SOS boxes, in technical background spaces of the tunnel, etc. The press-button fire signalling box is connected with the EFS system accordingly to the determined fire sections in the tunnel space. The press-button fire signalling box is intended for raising a fire alarm by a person who identifies a developing fire and activates the signalling box.

5.5.3 Automatic fire signalling box

Two types of automatic fire signalling boxes are used for fire detection:

- Point type
- Linear type (cable reacting to temperature changes)

The signalling box in the tunnel tube is usually located in the crown of the tunnel cross-section, under the ceiling. The fire signalling boxes used in the tunnel space must have minimum coverage IP65. In rooms and corridors the automatic signalling boxes are usually installed on ceilings.

6 Reliability of equipment installed in tunnels

6.1 Introduction

The main assignment of UPTUN project task 1.3.3. is to explore the availability of new, enhanced and highly reliable detection and monitoring systems applicable in automobile transport tunnels. For purposes outlined by the task, several web sites have been browsed and explored to assess the featured systems presented by different research centres, universities and manufacturers.

Innovative technology presented on the web in most cases did not constitute a breakthrough in new devices, neither in measurement nor evaluation methods. For the most part, these presentations featured upgraded methods of digital image processing based on different algorithms used in video detection for traffic measurements, incidents detection, or smoke and fire video detection.

The following chapters describe different areas of detection and monitoring and the types of equipment currently used in tunnels with indications of compliance or non-compliance included.

The chapter before the last one discusses system integrity in tunnels and industrial installations.

6.2 Video detection

6.2.1 Video detection used in practice

Video-surveillance systems applied in tunnels are recognised as regular video-surveillance devices (without video detection) and video-surveillance devices with built-in video detection.

Traffic measurements and incident detection

Video detection systems installed in tunnels are used for traffic measurements or as Automatic Incident Detection (AID) system mainly for the real time detection of stopped vehicles or traffic congestions in tunnels. The video monitoring system is integrated in the control system; retrieved information about detected traffic events and other traffic-related data is transferred to the control system.

Video detection currently uses real time (computerised) processing of video images captured by cameras. Advanced image processing methods allow eliminating gradually evolving variances in the image, for example slow changes that occur as the result of changed luminosity, changing weather conditions, etc. One of the major benefits of employing video detection in traffic measurements is the fast detection rate and the elimination of the need to install inductive sensors in the carriageway.

The automatic detection system which identifies a stopped vehicle or traffic congestion in a traffic lane inside the tunnel notifies the operator about an incident in the tunnel. The traffic sequence of the control system processes measured traffic variables (number of vehicles,

vehicle type, speed, etc.) and these measured results can serve as input data for activating automated responses in the control system.

An optional part of video detection is the "alarm monitor" function. This function displays the image captured by the camera, covering the area where the incident was detected, with overlay on the reported problem:

- Traffic problem
- Stopped vehicle
- Other

A CCTV system enhanced with the video detection function supports the following traffic measurements:

- Vehicle counts and classification
- Capacity
- Vehicle speed
- Traffic density
- Distance between vehicles (headway)
- Queue length

A video system with a video detection function handles automatic detection of traffic incident situations:

- Stopped vehicle
- Wrong way driver
- Congestion
- Headway between vehicles exceeding the limit
- Pedestrian
- Vehicle queue exceeding the limit
- Vehicle speed exceeding the limit
- Other

Measured data can be analysed separately for each traffic lane or for the whole group of lanes as required.

Video detection of emerging smoke or fire

The efficient use of video detection includes identification of smoke or propagating fire. Likewise traffic measurements and incident detection, the video detection system ensures efficient methods for smoke and fire detection by using computerised digital image processing. Compared to the electronic fire signalisation (EFS) system, a smoke and fire video detection system usually ensures faster identification of fire or smoke propagation. Based on this fact many European tunnels have already started to enhance their EFS systems with video detection. The existing legislation in force does not include fire and smoke video detection in the standard technical and safety requirements for tunnel equipment.

The fire detection delay in the EFS system, for example with fire alarm linear signalling boxes, is caused by the fact that a linear signalling box situated near the fire location has to acquire a certain temperature to be evaluated as fire incidence by the EFS system. The response of the EFS system depends on the extent of fire, the distance between the fire location and the installed linear signalling box, the heat capacity of the linear signalling box, and the temperature limit.

Benefits of the video detection system:

- Rapidity of detection
- Fast verification of an alert on the alarm monitor
- Detection of remote incidents with help of zoom lenses
- Easy identification of false or unwanted alarms using image analysis based on images stored in the alarm monitor archive
- Economically convenient solution, especially where video-surveillance (CCTV) is already installed

The limits of a video detection system are defined by its sensitivity rate and ability to recognise extraordinary events under the impact of external conditions, typically:

- **Darkness:** no smoke detection, while fire detection is possible
- **Fog:** no smoke detection, no fire detection
- **Storm:** smoke and flame is „dispersed“ by the wind, no detection guaranteed
- **Camera occlusion** (i.e. part of the visual zone gets covered by a vehicle): no fast detection guaranteed
- **Disturbance variables** in a scanned image can depreciate the quality of detection, for example:
  - Luminosity changes:
    - **1.1.1.** Daylight
    - **1.1.2.** Lighting system
    - **1.1.3.** Passing car headlights
  - Gleams:
    - **1.1.4.** Car headlights
    - **1.1.5.** Reflections
    - **1.1.6.** Sunshine at entry points
- **Smoke dispersion** caused by wind, strong flow, ventilation, vehicle travelling at high speed
- **Increased opacity** (opacification of the air inside the tunnel) caused by exhaust gases
- **Stained walls, cameras**
- **Vehicle and pedestrian traffic, passing cloudiness**

Testing methods

To date, no mandatory standards or binding regulations have been introduced for the testing and operation of fire and smoke video detection. For each video detection system, respectively for each camera if possible, it is necessary to run an on-site test for smoke and fire detection to determine the sensitivity rate of the detection function using accurately defined parameters for the environment and the defined equipment setup.

With installed video detection systems it is also necessary to assess how perceptive the equipment is to disturbance variables in order to achieve an optimal setup (parameterisation) of the system.

As a generally respected rule, during the video detection testing process only those incident simulations can be generated which ensure preclusion of conditions that might lead to multiple alarms (emergency states) triggered by false alert situations.

A general conclusion can be drawn at this point, that smoke and fire video detection systems offer a wide field for enhancements, as well as refinements in detection systems standardisation (input parameters, recognition, types of analysed events, and resistance to interferences) and testing methodologies.

Video detection system self-diagnosis of failure and status

The self-diagnostic features inherent in a video system enable to detect the following states and failures:

- Camera shifted from its referential position
- Loss of video signal from the camera
- Analyser unit failure
- Network transmission failure

Functions of the operator and control system

Video detection can be controlled by the operator who continuously observes camera images on the video-surveillance service monitors and evaluates incidents (if any) at his own discretion. This task of the operator is efficiently supported by automated video detection which allows the operator to concentrate on other priorities, mainly the checking and control functions within the system.

If the video detection system activates an alarm the operator can validate the alarm with help of video surveillance or other technologies he has at disposal.

If the alert proves to be an unwanted or false alarm, the operator cancels the system notification. No response to this alert is activated in the control system.

In case of a real incident, the operator releases the command for the activation of the appropriate system response to this alert; alternatively, if the operator does not react within a pre-defined time period, the control system can activate the appropriate response automatically.

6.2.2 Examples of currently used devices

Important notice

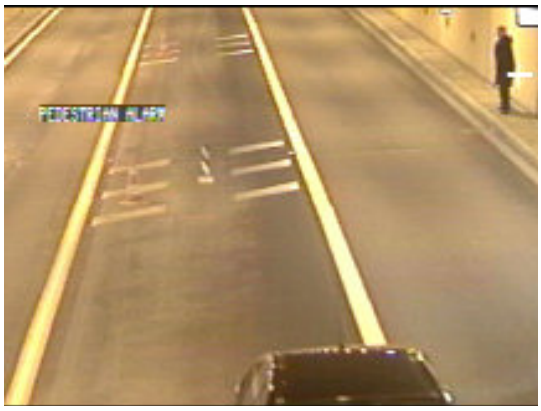
The following chapters give some examples of currently installed detection and monitoring equipment. The choice made does not cause any preference but is only based on information provided by the partners in the described task.

Traficon, traffic data, incident detection, smoke detection

Traficon nv (www.traficon.com) develops and supplies video detection modules for traffic control. The Traficon technology is used worldwide for data acquisition, automatic incident detection and intersection management. Incident Detection by means of a “state of the art” video detection system guarantees a fast en reliable detection system. It is a wide area and direct detection with dedicated functions for all application fields. The detection speed and the extra visual information is a basis for an effective and fast reaction of operators. The system has proved good performance in real conditions and can be recommended for tunnel installations.
Through real-time analysis of images of the camera, Traficon's tunnel incident detection module is able to detect all major incidents within seconds: stopped vehicles, wrong way drivers, queues, slow moving vehicles, fallen objects, smoke... This short time to detect and fast incident verification can seriously reduce the impact of the incident and prevent

Stopped Vehicle Detection

Inverse Direction Detection



Pedestrian Detection

Fallen Object Detection

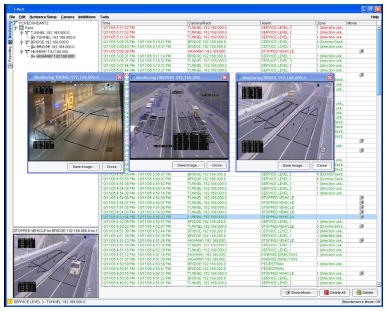
secondary accidents.

The VIP/I or VIP-T detector module developed specifically for incident detection, provides multiple functions supporting the process of incident detection in tunnels and traffic monitoring during tunnel operation. The VIP/D or VIP-T detector supports data monitoring and VIP/P detector supports traffic control at intersections. Via user-friendly Traficon Management Software (TMS product range), the user is able to remotely execute a complete set-up, modify detection zones and check the results on screen. The TMS software platform collects and stores data, events and pre-and post-incident sequences. T-Port serves as the interface between Traficon's incident detection system and the overall traffic management system in the control room.

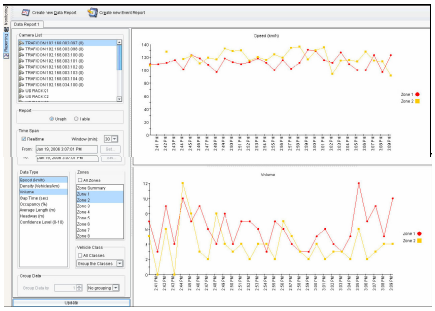
Functionalities of Traficon VIP modules

AUTOMATIC INCIDENT DETECTION	TRAFFIC DATA COLLECTION
Traffic incidents (=incidents directly linked to road traffic)	Traffic flow data (Traffic flow and speed can be monitored for 8 lanes concurrently)
✓ Stopped vehicle ✓ Wrong way driver ✓ Slow moving vehicle ✓ 5 types of traffic flow: normal, dense, delayed, ✓ congested, stop & go	✓ Traffic flow speed per lane ✓ Zone occupancy per lane
Non-traffic incidents	Individual vehicle traffic data
✓ Pedestrian ✓ Debris/Fallen object ✓ Smoke (only for tunnel applications)	✓ Volume (= number of vehicles) per vehicle class per lane ✓ Average speed per vehicle class per lane ✓ Headway ✓ Gap time per length class per lane ✓ Occupancy per lane ✓ Density (= number of vehicles/km) per lane ✓ Average vehicle length per lane

Via a user-friendly interface, T-Port monitors real-time traffic data and traffic events. In case of an incident (stopped vehicle, wrong-way driver, lost cargo…) an alarm image is shown on screen instantly. Also a movie sequence can be generated to provide the operator with pre and



T-Port software in 'Monitoring Mode' is used for real-time monitoring of traffic incidents and traffic data.



Within the 'Reporting Mode', it is possible to specify a query on the data of the selected cameras.

post incident information.

The VIP runs several algorithms in parallel. All of those algorithms are developed to give a well defined output with the best possible performance. Some of those algorithms are dedicated to detection while others are dedicated to eliminate negative influences of environment such as effects of rain, shadow, snow, light, blooming…

The Traficon VIP detection system can be defined as:

- ✓ **Versatile**: the VIP system is multi-functional and combines both data collection and incident detection with MPEG4 image compression.
- ✓ **Open**: the open architecture of the VIP system allows seamless integration via a straightforward TCP/IP protocol into other new or existing traffic management systems.
- ✓ **Flexible**: the modular structure of the VIP system makes it easy to extend and to update to changing traffic situations or additional traffic requirements.

The manufacturer declares the system ensures fast incident detection and proves high reliability:

- ✓ Fast detection (< 10s)
- ✓ High detection rate & low false alarm rate
- ✓ Video over IP
- ✓ MPEG4 compression
- ✓ IP-Addressability
- ✓ Scalable system
- ✓ Remote set-up
- ✓ High quality visual feedback
- ✓ Embedded solution: no moving parts
- ✓ High MTBF (> 20 years)
- ✓ Life time expectancy above 15 years

The web site presents specifications of detectors, cameras, etc., and short demos of the video detection function.

Citilog, traffic data, incident detection, fire detection

Citilog company (www.citilog.com) develops and supplies traffic incident detectors developed on the basis of video detection. The system uses functions for detecting stopped vehicles and queues. Other detection functions provided by the system are not used with regard to data transfer to the control system. The system is recommendable for use in tunnels, but there is very little experience with its application in real conditions.

Citilog is the supplier of a video system containing a video detection function intended for use in road tunnels. This system ensures traffic data monitoring and incident detection. The supplier declares the system can detect a developing fire, but this feature is not mentioned among the general functions.

„Media tunnel“ designed for tunnel management offers the following functions (outlined in the table 2 below).

Table 1: General functions of „media tunnel“ video detection

Automatic incident detection	Traffic measurements
stopped vehicle	traffic flow (number of vehicles, passenger cars, heavy goods vehicles)
congestion	speed
pedestrian, cyclist	occupancy
vehicle breakdown	vehicle passage
slow vehicle	classification of vehicles
object on road (and object size)	passage time
unobserved passage of vehicle (at the entry point)	numbers of vehicles in tunnel sections (according to video detection sequences)

At the moment of fire incidence inside a tunnel, the most important functions for the operator are the fire (flame and smoke) detection, and the actual count of vehicles inside the tunnel. This information is essential for the tunnel operator to proceed with the decision making process in resolving the extraordinary situation. The system is resistant to any disturbances caused by reflections, moving headlights, etc.

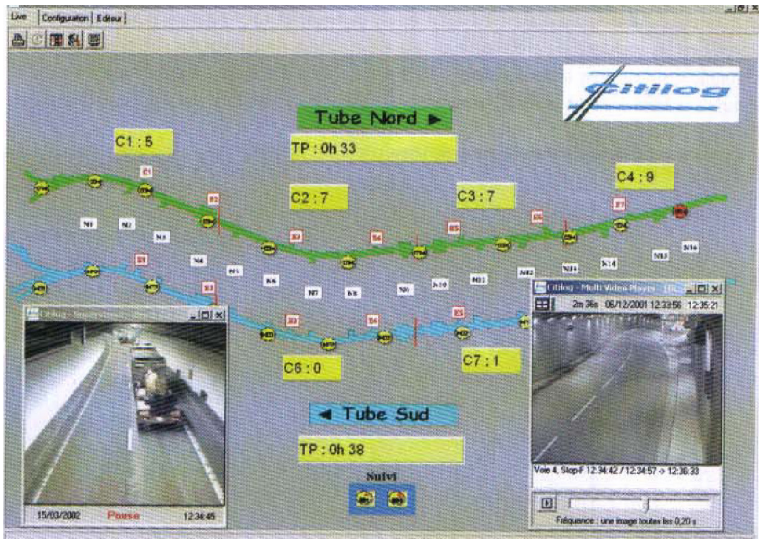


Figure 1: Example of a tunnel display with camera images

In the process of incident detection the camera images are recorded in digital format onto a disk; the captured and stored images can be later retrieved in the form of randomly selected video sequences with a defined starting point before or after the incident. Full-range communication between the video system and the control system runs via standard network protocol.

The graphical interface of detected functions displays locations and functions of different cameras on the tunnel background, as well as traffic measurements results and detected incidents (see figure 2), and the actual distribution of vehicles in the tunnel (figure 3). The interface allows displaying multiple camera images at the same moment, depending on the size of the selected window on the monitor (for example, images of 9 cameras).

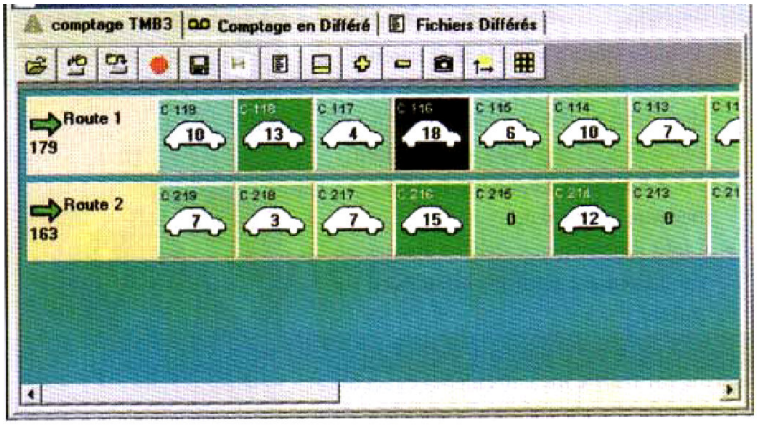


Figure 2: Count of vehicles and their distribution inside the tunnel

The manufacturer gives a highly positive characteristic of the system:

- Standard industrial components
- Standard cameras (fixed, adjustable)
- Easy set-up

- Highly efficient system ensuring safety
- Detection rate approx. 99 %
- Detection time < 10 s
- Less than 1 false alarm/camera/40 days
- Automatic recording of video-sequences before and after an incident, based on:
  - Image detection
  - Monitoring
  - Operator's request
- Multi-camera video-sequences

Autoscope – traffic data, incident detection, traffic management

Video-surveillance and video detection systems supplied by AUTOSCOPE are suitable for motorways, highroads and tunnels. AUTOSCOPE technology serves to detect stopped vehicles in two internal tunnel cross-sections and at tunnel entry points. In addition the system supports traffic data measurement analyses. The systems described are currently preferred for installations in tunnels.

These include video data evaluation technologies enabling traffic data and incident detection. An advanced camera type with a processor is presented in the following picture.

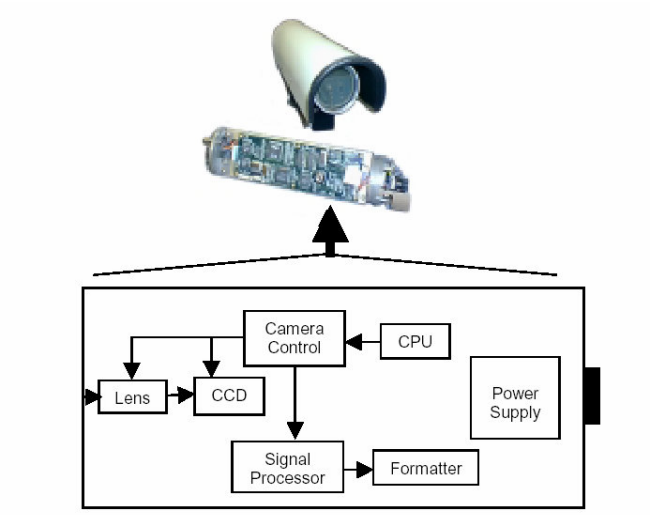


Figure 3: Camera with processor

Computer network practice and technologies are leveraged in the communication process, i.e. TCP/IP communication protocols, image digitisation and compression, image multiplexing/demultiplexing, structured cabling (see figure 5).

With a SW extension installed some of the mentioned systems are suitable for tunnel traffic management. Cameras are installed differently for incident detection and for traffic data measurement purposes. For incident evaluation purposes some cameras are supplied with algorithms. One of those is the Automatic Incident Detection Algorithm (AIDA) supplied by Autoscope. AIDA algorithm has been applied in a number of projects, for example Olympic

Road Freeway in Soul, Korea; Gowanus Expressway in New York; the tunnel to the airport in Hong Kong.

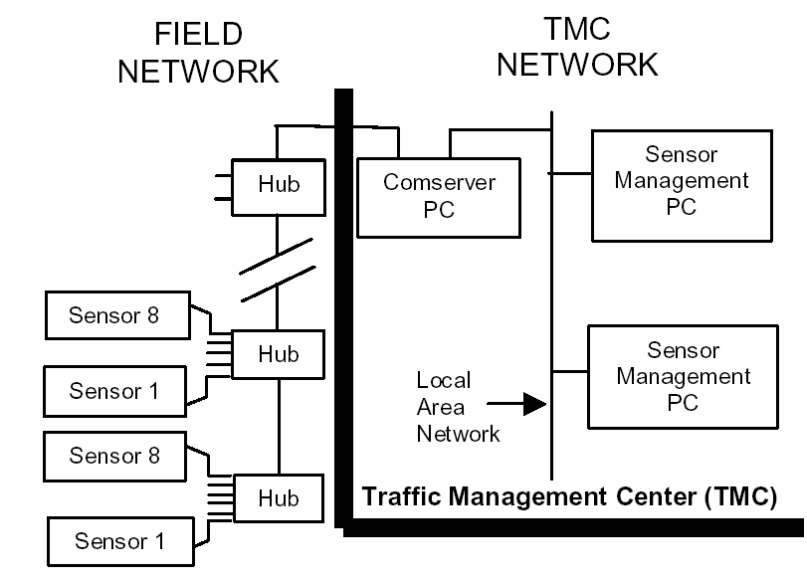


Figure 4: Network architecture for camera connections

AIDA program continuously processes changing traffic parameters, i.e. occupancy, density and speed of the traffic flow, and uses the measured values for detection of instant changes in traffic lane that are typical for incidents (see figure 6). In the camera's field of view the algorithm enables detection of stopped vehicles in a certain lane and automatic detection of vehicles pulled across shoulder lanes intended for emergency situations.

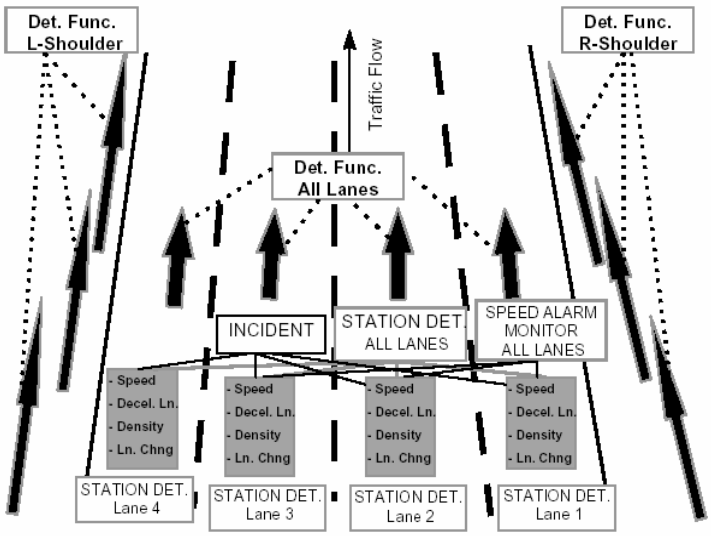


Figure 5: AIDA – detector configuration for 4 lanes

AIDA algorithm description:

- Traditionally processed values are translated into measured speed or traffic flow/density of vehicles. Threshold traffic values are selected according to the road capacity, or adjusted according to user requirements. Traffic levels are counted for three different time intervals (to determine the traffic situation development across time and the speed of changes).
- An incident classified as a traffic accident reduces the lane capacity which leads to instant traffic reduction in the affected lane and subsequent alarm call-up which is activated by the algorithm. This means the algorithm identifies an incident at the moment the flow speed rapidly decreases while the occupancy instantly increases, which results in roadway capacity reduction. The algorithm works for the detection point (camera) and cooperates with alarms generated along the lane in order to ensure recognition of slowly developing changes and to maintain independence on neighbouring detectors. An alarm is cancelled at the moment when all stations (cameras in all lanes) reach a user-defined value (in %) in relation to the pre-set congestion value. According to traffic testing results, the reduce in capacity happens in a similar way if the detection for an incident alarm works with help of AIDA program.
  An incident classified as congestion is followed with a surprisingly fast stoppage of the traffic flow accompanied with loss of capacity. Reduction of capacity generates an instant amplitude change during congestion in the morning peak hour or during any other extraordinary event. In accordance with alarm scenarios, incidents have an effect on the management and control functions of the motorway corridor; this relation depends on time information which activates time responses, i.e. modifications for access ramps, convertible traffic signs and traffic data facilities (variable message signs), information for traffic lane allocation, or transmission of an alert message to the assistance service, police, etc., requesting intervention to clear a problem.
  Environmental changes are compensated in AIDA algorithm by changes of roadway capacity in consequence of changed weather conditions (snow, fog, rain, smog, etc.).
- In the camera's entire field of view the algorithm is able to detect stopped vehicles in lanes, shoulder lanes or entry and exit ways. This type of a detected incident means:

  1.2. A serious secondary incident – a vehicle stops off the main lane

  1.3. Detection of stopped vehicle in consequence of a very weak traffic flow

  1.4. Detection of a breakdown vehicle during large-scale problems in the area (tunnel or adjustment of elevated junction geometry)

  1.5. Traffic is completely stopped in the monitored area (which causes alarm redundancy in respect of traffic information and capacity reduction)

  1.6. Stopped vehicle detector can be used only for detection of queues on ramps in order to avoid congestion on adjacent trunk roads with help of traffic control on the ramp

Ascom, traffic data, incident detection, traffic management, smoke and fire detection

Ascom (http://www.ascom.com/securitysolutions) supplies a video system with a video detection function intended for use in road tunnels. The system enables smoke detection and analysis to determine the possibility of fire. The SW labelled „INVIS Smoke“ has been first used in Mosi tunnel in Schwyz canton.

„INSIS Smoke“ system represents a new trend in video detection. The system facilitates decision processes in crisis situations and forms an efficient part of the tunnel safety system. „INSYS Wrong way“ is another module which ensures automatic detection of changes occurring in the traffic environment, and „INSYS Traffic“ module handles traffic measurements and incident detection (stopped vehicle, congestion, and other).

The principle of the function is such that the system analyses the camera digital image using a real-time algorithm. Provided that the function identifies smoke incidence, it continuously analyses the changes on subsequently scanned images. The screen is gridded into rectangular fields (see figure 7) which can be analysed by the system in relation to actual variations of contrast and brightness. In addition to static parts of the image, the system can analyse movements of different elements in the image, i.e. smoke clouds, flames, etc.

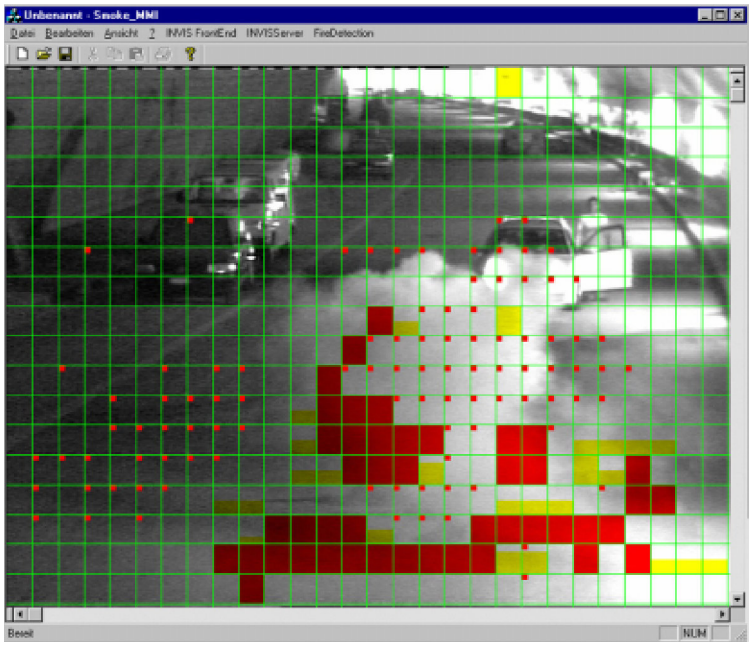


Figure 6: Example showing the detection of zones with a higher gradient of image changes

The system activates an alarm within 1 minute. The system is able to activate an alarm even earlier than the EFS fire signalling boxes start to react.

Following the installation and start-up phase, the „INSIS Smoke“ system learns to adapt to the surrounding conditions at the site where it is installed, and it customises the image and decision database supporting the detection of smoke and other volatile matters.

Securiton

Securiton (http://www.ascom.com/securitysolutions) supplies the „FireVision“ video detection solution designed for road tunnels. The system handles smoke and flame detection functions without any special requirements for the image setup.

The „FireVision“ system works with video signals which are digitised in the evaluation unit and analysed on the basis of special real-time algorithms reflecting on smoke or fire incidence. In the evaluation process these algorithms suppress extensive changes in the image with help of a combined evaluation. The „FireVision“ system is outlined in figure 8.

The system can consist of 64 units FU-317. Each of these units can be connected with 8 cameras. Each unit connects to the system via 100 Mbit ETHERNET connections. FU-317 also contains an interface for connected video equipment, RS 232, alarm outputs and control inputs.

An alarm notification during smoke or fire incidence is generated in two levels:

- Reported change in the image – and subsequent alarm signalling
- Which can be customised by the user

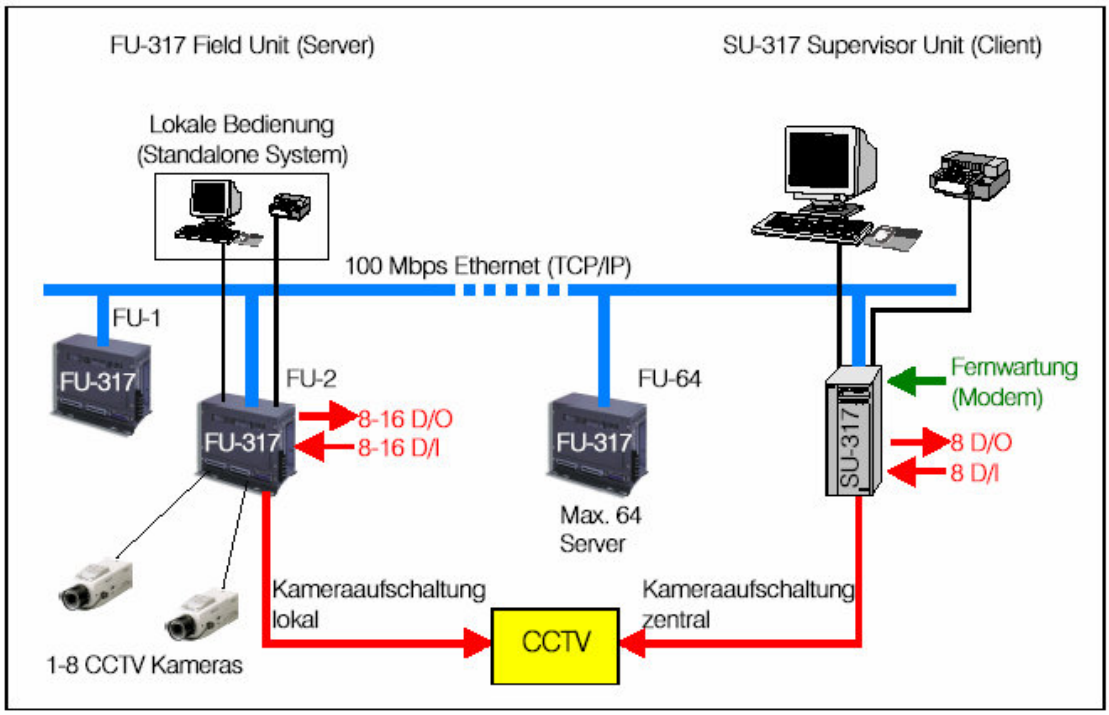


Figure 7: „FireVision“ video detection system

In the moment of alarm activation the relevant camera image is displayed in the larger field; the alarm message (smoke/fire) and side bars determine the division of the display for smoke or fire in percent. Detection displays are presented in figure 9.

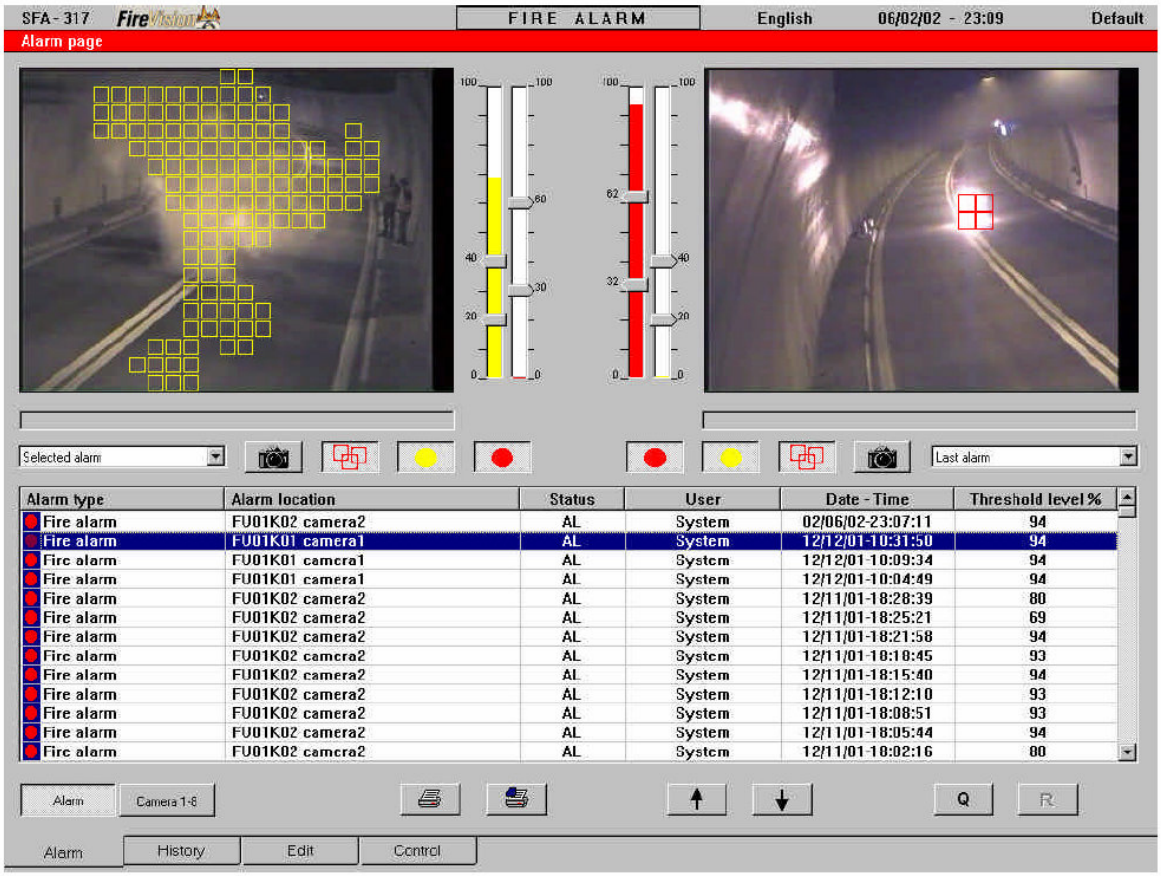


Figure 8: Examples of displayed smoke and fire detection

6.3 SOS boxes

SOS boxes in automobile tunnels are standard equipped with a phone (communication with the operator), internal lighting, three emergency press-buttons (police, emergency, rescue service), and a press-button fire signalling box, see figure 10).

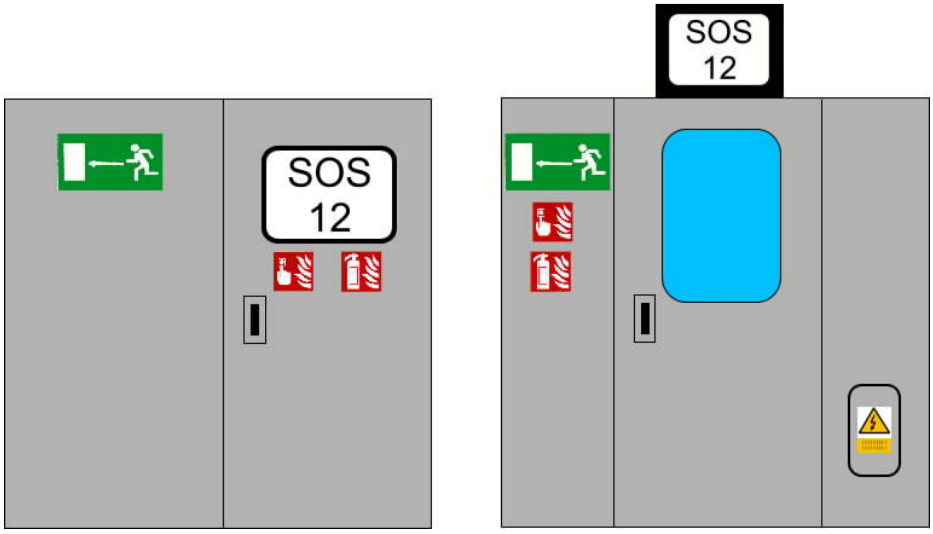


Figure 9: Example of SOS box arrangement

The most recent recommendation for emergency call systems is telephone switchboards with TCP/IP communication protocol. This solution facilitates integration with the control system.

A back-lit D22 „telephone“ traffic sign with a yellow double flashing light is positioned above each SOS box and a halogen floodlight is attached below the tunnel tube ceiling to light the space in front of the SOS box. The flashing indicators and the floodlight are activated at the moment a person enters the SOS box. Each SOS box has a regular power supply system with a stand-by source with sufficient capacity for approximately half an hour.

Some SOS box constructions are divided into two parts; the first is freely accessible for road users who need to report an incident or ask for help, while the second part (electro-section) is not accessible to public and serves for maintenance and power supply for the installed technology.

The entrance to the electro-section of the SOS box is mechanically shut off to prevent access of unauthorised persons. The electro-section shelters a socket-box and switchboard for the SOS box. Each switchboard has its UPS source ensuring power supply and control of the SOS box, power supply to video-surveillance cameras, socket-box, and possibly other installed devices.

One manufacturer is ELTODO Power, Prague. Similar equipment is manufactured by Siemens ITS.

Supplied products represent a standard solution suitable for the tunnel environment. The final layout of SOS box equipment is arranged and refined for each installation according to the submitter’s requirements.

Functions of the SOS box equipment meet all standard requirements and prove a minimum failure rate. In view of the above facts it is highly recommendable to use the equipment supplied by the two above mentioned manufacturers in new tunnel structures as well as in reconstructed tunnels.

6.4 CO concentration, opacity, stream velocity measurements

Many tunnels use equipment supplied by SICK for the following measurements:

- CO concentration and opacity measurement using VICOTEC 414 system
- Air velocity measurement using FLOWSIC 200

These measuring devices work reliably in the tunnel environment. The long-term application of these systems in tunnels has proven a low failure rate. If sensors become stained during regular operation, the state of the measuring system is diagnosed and indicated.

It is highly recommended to use VICOTEC 414 and FLOWSIC 200 systems in new tunnel constructions as well as in reconstructed tunnels.

For CO concentration and opacity measurement the equipment supplied by JES is frequently used with combined induction for opacity and CO analyses.

Based on the available information the measuring equipment supplied by JES works reliably and without any problems. The disadvantage of this measuring set is the necessity to draw air from the tunnel to the measuring site.

6.5 Radio communication

Radio communication ensures a communication link between integrated rescue service (IRS) teams and streamlines coordination of assistant services.

Provided that the tunnel equipment includes the necessary technology for radio broadcasting in tunnels, the tunnel operator can interrupt radio broadcasting and step in with emergency messages. The operator is able to provide information to road users inside the tunnel, especially traffic data and instructions in extraordinary situations. Radio broadcasting equipment inside tunnels is a significant component of tunnel safety.

The wireless phone network has proven its qualities as another efficient medium for traffic event notifications by road users who travel directly inside a tunnel. In view of this fact it is necessary to provide tunnels with equipment ensuring mobile phone communication. The system implementation design shall count with the 3-rd generation mobile phone network (UMTS).

In addition to radio broadcasting and mobile network communication, the installed radio equipment also ensures duplex communication for emergency parties and service teams. The minimum requirement is to ensure the following communication types:

- At least one radio broadcasting station with traffic information where priority is given to stations with RDS-TMC (Traffic Message Channel)
- A channel for the firemen, rescue service and police
- A channel for operations control, respectively assistance service,
- One mobile network operator for emergency mobile communication

There are a lot of manufacturers offering radio communication equipment.

6.6 Traffic measurements, traffic alerts

6.6.1 Implementation of traffic measurements and resulting evaluations

Traffic data (vehicle type, number, occupancy, speed, etc.) can be measured with help of different measurement devices working on different principles. Based on project specifications and depending on the specific tunnel length, all required measurements are taken at several points inside the tunnel. To comply with traffic measurement requirements for the purpose of traffic problem detection (congestion, vehicle stoppage, etc.) it is recommended to locate detection devices within shorter distances.

Communication between the control system and measurement devices runs through binary inputs/outputs, a serial communication line, the network (TCP/IP protocol), etc.

Data, messages and instructions are stored in the control system archive.

If the interval of admissible values is exceeded the control system notifies the operator. If critical values are reached the control system automatic mode uses these values for further identification of incidents in the tunnel and for activation of appropriate responses.

For the purpose of traffic incidents detection in tunnels, i.e. congestion, stopped flow, reverted flow, etc., special evaluation devices are used for direct analysis and evaluation of the detected incident, or alternatively, traffic data can be transferred to the control system for analysis and final evaluation of the detected incident.

The response mechanism of the control system and operator is similar to the response activated by video detection during an incident. The control system responds to the incident by passing an alert message to the operator, and the operator either validates the incident entry in the control system, or cancels the event as a false alert.

The commonly used traffic measurement methods are as follows:

- Video detection
- Inductive loops with detectors
- Microwave sensors, radar devices

Video detection

Traffic data monitoring and incident detection is described in chapter 6.2 of this report. The major advantage of the presented type of detection is the elimination of structural disturbance of the carriageway.

Inductive loops

Inductive loops integrated with detectors represent a standard method for traffic data acquisition and incident detection. The disadvantage of installing inductive loops is the need to disturb the road surface layers during installation.

DATAMER induction loop detectors, type LD1, and MRP type evaluation devices are examples currently used in tunnels. These devices have proved a good performance rate and are recommendable for tunnel installations.

Microwave sensors, radar devices

Radar devices installed in tunnels are used for speed and vehicle length measurement; measured values are used for traffic management with help of the control system and for police reports to document vehicles with exceeded speed limit. The data outputs from approved police radar devices are usually transferred to relevant police stations for further administration or action as needed. Communication is handled by network protocols. Also with these systems, it is not necessary to make any structural changes in the carriageway.

6.6.2 Excess vehicle entry

To prevent the entry of an over-sized vehicle into the tunnel space, some automobile tunnels use passive barriers or active systems at entry points for the detection of exceeded admissible height of vehicles. Once activated, the detection system transfers an excess height alert to the control system which responds by activating relevant traffic signals to restrict vehicle access at the indicated entry point.

The detection system usually works with the following tools:

- Two successive light barriers positioned in the traffic direction (excess vehicle height indication is evoked by alert signals received from both barriers concurrently)
- Light barrier and induction loop (excess vehicle height indication called up by the engaged loop and an alert message from the barrier)

The excess vehicle detection system often used in tunnels is HISIC 450 combined with two light barriers, supplied by SICK.

The system works reliably in the tunnel environment. The long-term application of this system in tunnels has a proven low failure rate.

It is highly recommended to use HISIC 450 (or new types developed on the basis of this proven system) in new tunnel constructions as well as in reconstructed tunnels. Alternatively, it is possible to use a similar system including one light barrier (used in former systems) combined with an induction loop and DATAMER LD1 evaluation device for engaged loop detection.

6.7 Fire safety system

The fire system consists of electronic fire signalisation (EFS) control panels, press-button fire signalling boxes, automatic fire signalling boxes, and fire alarm linear signalling boxes which are frequently used in tunnel tubes, as these signalling devices react to the rising air temperature accordingly to a defined time interval or absolute values of air temperature, or to both factors respectively. The evaluation device determines the location of the anomaly on the basis of changed physical characteristics of the fire alarm linear signalling box and the EFS indicates this location as the fire incidence site and calls up an alarm.

The linear signalling boxes have a certain heat persistence which causes a time delay between fire incidence and its indication. Other present influences:

- Dstance between the fire location and the linear signalling box
- Extent of fire
- Air velocity and direction inside the tunnel (this can impact the precision and speed of fire detection).

The recommendation for future use is to combine EFS systems with fire and smoke video detection. As already mentioned in chapter 6.2, video detection proves advantages (rapid detection, ...) as well as some disadvantages (detection efficiency impacted by external factors, the need to set up the system depending on conditions at the installation site, ...). The combined use of both systems gives a strong premise for improving the reliability of smoke and fire detection.

EFS systems from different manufacturers are applied in tunnels. Linear fire signalling boxes are used in most tunnels.

For recently completed or developed tunnel structures especially in Czech Republic and Slovakia, priority is given to EFS systems with FibroLaser fire alarm linear signalling boxes supplied by Siemens Building Technologies (Cerberus division).

The range of marketed fire alarm linear signalling boxes includes an interesting offer by SECURITON (http://www.securiton.de/tsc_sens.asp). The presented product is Kabel SecuriSens TSC 511 with addressable heat sensors (8 cores). The operational temperature span for the cable is from –40 to 95 °C. Temperature data from different sensors of the TSC 511 cable are transferred through a data bus within the cable.

Spacing of sensors in the cable:

- 4 m (total length 1 km)
- 7,2 m (total length 2 km)

The electronics operational temperature limits range from –55 to 125 °C, precision ± 2 °C at sensitivity rate 0,1 °C.

Data evaluation is processed by SecuriSens® TSC 511 SW – an application running under MicrosoftTM Windows®, which enables individual configuration and data processing; visualisation is processed on a remote PC. The CTP 511 evaluation unit is standard equipped with two potential-less contacts. Auxiliary attachments to the unit are 32 potential-less contacts and 16 contacts with an open collector.

The reporting of exceptional events with fire incidence in tunnels is such that after a fire is detected by the EFS system, the control system operator verifies the plausibility of the alarm (for example, a false alarm caused by a faulted sensor, etc.).

In the event of a false alarm, the control system operator deactivates the alarm and resets the EFS control panel. The initiated alarm notification in the EFS control panel is not reported to the fire department's operation centre.

In the event of fire, following the validation of the detected incident the control system operator requests the fire department (or integrated rescue service) operations centre for intervention. Based on this emergency message the fire-fighting team sets out to action.

The time interval between an alarm call-up at the EFS control panel and the operator's request for intervention can be reduced by using an alarm receiving centre (ARC) with a direct link to the fire department operations centre. The advantage of this solution is the immediate transfer of emergency messages to the fire department operations centre which ensures faster arrival of the fire-fighting team to the fire location. The disadvantage of this solution is the higher rate of unnecessary responses of fire teams to false alarms, failures, etc.

The ARC is operated at regional level. If an ARC control desk is planned for integration with automobile tunnel control systems, the following aspects must be taken into account:

- Assess the applicability of the offered device intended for integration with the ARC control desk and EFS system
- Verify the device homologation
- Verify the equipment reliability
- Verify back-up functions and bi-directional communication
- Verify ARC control desk connections to the local rescue service centre (which has the capacity for interventions in automobile tunnels)
- Other

6.8 System integrity

System integrity represents a relation between logical sequence, priority and reaction capabilities, response and bi-directional verification, and response testing of the installed equipment. This pertains to the fire protection equipment and safety, operational and auxiliary equipment. Ensuring system integrity is accompanied with certain problems in the field of industry as well as in tunnels.

To resolve the tasks outlined within scope of the UPTUN project, there is high potential to improve safety in tunnels by ensuring system integrity both in the design and operation phases.

In terms of safety equipment installations in industrial plants and in tunnels, it is of key importance that safety systems which are intended to cover a local area also ensure monitoring of specific parameters and in the case of identified changes ensure response activation (defined control system responses) at local level and in the whole control system. The reactions within scope of the whole system must be interconnected and must maintain coordinated response to the actual development of an incident in the reported location.

All these systems are required to have a guaranteed back-up of operational elements, units and the system as a whole. It is a prerequisite that the system ensures execution of pre-defined tasks if a total break down situation comes up.

Examples of positive and negative observations in the area of system integrity:

- **Confusion of facilities**
  This includes gas escape detection devices and emergency monitoring
  The ***gas escape detection*** device is capable to carry out a self-diagnosis of its own function and if it recognises a failure it signals a failure notification to the service and maintenance centre which has pre-defined algorithms for technical, organisational, or technical-operational measures readily at disposal.
  Emergency monitoring is a facility that is not capable of its own function self-diagnosis.
  In real conditions during a power supply failure the gas detection device is automatically re-connected to a stand-by source and the service staff is duly informed about the device switch-over to a different mode which is dependent on the operational interval of the stand-by source function. During the stand-by source function interval the service staff has time to take appropriate measures (physical inspection, stoppage of production, etc.). While in the same situation (power supply failure), the emergency monitoring is out of operation and no information is forwarded to the plant or central control room (the problem could be a defect on the feeder cable in the wiring system beside the monitored plant).

- **Reserve sources.**
  In many cases (most of the reported situations) there is an absence of pre-defined steps for a system response to an insufficiently functioning stand-by source.
  In real conditions the safety system anticipates a switch-over to a stand-by source of energy (raw materials, etc.) but at the same moment there is no feedback information available to determine whether the alternative source is fully functional. This might result in a failure to connect the affected

production or operational unit to a stand-by source during a power supply failure, in which case the assumed time interval for introducing operational technical measures has no value (zero). This situation might lead to a breakdown or emergency situation.

- **Setting up system response values.**
  The setup process works with precisely defined values and corresponding responses.
  For example, during an escape of combustible gas in a pressure cylinder filling station, the so-called operational leakage, i.e. concentration over time, must be respected. The progressive growth of combustible gas concentration in space and time has to be carefully detected and subsequent automatic activation of other equipment has to be ensured.
  Example:
  5% (LEL) - activation of operational ventilation,
  10% - + visual indication,
  15% - + audible signalling,
  20% - + automatic closure of filling machine fixtures,
  22% - + activation of emergency ventilation,
  25% - + fire alarm at the workplace,
  30% - activation of sprinkling,
  35% - evacuation alert for persons in the plant,
  40% - + fire-fighting team intervention.
  All the mentioned actions have to be carried out in relation to response times of the progressive growth of combustible gas concentration in the filling station.
  If the lower explosion level (LEL) value is attained, for example 30% within a 60-second interval, the whole system is activated consistently, which includes visual and audible signalling, closure of the filling device fixtures, fire alarm call-up, sprinkling activation, fire alarm in the plant and information sharing with the fire department centre.

- **System integrity in tunnels.**
  In the event of detected fire, vehicles are prevented to enter the tunnel and relevant safety systems are activated – including ventilation, traffic control, lighting, barriers to shut off access to vehicles, etc. The fire department is notified about the incidence.
  Additional tasks are assigned to entities in the organisational structure:
  1.7. the tunnel operator at the local traffic technology control desk,
  1.8. the police at the traffic control centre,
  1.9. other sections of the regional IRS.
  These tasks are carried out by all sections in charge.

- **Reliability of the safety system**s which is not sufficiently tested, or if certain conditions are present which eliminates the protective function of the system.
  For example, during a fire of a passenger vehicle the ERIKA linear fire signalling box was not activated in the EFS system because the natural air circulation in the tube prevented the temperature under the tunnel ceiling to grow to the point (threshold value) when the EFS system usually detects fire incidence. Another fact that has to be taken into account is that a higher temperature cumulates under the ceiling in a further away from the actual fire

location (caused by the flow inside the tunnel). The above mentioned fire was recognised by a policewoman at the control desk with help of the camera surveillance system.

- **Functional and operational testing, technical audits of fire safety equipment**
  Prior to activation in real conditions, all fire safety equipment is required to undergo operational testing. This includes equipment testing. Operational tests are carried out periodically. Periodical testing does not include naturally created conditions for the purpose of activating an operational test. Relevant system states are not created which can lead to the situation where the equipment shows no response.

- **System integrity – an example from chemical industry**
  The compressor serving to increase the combustion gas pressure is attached to a turbine. In the event of detected non-operational parameters, flame, or rapid increase of combustible gas concentration, the following actions are automatically activated:

  1.10. the turbine is put out of operation,

  1.11. input and output fixtures are shut off,

  1.12. combustible gas is securely carried off (depressurised) to a free space away from the plant,

  1.13. turbine oil is repumped do a safety well,

  1.14. the automatic extinguishing system is activated,

  1.15. the hall spaces are mechanically ventilated,

  1.16. a fire alarm is called up in the whole plant,

  1.17. the incident is reported without delay to the fire-fighting team which takes immediate action,

  1.18. the standby (alternative) source is activated,

  1.19. the hydrant system booster pumps are activated,

  1.20. the control centre is duly notified about the situation,

  1.21. an alarm is raised through the public address system in communities in the surrounding area.

  Pursuant to organisational provisions all persons in the plant are requested to leave the premises and gather at a pre-determined place. This excludes the minimum number of persons required to stay at the control centre and the fire-fighting team.

6.9 Example of detection system failures and fire incidence

This example for a tunnel operation assessment was carried out for Strahovský automobile tunnel (SAT) in Prague in 2002. Selected extracts focusing at the application of detection systems were prepared from the records.

Safety system

SOS boxes have proved to be beneficial during incidents inside the tunnel. 12 SOS boxes are installed in the SAT west tunnel tube and 13 SOS boxes in the central tube.

Unreasonable entries in SOS boxes were recorded 3 times during the year (drunken person, a homeless). Communication with the person in SOS box was not initiated. At one entry a theft of a fire extinguisher was identified.

One technical fault was detected during the year – an outage in one of the SOS boxes.

During a fire incidence in the SAT none of the road users used an SOS box to notify about the fire. The SOS box was used for communication with the central control panel by the intervention team who had been called to the fire.

In some situations, especially vehicle breakdowns, road users do not use SOS boxes to report an extraordinary event and to agree on further steps in resolving the event in cooperation with tunnel operators. Provided that mobile phones are functional even inside the tunnel, road users prefer to call their friends or a towing service and ask for help, but they do not communicate with operators in the tunnel.

Radio communication – mobile phones

During an incidence in tunnels the road user has the possibility to inform about the incidence through his mobile phone.

Video-surveillance

The SAT is set with 15 + 16 cameras in the tunnel tubes, 1 + 2 cameras on portals, and 1 + 1 cameras at intersections in front of the tunnel entry points.

Video-surveillance failures in SAT in 2002 occurred in 17 days throughout the year and were reported as 17 events. Of those 13 events were serious failures of video monitoring which resulted in tunnel closures with total time of closure 26 hours and 30 minutes.

Video-surveillance failures were prevailingly caused by communication failures between SAT localities (technology control) and the main traffic control centre (traffic management). In one instance the reported video-surveillance failure was rather curious as it was caused by a theft of an optical fibre on the transmission path.

Detection of stopped vehicles or accidents inside the tunnel was in most cases handled by the operator with help of the video-surveillance system. Stopped vehicles or traffic accidents were also reported by road users through SOS boxes subsequently after the operator identified such incidents. Incidents of „road accident“ or „stopped vehicle“ types inside the tunnel tube usually led to a road traffic closure in the affected tunnel tube for a time interval necessary for accident enquiry and damage removal.

In 2002, altogether 11 events for stopped vehicles and 9 traffic accidents were reported in SAT. In one instance a stopped vehicle with fire incidence was detected (see description in EFS section). The total time of tunnel tube closure in SAT for the above mentioned reasons was approximately 20 hours and 40 minutes.

CO concentrations, opacity measurements

In 2002, the incidence of CO concentration or opacity measurement faults in SAT was reported for 14 days. These faults did not impact the control system to a degree that would require SAT tunnel closure.

Traffic measurements, traffic alerts

Traffic data measured in SAT include vehicle count and maximum and average speed in the tunnel tube. Congestion is detected on the basis of traffic measurements. As an additional option, congestion can be identified by the operator with help of video-surveillance. The traffic operator responds to congestion by introducing relevant measures in the traffic flow or by closing the tunnel tube where the congestion has developed.

The frequency of traffic measurement faults in SAT was 15 days in 2002. The total time of fault duration was not recorded. These faults did not impact the control system to a degree that would require SAT tunnel closure.

Fire safety system

ERIKA linear fire signalling box is used in SAT tunnel tubes. Press-button fire signalling boxes are used in SOS boxes. Automatic and press-button fire signalling boxes are used in adjacent facilities out of SAT tunnel tubes. SAT fire protection is ensured by two Schrack EFS control panels. The master works at SAT central control desk, and the slave is situated in Hg2 (room indication).

The EFS system in SAT has problems with false alarms caused by fire signalling boxes in consequence of humidity at the installation sites. The frequency of false alarms in 2002 was 12 days. Defective fire signalling boxes are replaced immediately after a fault is identified.

Recurring false alarms result in situations when a fire alarm can be activated by a fire signalling box in a SAT section which has no video-surveillance coverage and is located out of the tunnel tube; a fire guard has to be sent to check the section, and under normal conditions no fire incidence is reported to the integrated rescue service centre (IZS). A fire incidence can be reported only after on-site verification by the fire guard. This time delay represents a loss of valuable minutes that are necessary for the intervention of the fire-fighting team. To date, in all reported events the fire guard has identified a fault on the fire signalling box.

The time-out (approximately 5 – 10 min.) needed for a fire signalling box function check-up might cause delays in:

- Fire alarm activation in SAT
- Adoption of necessary measures
- Arrival of the fire-fighting team

Fire inside the tunnel:

In 2002 one false alarm with an emergency call for the firemen occurred independently of the EFS system. An unknown person requested intervention of the firemen without any reason. The person who made the call was never identified.

In one instance a „fire“ exceptional event occurred in SAT. A passenger car was on fire.

The incident was detected February 13, 2002, at 5:13 p.m. A vehicle entered the tunnel from the south (central tunnel tube) and travelled some tens of meters before it started showing signs of smoke; after immobilisation the vehicle was on fire. The incident was detected by the traffic controller (police) at the main traffic control centre (TCC) with help of video detection. The operator immediately informed the intervention teams and closed the tunnel for traffic. The fire team arrived at 5:18 p.m. and by 5:40 p.m. the smoke was dispersed and the intervention was actually ended.

The fire was eliminated and no damage was caused on human lives or tunnel equipment. The EFS system with ERICA linear fire alarm linear signalling box did not respond to the fire inside the tunnel.

The state of the tunnel was inspected by the technology controller and the vehicle was towed away at 6:20 p.m. No material damages were found on the tunnel and the west tunnel tube was opened for normal road traffic again at 6:28 p.m. (Břevnov - > Smíchov direction).

The cleaning vehicle arrived at 7:24 p.m. After the carriageway was scavenged and checked by the police patrol (and controller) entry of traffic was allowed in the central tunnel tube at 7:59 p.m. (Smíchov - > Břevnov direction). Signboard warnings were cancelled and relevant local organisations, i.e. the traffic information centre (Centrum dopravních informací), Rádio City broadcasting and metropolitan transport company bus line division (Dopravní podniky – sekce autobusy) were informed about the traffic situation.

Note :
Due to installation works on the control system integration in Strahov tunnel, the control system did not function at the time of fire incidence. Traffic inside the tunnel was regulated by pre-defined technical and organisational alternative measures. The end of the alternative mode was planned for February 13 at midnight, with expected tunnel closure for complex testing purposes, and with planned re-opening by February 13, midnight.

The state of tunnel technology prior to the fire incidence

Works on the control system integration included tasks that temporarily impeded regular function of the control system; due to that fact the following safety measures were applied:

Technical measures:

- Traffic in both tunnel tubes was reduced to one traffic lane
- Stoppage of traffic regulated by traffic light signals and additional red flashing lights (modem-activated) placed at tunnel portals
- EFS centre in full operation with ensured controller’s supervision

Organisational measures:

- Technology controllers and the police were duly trained for the alternative mode: supervision over EFS, manual switching of ventilation, manual stoppage of traffic, etc.
- Ramp D from Kartouzská street was closed
- Signboards informing about the exceptional state were installed in the access zone to the tunnel

7 Equipment installed outside tunnelling

7.1 Introduction

According to the goals defined in activity 1.3.2 of task 1.3 only a limited amount of information could have been made available about monitoring and detection systems in industrial plants, especially in terms of chemical industry.

The process of acquiring information about used technologies and transmission of messages to control centres in exceptional situations, etc., has proven to be a rather problematic task. From an organisation's perspective, the conveyed information is of strategic nature and as such is effective on regional or national levels depending on the specific situation. The risk prevention and emergency control strategy applied within range of organisations, regions, etc., caused that the acquired information is of a very general nature and it can not be assumed that some new and more detailed information would be provided in addition. The 11th September of 2001 events and the possibilities of terrorist attacks raised by media attention are the main reasons for the „non-disclosure" policy.

To acquire specific information about detection and monitoring systems we have contacted a number of major chemical processing plants, but without any tangible results. Monitoring section employees believe that publicising this type of information is inappropriate.

Monitoring and diagnostics of extraordinary events in used technology and the detection of dangerous conditions in the surrounding areas that might develop into an incident, is generally ensured by systems that are used for emergency/safety monitoring processes in organisations. These systems usually consist of unique devices specifically designed for respective production control systems.

The mentioned systems are used for monitoring, detection and safety control of a manufacturing or processing complex in the following aspects:

- Fire incidence
- Leakage of dangerous substances
- Illegal access
- Other

Information about the monitored system or about an exceptional event is transferred to the control room in the organisation where the operator takes appropriate action according to scenarios that are prepared for regular or exceptional situations. The control room in the organisation reports to the control centre on a higher level.

The emergency plan devised by the operator of at-risk operations is based on the organisation's needs, determined extent of possible risk exposure and the knowledge of the technology operated in the plant. The concept of the emergency plan is built on a thorough risk analysis worked out for the respective operation and the surrounding areas. The general purpose for creating and implementing an emergency plan is to ensure the state of readiness of all employees in the operation, technical facilities needed to resolve the incident and to mitigate damages in the early stages of a developing incident.

For the needs of technology supervisors, intervention team leaders (fire department units), second-phase units, emergency planning, etc., the information about an operator of hazardous

operations and dangerous substances is processed by a purpose-built software – the emergency information system. Computerised processing enables fast orientation of intervention teams in terms of communication access, incidence and localisation of dangerous substances, escape routes, and other.

One partner from Czech Republic performed a general analysis on risk prevention and accident control based on the national regulation in Czech Republic and partly in Slovakia. They also show some examples of applied systems in industry in both countries. This evaluation is presented in the following chapters.

7.2 Risk prevention and accident control

7.2.1 Legislation to enforce risk prevention in the Czech Republic

In order to ensure the enforcement of risk prevention in the CR a legal framework has been created in compliance with EU guidelines – in particular, amendment to the directive 96/82/EC (Seveso II Comah) „On the Control of Major Accident Hazards Involving Dangerous Substances“ (effective from January 1997).

Risk prevention is ensured by technical and administrative measures in those organisations where a possible accident might have serious impacts on human health and the environment. Risk prevention decreases the risk of the development of an accident. With a risk prevention and safety control framework in place, based on adopted measures and requirements within an organisation, if some extraordinary event occurs, then minimised damages can be expected.

The implementation of a risk management program significantly mitigates the impacts of an accident.

The key elements of a risk management program are:

- Well-devised operating regulations
- Efficient maintenance
- Operators training
- Emergency plans
- Identification of risk sources
- Investigation of emergency situations
- Risk assessment
- Risk mitigation
- Risk analysis
- Risk reduction and prevention
- Risks insurance policy (entered into when a risk can not be ruled out; serves to minimise damages in situations when an accident occurs despite all protective measures taken)

From the legal aspect, the methods for risk prevention and risk assessment are based on and regulated by the following statutes:

- **Act No. 353/1999 Coll.** on the prevention of major accidents caused by selected dangerous chemicals and chemical agents, and the amendment to Act No. 425/1990 Coll. on regional offices, regulation of their scope of powers, and related additional measures as amended by later regulations (the prevention of major accidents law).
- **Decree of the government of the CR No. 6/2000 Coll**. to regulate the methods for assessing a safety program for the prevention of major accidents and for working out a safety report, an annual inspection plan report, procedures for inspections, the content of the annual inspection plan report, the procedure for inspection, the content of the information and the content of the inspection final report.
- **Decree of the Ministry of the environment of the CR No. 7/2000 Coll.**, to regulate the extent, scope and methodology for preparing a report of a serious accident, and the final report about the development and after-effects of a major accident.
- **Decree of the Ministry of the environment of the CR No. 8/2000 Sb.**, to regulate the rules and principles for risk assessment of major accidents, the extent, scope and methodology for working out a safety program to prevent major accidents and for preparing the safety report, for working out an internal emergency plan for an organisation, for processing background materials to determine safety zones for emergency planning, and for preparing an external emergency plan, the extent of information and the way of disseminating information intended for the public, including a procedure to assure the flow of information to the public who reside in an emergency planning zone.
- **Decree of the Ministry of interior of the CR No. 383/2000 Coll.**, to regulate the rules and principles for determining an emergency planning zone, and the scope, extent and mode of preparing an external emergency plan for accidents caused by selected dangerous chemicals and chemical agents.
- **Act No. 239/2000 Coll.**, to regulate the integrated rescue system and amendments to laws as appropriate.
- **Act No. 240/2000 Coll.**, to regulate the crisis management system and amendments to laws as appropriate (the crisis Act).
- **Act No. 241/2000 Coll.**, to regulate economic measures for crisis states and amendments to relevant laws as appropriate.

Within scope of accident control and risk reduction, organisations who apply dangerous processes frequently have their own fire & rescue teams that operate also within the regional integrated rescue system and the transport information and emergency response system (TRINS), and it is understood that their scope of competencies reach beyond the organisation’s premises.

Within scope of risk prevention, in coordination with the respective regional integrated rescue system, topical field-trainings are regularly organised addressing the proper application of procedures in handling industrial accidents.

7.2.2 Transport information and emergency system for chemical industry in the Czech Republic

The TRINS Transport information and emergency response system association („Transportní informační a nehodový systém“) has been established in the CR. Currently, TRINS association is formed by 23 companies operating in chemical industry. In compliance with the goals of the Responsible Care program, the chemical industry association – respectively the member companies – are ready to voluntarily provide assistance within scope of their capabilities in extraordinary (emergency) situations that might arise from transport of hazardous materials or other manipulation thereof across the territory of the CR.

The „Responsible care“ initiative has global efficiency. The east European countries who confirm their participation in this program are the Czech Republic, Slovakia, Hungary and Poland.

The Responsible Care program in the CR is a voluntary initiative of the chemical industry, formed under the auspices of the country’s Association of Chemical Industry (Svaz chemického průmyslu), closely cooperating with its European counterpart – CEFIC, the European Federation of Chemical Industry.

Through its centre TRINS provides continuous assistance in resolving extraordinary situations connected with transport or storage of hazardous materials in CR territory. TRINS worked out a list of dangerous substances (products) in the case of which TRINS members provide assistance.

Effective of July 1, 1996, it is possible to request advice from TRINS through operation centres of regional fire departments (or integrated rescue service teams) for the following on the following subjects:

- Information about products, substances and their non-problematic transport and storage
- Practical experience in manipulation with dangerous substances or liquidation of incidents connected with dangerous substances
- Practical (in-kind) assistance in clearance and liquidation of damages incurred by an exceptional situation connected with a dangerous substance

If an accident occurs on CZ territory during the transport of dangerous substances or manipulation thereof, the fire department operation centres (or integrated rescue system centres) can use professional advice or practical assistance in dealing with an extraordinary situation in order to mitigate the after-effects as much as possible.

Assistance from TRINS can be requested only through fire department operation centres (integrated rescue system centres). Assistance is provided on the basis of contractual relations between the CR Association of Chemical Industry and the CR Ministry of Interior – the CR General Management of the fire department. In this way, competencies and responsibilities are maintained in full extent in the process of resolving crisis situations.

The above indicated assistance shall be provided in stages as described hereunder, by companies-participants of TRINS program depending on the urgency, nature of the incident, and imminent danger localised at the position of the accident:

1st stage – telephone assistance/advice

Information, consultation or advice provided by a professional – specialist via telephone.

This includes transfer of specific information per request by TRINS (especially in a situation when the manufacturer, purchaser or consignee of a dangerous substance is not accessible) by the company which disposes of the necessary information about the dangerous substance (presented in the list of selected substances). This information shall be presented to the manager responsible for the teams summoned to the requested intervention (accident) site according to the described situation and to the best knowledge acquired. Advice and recommendations are provided until the time the respective manufacturer, purchaser or consignee is contacted and the consultancy can be delegated to his competence.

2nd stage – assistance at the place of intervention (accident)

Legation of a professional – specialist to the intervention (accident) location in the shortest time as possible from the moment of calling in the request; the mode of transportation to the site shall be always negotiated and resolved depending on the specific situation and with respect to the possible danger in delay, either by means of the fire department team (integrated rescue team) or by a company as requested by TRINS.

In the case of a further distance from the accident position or inaccessibility of the manufacturer, purchaser or consignee of the dangerous substance in question, the nearest located TRINS centre shall provide – according to its available resources – advice through its own specialists and its own experience and best knowledge (see Lists of dangerous substances).

3rd stage – practical assistance at the place of intervention (accident)

Sending out forces and resources to the crisis location in the shortest time possible from the moment of receiving the request call for practical help in handling an incident.

Practical aid in the form of forces and means provided by companies – TRINS members – is effectuated on the basis of a request placed with the fire department (integrated rescue system) operation centres. Assistance is provided by specific TRINS centres for a limited number of dangerous substances (presented in the List).

TRINS centres have the right to decline a request for practical assistance in the case when an exceptional event is already being handled at the premises of an own company, or in the case of a running engagement of forces and resources out of the company premises, or if the supply of forces and resources at the given moment might seriously threaten the safety of its own operations.

In respecting these conditions the leader of the summoned TRINS forces provides information to the chief of intervention teams at the place of the accident and supports him with currently available resources and devices provided by TRINS.

Prevention measures

The functional range of the TRINS system is not limited only to resolving crisis situations that might arise during the transport or storage of dangerous substances; in addition, within the framework of past negotiations held among member companies, new proposals are created for important preventive measures that are intended to prevent the development of crisis situations and eliminate possible impacts of actual incidents as much as possible.

In 2001, TRINS system reported 17 situations where assistance was provided (including topical field trainings and information flow audits within scope of international training programs). The most significant 3rd stage of practical assistance was provided in two situations.

In 2002, TRINS system reported 48 situations of which 14 were provided with assistance at stage 3 (technical assistance).

All information about the association, contacts to regional centres for reporting exceptional events are presented, for example, at www.schp.cz/schp/zpravy/zpr15.html, www.chemopetrol.cz/bp_trins.asp .

7.2.3 The transport information and emergency response system for chemical industry in the Slovak Republic

The DINS system was developed in the Slovak Republic as a parallel version to TRINS in the Czech Republic.

The DINS abbreviation denominates the traffic, information and accident control system (Dopravný, informačný a nehodový systém). The project dealing with transport of dangerous substances was prepared by the Association of Chemical and Pharmaceutical Industries of the Slovak Republic (http://www.zchfp.sk/charakteristika.html).

DINS started its function as of August 21, 2001, by entering into an agreement of cooperation between the Ministry of Interior of the SR – the fire prevention authority, and the Association of Chemical and Pharmaceutical Industries of the SR (hereinafter Association). The Association is a voluntary system the goal of which is to provide accurate information, advice and technical assistance to the fire-fighting department and thus to minimise the impacts of accidents involving vehicle transport of dangerous substances.

Altogether 10 companies of the Association are engaged in DINS, and the central coordination desk is seated in DUSLO, a. s. Šaľa, Slovakia.

A „Manual“ was worked out to make the best use of DINS system; it contains standard procedures for providing help, a list of DINS centres, contact information for specialists, and a list of chemicals included in the assistance scheme for requesting help or advice.

7.2.4 Examples of risk prevention and accident control in selected companies in the Czech Republic

Operational safety and risk prevention schemes have been introduced in many chemical processing plants where the possibility of an emergency situation has to be taken into account and where any kind of incident might impact employee health, the surrounding area and the environment.

Details about used technologies for monitoring of production processes can not be presented here, as for security reasons none of the addressed entities were willing to disclose any information about the extent of installed fire safety equipment. Also, these bodies do not share any information about the types or manufacturers of used technologies, operational details regarding reliability, fault rate, false alerts, etc., for the purpose of a general analysis.

As an example, some information about solutions for handling emergency situations in selected companies in the CR, acquired through public sources, is presented in the following text.

7.2.5 Applications

Spolana a.s.

SPOLANA a. s. has worked out an emergency plan for the escape of dangerous substances into the environment based on mathematical modelling of emergency situations. Also prepared are flood protection plans and plans for dealing with leakage of dangerous substances into surface layers, underground waters and the soil.

The company confirms observance of the Responsible Care program.

The accident control system for gas escape detection includes 246 sensors located within the premises. The outlets are connected with the fire department operational desk and the technologies control centres. Worksites with increased fire risk are equipped with EFS linked with the fire-fighting operation centre.

Pursuant to Act. No. 353/1999 Coll. the required „Safety report“ was worked out in 2002. The company has implemented an environmental management system in compliance with ČSN EN ISO 14001 national standard.

In 2002, four accidents were reported, of which three represented leakages of dangerous substances into the environment during August floods. In consequence of attendance failure an explosion was reported in June 2002 at VCM operation during manipulation with the cracking furnace. The incident did not cause any escape of chemicals into the environment.

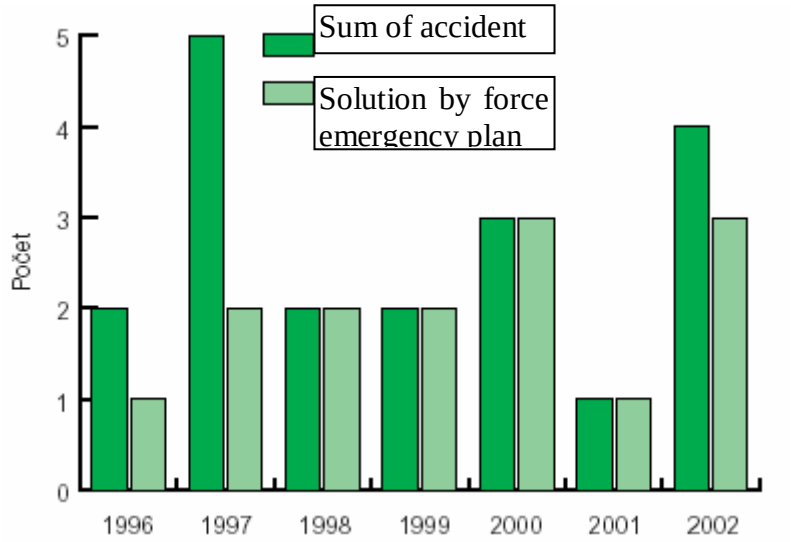


Figure 11: Report of operational accidents (emergency states) in SPOLANA, a.s.

The August flooding affected the liquid chlorine storage and in consequence of this incident the substance leaked out into the air and water. Chlorine escape occurred again during reclamation works on the damaged equipment. Mazut (black oil) escape was also reported by Energetika operation in consequence of the flood. The final statement of escaped chemicals was published by the company on August 29, 2002.

The development of the accidents in Spolana in the period 1996 - 2002 is presented in figure 11.

An important task for the risk prevention section of the company's production division was to ensure observance of Act No. 353/99 Coll. in real conditions. This included a large-scale assessment of all possible risks, and the completion of the organisation's safety report till the end of the calendar year. In cooperation with TLP Company, the report was worked out in compliance with the law and filed with the regional office for discussion at the beginning of 2002.

Chemopetrol

In 2002, Chemopetrol was granted the European-wide recognised „Safe Company" title. The Czech Safety Authority honoured the systematical approach of Chemopetrol to the problem of operational safety and risk prevention which complies with European standard.

The company confirms its observance of the Responsible Care program.

In between 2001 and 2002, the main task of the company in terms of safe operation of technologies was to meet the requirements stipulated by Act No. 353/1999 regulating the prevention of major accidents.

Following the notice of inclusion of the plant to „B" class in July 2000, the company started to work out the „Safety report" (including the „Prevention of major accidents program"). The results of analyses that had been systematically performed since 1992 were used in this Report.

A special program was used to create forecast models of impacts caused by possible accidents. The prevention scheme for major accidents was included as part of the system into the „Safety Policy.“ Another document required by Act No. 353/1999 Coll. pertaining to companies ranked in „B“ class was the „Organisation’s internal emergency plan.“ This document was worked out on the basis of the completely re-worked „Organisation’s emergency plan“ from 1997.

Both documents have continuously incorporated the changes connected with the organisation’s extensive investment activities – development of a high-density polyethylene unit and substantial reconstruction of the first production phase of polypropylene processing.

In 2002, emergency plans for different production units were completed as the second layer of the organisation’s internal emergency plans. The following document worked out in compliance with Act No. 353/1999 Coll., was the „Material for determining the emergency planning zone and for working out an external emergency plan for the region.“ At the end of 2002, work started on applying the CPR 18E method according to the Purple Book; this effort included selection of new risk sources for determining a major accident with the purpose to use the findings for updating the existing „Safety Report.“

The organisation’s internal committee investigated 28 undesired extraordinary events within the organisation in 2001, and 26 in 2002. None of those incidents had the nature of a serious industrial accident, and the findings were used further in the prevention measures against the possible recurrence. The long-term development of emergency situations in the organisation is presented in figure 12, and the number of fires in figure 13.

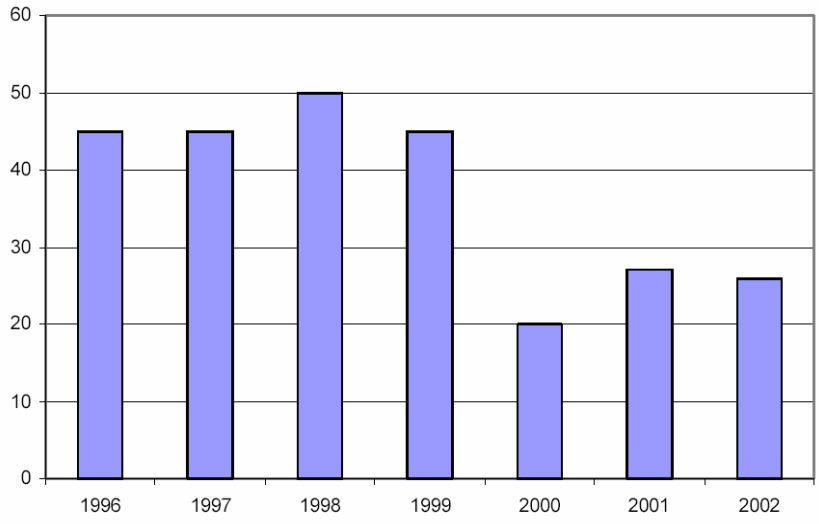


Figure 12: Development rate of the number of undesired extraordinary events in Chemopetrol inspected by committees in 1996 – 2002

Chemopetrol pays attention to safe manipulation and transportation of dangerous substances; for this purpose two employees were educated and granted certificates of competency for safety consultancy during transport of dangerous materials in the road infrastructure.

Chemopetrol has introduced a preventive operational mode for „close-to accident states“ and „risk situations“ which applies experience gathered in the field of „risk situations and close-to accident states.“ This preventive mode extends on the „organisation’s incentive system“ which is intended to support personal involvement of employees to improve operational

safety and health protection. To increase the efficiency of this system and to promote the desired purpose, the company uses its internal broadcast and press service to organise campaigns for its employees.

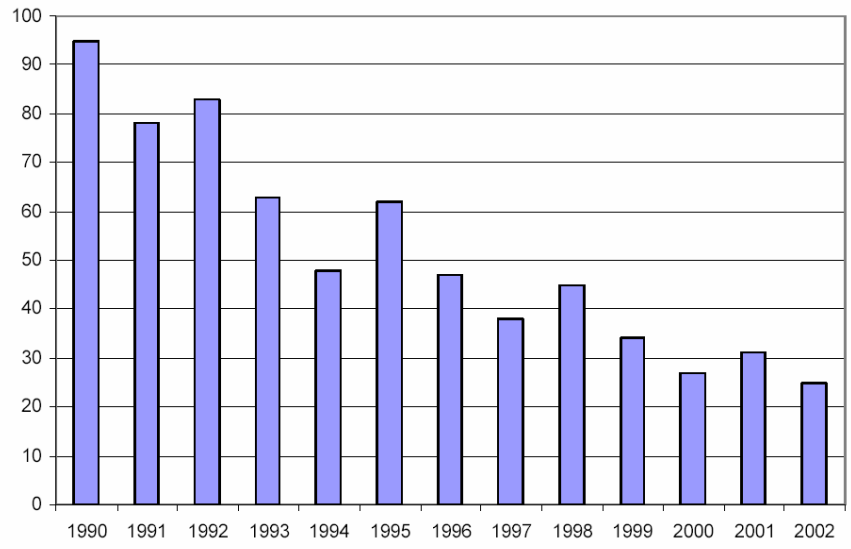


Figure 13: Fire incidence and fire development rate in Chemopetrol in 1990 – 2002

In terms of emergency documentation administration, in the period 2001 – 2002, emergency plans were completed or updated for all operational units; to date the total number is 23.

In 2001, in different production units 183 emergency action training courses were organised. Of those, 132 courses were in the form of theoretical training or oral tests, while 51 consisted in simulations of actions taken in attending the production technology. Two emergency trainings were in coordination with the fire department section. During the indicated period, 17 random audits took place to verify the emergency training courses conducted by authorised divisions (SRM, SBP, SPD – internal labelling at Chemopetrol).

In 2002, the number of emergency training courses increased. The company organised altogether 202 sectional training courses, of which 113 were theoretical training sessions and oral tests, and 89 emergency field trainings focused on simulation of actions in attending production technology, and 3 trainings were in coordination with the fire department section. The number of audits performed by authorised sections has increased.

In the above indicated period 28 spot checks of emergency training were made with special attention to the observance of Guideline 437, and to verify the functionality, connectivity and efficiency of emergency plans and the quality of field training. In Q3, 2002, an emergency training was performed to verify the functionality of the internal „organisation's emergency plan"

Koramo

In compliance with industry-specialised requirements KORAMO has introduced an industrial accident prevention control system which is being continuously improved. A binding procedure has been worked out for emergency planning, documentation, employee training and assurance of internal and external flow of information (increased emergency awareness).

Relevant emergency plans have been worked out for areas most likely exposed to emergency situations.

KORAMO is a member of TRINS system. Pursuant to Act No. 353/1999 Coll., the company completed the „Safety report“ in 2002. The company implemented an environmental safety management system in compliance with ČSN EN ISO 14001 national standard.

In 2001, KORAMO was granted the Responsible Care title.

A fire team operates within the company; its activities are focused on fire prevention and repression on the premises and within scope of the regional integrated rescue system and TRINS system, the team intervenes even at regional level as needed.

In compliance with adopted risk prevention measures and in coordination with the integrated rescue system in Kolín region, topical trainings are regularly organised with special attention to the application of proper procedures during the liquidation of industrial accidents.

Fire prevention in KORAMO is ensured at several levels. Workers of the inspection division and internal services perform regular audits on the company premises. Spaces with increased risk of fire are secured by an electro-fire signalling system and fire extinguishers (partly stationary).

In 2002, the HZS fire team participated in the rescue operations connected with the liquidation of damages caused by the August flooding in chemical processing plants KAUČUK Kralupy nad Vltavou and SPOLANA Neratovice. 15 fire-fighters were on duty for 14 days.

Table 3: Number of interventions handled by HZS in KORAMO

Intervention	1998	1999	2000	2001	2002
fire	13	15	3	-	3
traffic accident	4	-	-	-	-
works on water	-	-	-	-	20
water pumping	-	1	-	1	15
oil accident	1	4	10	4	14
technology assistance	2	5	3	3	6
technical aid	-	2	2	6	5
other technic.intervention	2	2	11	6	3
escape of substances	1	1	-	1	1
training for coordination	1	1	-	4	1
false alert	8	5	4	2	7

Risk prevention and industrial safety in areas that are most likely exposed to emergency situations is ensured by emergency and safety plans. An internal company guide has been

introduced to improve the readiness for emergency situations and the adequate response actions.

Lučební závody

The company has implemented an environmental management system in compliance with ČSN EN ISO 14001 national standard. Pursuant to the provisions of Act 353/1999 Coll. the company's „Safety report" was worked out in 2002.

Furthermore in 2002, within intentions of the outlined environmental policy relevant attention was given to the areas of emergency readiness, prevention and settlement of extraordinary events. The acquired certificate of approval of the environmental management system also verifies the appropriate management method applied in this field of environmental safety management.

In 2002, one extraordinary event was reported on the company premises; an overflow of a raw materials container occurred due to the inattentiveness of the operating staff, and only the rapid intervention by responsible teams diverted an environmental hazard. In reaction to this situation technical measures were taken immediately to avoid another similar risk incidence. Vibration sensors were installed to measure and control the maximum level of the container content.

Within the framework of the environmental management system training was performed at selected worksites to practise the response to a situation when an accident is reported. The training verified the preparedness of company employees, efficiency of the existing emergency plan and the sufficiency of rescue & sanitary equipment and technology.

Kaučuk

KAUČUK Joint Stock Company dedicates great attention to operational safety and risk prevention. As early as in 1998, the company determined safety zones for different operational technologies and consequently implemented safety measures to prevent any hazard in the surrounding area on part of KAUČUK, a.s. At the same time the „Emergency plan" was worked out to ensure the readiness of employees and technology to resolve emergency situations and minimise the damages caused by the development, duration and liquidation of an incident.

The company has implemented an environmental management system in compliance with ČSN EN ISO 14001 national standard. Since 1995, the company has carried the Responsible Care title and has been a TRINS member.

Act No. 353/1999 Coll., to regulate the prevention of major accidents, came into force December 9, 1999. As of that date, KAUČUK, a.s. was ranked in the „B" class in accordance with the mentioned Act. With respect to the operated volume of dangerous chemicals, and pursuant to the requirement for inclusion in the „B" class, the company worked out a „Safety report" based on the previously determined safety zones and the internal emergency plan.

KAUČUK, a.s. is continuously working on the „Safety report" document in order to decrease the rate of possible risks. The report is available at www.kaucuk.cz/cz/katsd.asp?id_kat=13&id_doc=45 .

7.3 Central security desk

Safety-specialised companies in Prague and in the Czech Republic develop safety systems based on „Central security desks“ intended for integration with EFS and EZS in households, offices and technological facilities.

Among companies who supply their proprietary control panels and provide CSD service with guaranteed transmission is M connection, s.r.o., Pomezní 10/1369, 182 00 Praha 8 (www.mconn.cz). The control panel is supplied under the produce name Telenot ÜZ 7500. Through the operator, the system works in coordination with Prague HZS (fire department) control centre (OPIS of the Capital City Prague) thus helping to decrease the time interval that elapses from a „fire“ incident alert reported in the property guarded by the EFS system, till the response of the HZS team.

The CSD provided by the mentioned company enables property surveillance with the possibility of bi-directional communication via commercially accessible ISDN and GSM networks. Communication routes are reciprocally backed up. The main benefit of the bi-directional CSD system consists in the verification and security features ensured by the transfer protocol. As another advantage, the CSD operator is able to control the technologies in the surveilled property prior to the arrival of the HZS team.

On January 10, 2003, the General Management of the HZS Fire Department of the Czech Republic under the authority of the Ministry of Interior granted a „Certificate of assessment and model approval of data communication system (CSD) developed by M connections s.r.o., Praha“ to the mentioned supplier, permitting the use of the system in fire department stations across the Czech Republic, thus moving the system to the implementation phase of using the CSD system for intended operational use.

The architecture of the Telenot ÜZ 7500 receiving control panel is modular, affording the use of 4 access panels. A full-fledged installation with ISDN panels can include up to 8 extensions, while in the case of virtual fixed lines each panel can offer a capacity of 10 logical channels. In total, one installation can contain 40 lines created in this manner. The central control panel consists of an autonomous unit with a built-in printer, a four-rowed alphanumeric display and a control keyboard. The control panel memory is able to capture up to 1 000 events (messages); two serial outputs with V.24 protocol allow for PC connection.

The whole group of euroISDN2 connections can be configured within the Czech Telecom a.s. network as one closed user group (CUG). This configuration enables to create closed logical groups in the data network. Without a valid membership of this group it is not possible to call CUG members. This arrangement minimises the risk of a system attack from outside.

The system provides for automatic notification through the following services:

- Fax
- E-mail
- SMS.

In order to assure improved information flow to the HZS about the incidence of extraordinary events the application of CSD in automobile tunnels in Prague is under consideration.

As an example, the following overview presents a list of selected operators (or manufacturers) of CSD linked to EZS and EFS (website links only):

http://www.volny.cz/schwarzpb/
http://www.wackenhut.cz
http://www.fides.cz
http://www.echoalarm.cz
http://www.elzy.cz
http://www.marcontrols.cz
http://www.nam.cz

7.4 Emergency information systems – programs

7.4.1 General information

Emergency information systems represent an essential tool for resolving crisis situations in organisations. These programs create emergency plans and scenarios and handle administration in the process of resolving crisis situations.

For information purposes presented hereby is a list of emergency management systems used for risk prevention and industrial safety in organisations in the CR. Information about programs have been compiled from publicly accessible supplier information.

7.4.2 TLP - ROZEX, TNO Effects

TLP, S.r.o. Company is a Czech engineering and Consultancy Company specialised in the creation of emergency plans and risk assessment models for possible impacts of industrial accidents (www.tlp-emergency.com).

Currently, the company includes the following active sections:

- Industrial safety
- Crisis management,
- Emergency management
- Environmental management and quality control (in preparation)

The mentioned company has developed its proprietary software named ROZEX. The software supports modelling of impacts of industrial accidents accompanied by escape of dangerous substances, and modelling of the final effects of industrial accidents in the affected areas.

ROZEX 2001 extends on the preceding program versions of ROZEXs, ROZEX Bas, ROZEX Pro and ROZEX Has. ROZEX 2001 was developed with maximum emphasis on user comfort and credibility of interpreted results.

In connection geographic information systems (i.eArc-View, Map-Info, etc.) this product represents a powerful and efficient tool for modelling the possible impacts of industrial accidents.

ROZEX 2001 is intended for fast and accurate risk assessments and forecasts of the after-effects of accidents. In emergency situations the system analyses the impacts of:

- Toxic matters
- Flammables that convert from burning to detonation when mixed with air
- Heat radiation caused by fire

ROZEX 2001 is primarily intended for creating forecasts of the symptoms of certain types of accidents where only little information is available or attested about their development. The concept of the program is built on the philosophy of obtaining a conservative result which assures a sufficiently precise forecast even without the knowledge of the exact development of an accident. Entry parameters used for the forecast calculation are limited in number to the necessary minimum.

Per the client's needs ROZEX system architecture can consist of specialised modules that resolve:

- Nonrecurring toxic leakage – TOXI PUFF DEFINED
- Continuous toxic leakage – TOXI PLUME DEFINED
- Continuous toxic leakage through an identified leak – TOXI PLUME LEAK
- Surface evaporation of toxic liquids – TOXI PLUME SURFACE EVAPORATION
- Turbulent toxic leakage through a defined leak – TURBULENT TOXI JET LEAK
- Incidental leakage of flammable matter with consequent explosion – UVCE PUFF DEFINED
- Continuous leakage of a flammable with consequent explosion UVCE – UVCE PLUME DEFINED
- Continuous leakage of a flammable through an identified leak with consequent explosion – UVCE PLUME LEAK
- Surface evaporation of flammable spill with consequent explosion – UVCE PLUME SURFACE EVAPORATION
- Turbulent leakage of a flammable through an identified leak with consequent explosion – TURBULENT UVCE JET LEAK
- Overflow of a container with condensed inflammable gas and consequent flare-up – EFEKT BLEVE
- Pool fire of an inflammable liquid – POOL FIRE
- Fire of an inflammable gas escape through a jet – JET FIRE

To apply the product in real conditions a database of dangerous substances was created including all physical and chemical characteristics that are necessary for impacts modelling.

In the field of developing solutions for industrial safety problems TLP company cooperates with the Netherlands TNO Institute of Industrial Safety (www.mep.tno.nl).

The computing system TNO Effects, version 4.0 is used in creating models and analyses of dangerous substance escapes.

More information is available at www.tlp-emergency.com .

7.4.3 T-soft - EIS/InfoBook, TerEx, EMOFF

T-soft is a company specialising in the development of information systems, creation of distributed systems, system inter-operability and information security at all levels of data storage and use. The portfolio includes fully scaled systems for crisis management and decision support in emergency situations:

- Crisis management
- Inter-operability of systems
- Data and IT security

The crisis management solution developed by T-soft (www.tsoft.cz/cz/00.asp) consists of a group of programs, of those presented further in this paper are EIS/InfoBook, TerEx, and EMOFF.

EIS/InfoBook

EIS/InfoBook is a system intended for all control levels in crisis management; it offers a user-friendly environment and format. The regular management block (Fig. 4) is easily understandable and it ensures smooth transformation of all necessary data pertaining to crisis management into computerised form.

Thanks to its modular architecture EIS/InfoBook offers immediate synoptically data about a situation and its progress, about sources of the risk on the given premises, task forces and devices, their functions, assignments and application, description of a specific territory; areas, properties and facilities from different aspects – possible risks, resistance, occupancy, equipment and other. The system affords the possibility to create accurate plans for specific actions, shelter and evacuation.

The system offers a wide range of options for working out procedures and guidelines for managers, emergency and rescue teams, organisational units and the entire organisation. The database of risk entities, hazardous materials, and engagement of computing and modelling programs for assessing escapes of dangerous and toxic substances provides for the easy completion of risk assessments and fast orientation if an emergency situation occurs. In terms of human resources, it is possible to monitor a series of parameters defined for qualification, availability, training, and health condition required for an emergency call, required protective means and accessories. The product supports the use of graphical tools and a map interface through GIS interconnection.

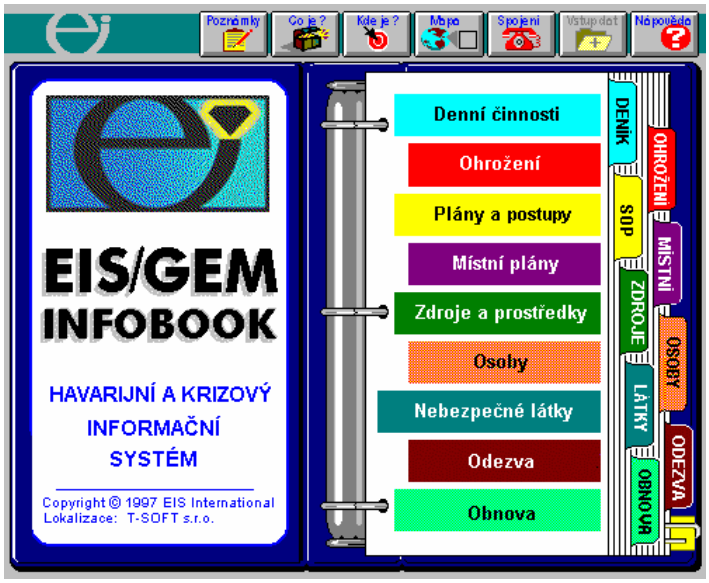


Figure 14: EIS/InfoBook layout

Overview of modules:

- **Daily functions** (Denní činnost) – the module helps to accumulate, manage and process records about a situation and the applied response action (solution); it supports generation of summary data and summary reports, it ensures monitoring of tasks that have to be performed within defined time sections, and the updated status of information.
- **Resources and accessories** (Zdroje a prostředky) – this module is intended for acquisition and administration of data pertaining to resources, available forces and accessories for their application. It is possible to work with real-time
- **Plans and functions** (Plány a činnosti) – this modules helps to work out standard procedures for functional areas, bodies and organisations, operational control centres and individuals.
- **Tactical procedures for intervention teams** (Taktické postupy zásahových sil) in challenging emergency situations – this module affords the possibility to create a complete emergency plan for a whole territory or an object at any level.
- **Dangerous substances** (Nebezpečné látky) – the module enables monitoring of risk properties or facilities with respect to the existing legislation in force or expected regulations, and in dependence on specific dangerous materials stored in the monitored areas of interest.

1.22. Parts of the module are two independently supplied optional databases of materials that serve to acquire safety data and accident data. Based on this information it is possible to create selections of materials according to appearance, scent, storage conditions, used containers and effects, as these data are very helpful in the process of identifying an unknown substance.

1.23. Options are provided for connecting computing and modelling programs, for example ALOHA – the program for modelling accidental leakage of chemicals.

- **Recovery** (Obnova) – this module helps to create an overview of losses and other impacts caused by a crisis situation, subsequent forms of aid provided to families and individuals, renovation of transport, infrastructure and supplies. Information is maintained about volunteers and humanitarian aid.
- **Exposure to risk** (Ohrožení) – the module is intended for processing risk analyses for sites, localities or areas; the program offers wizard guidance for analytical processes.
- **Local planning** (Místní plánování) – this module handles the creation and maintenance of technical descriptions of sites and areas for crisis and emergency management purposes, charts of fire-extinguishing and fire safety equipment installed within premises, buildings and rooms, and overviews of implemented protective measures.
- **Human resources** (Osoby) – this module is used to administer the database of professional resources at crisis control centres, intervention groups and other professional teams, as well as a survey of all persons who in some way participate in the scheme of resolving crisis situations. Monitored key data include contact information, qualification, availability, education and field training; this information can be used for career planning and training courses. An overview of operational engagements and experience is continuously maintained. The program also administers an information base about all bodies and organisations used by EIS/InfoBook modules.
- **Response** (Odezva) – the module manages response, entry of a reported situation in the system, processing of obtained information, completion of analyses, data transfer, storage, task assignment and inspection of released duties. The program provides a standard sequence of procedures for resolving natural disasters and accidents, escape of chemicals, traffic accidents, evacuations, public attendance and safety and shelter.

Through its open architecture EIS/InfoBook provides reliable access to information technologies and convenient ways for their coordinated and optimised application. The management information system is clearly understandable, it helps users to maintain daily functions in all types of organisations, and to acquire and work with real-time data about emergency situations.

Simulator

An additional option to EIS/InfoBook is EIS/SIM subsystem which offers simulated processes for user training, response action training and coordination between different organisations and entities, and development of operational procedures with integrity assurance testing.

TerEX

TerEX is a program for immediate risk assessment of fire, explosion and escape of chemicals.

TerEx – assessment of four general-type emergency situations:

- TOXI type models – analyse the shape and reach of the cloud; both variables depend on the concentration of the selected toxic substance, and
- UVCE type models – analyse the reach of the air shock wave caused by the detonation of substance and air mixture; the assessment runs for models dealing with different accident types:

1.24. PLUME models:

- Long-term gas escape into clouds
- Long-term leakage of an ebullient liquid with rapid evaporation into a cloud
- Slow evaporation from a liquid spill into a cloud

1.25. PUFF accident models:

- Incidental gas escape into a cloud
- Incidental leakage of an ebullient liquid with rapid evaporation into a cloud

- FLASH FIRE models are used for the assessment of spatial dimensions

1.26. humans exposed to danger of a flaming zone – Flash Fire effect:

- BLEVE – exposure of a container to flat fire
- JET FIRE – long-term massive gas escape with flaring
- POOL FIRE – combustion of a liquid spill or ebullient liquid.

- TEROR type model – analyses possible impacts of a detonation of explosive systems based on the condensed phase and used intentionally to endanger the surroundings of the detonation site.

EMOFF

EMOFF is a set of programs to support analyses, planning and resolution of crisis states and extraordinary events. The properties of the system are based on analyses of crisis management processes and analyses of assumed requirements for the system information safety and operational continuity. The system supports coordination of individuals, organisations and bodies on different hierarchic levels and of different specialisations.

The system supports three primary phases of crisis management:

- **Risk analysis** – identifies the endangering and endangered entities, determines the types of risks and possible impacts on the population and service networks,
- **Planning** – supports the creation of model plans which are used by central administrative bodies to determine the rules, principles and measures for dealing with crisis situations, and to recommend standard operational procedures to implement these measures. Model plans represent a general framework for working out different types and sections of specific crisis plans,

- **Resolving an incident** – automatic notification of defined persons, monitoring of resources and technology applied to resolve the crisis situation, monitoring the implementation of defined procedures and measures in real conditions, task assignment and performance monitoring, creation of status reports and progress reports on the developing situation, and compilation of background materials for renovation works.

EMOFF key modules:

- Organisation (Organizace) – record management
- Human resources (Osoby) – personal records, competencies, performance monitoring during crisis situations, and other
- Sources (Zdroje)
  - **1.27.** Forces (Síly, i.e. human resources, intervention teams, other teams)
  - **1.28.** Hardware (Prostředky, i.e. material and technical sources)
  - **1.29.** Facilities (Zařízení, i.e. buildings, shelters, different facilities, etc.)
- **Exposure (Ohrožení)** – a module for determining crisis states, incidents, place of origin, health and environmental impacts)
- **Model plans (Typové plány)** – used by authorised bodies to determine procedures for settling incidents
- **Crisis plans (Krizové plány)** – used to create crisis plans to avoid negative effects of an incident; it supports efficient resource planning for the settlement of a crisis situation, etc.
- **Measures (Opatření)** – used for implementation of measures to eliminate or mitigate the impacts of a crisis situation
- **Standard operational procedures (Standardní operační postupy)** – who and what, control levels, etc.
- **Notification (Vyrozumění)** – ensures due notification of respective organisations, intervention & rescue parties, experts, etc., and creates necessary protocols about transferred message, etc.
- **Exceptional events (Mimořádné události)** – this module handles processing of adequate EVOFF responses/reactions to a reported incident; it also supports the creation of an in-house solution for a specific situation
- **Map module (Mapový modul)** – supports risk assessments and other analyses in the process of resolving a crisis situation; it provides different functions

7.4.4 Mediasoft – Emergency and crisis planning information system

The emergency and crisis planning information system (HKP) is provided by Mediasoft a.s. (www.mediumsoft.cz).

HKP system is built as a web-based application with optional use in local intranets or in a protected internet version. Users only need a web browser to operate the system. Controllers are based on customary web practice. The system works under ARCIMS map server to enable work with map materials. Data storage is handled by reliable database engines. Processing in one site facilitates data security and archiving; users can enjoy fast and reliable data access with help of the employed technologies.

HKP system can handle data administration for several sections and organisations; at the same time it controls authorised user access to a specific plan or data record. Per requirement it is possible to share data and take part in their preparation and processing, while some other data can be stored separately.

The system is structured according to the public administration hierarchy and it is therefore suitable for devising emergency and crisis plans from community to regional levels, including automatic access to plans of subordinate levels (units). Cooperation based on one shared system is a great support for all involved user parties.

The HKP menu structure is divided into two parts. The administration part supports processing of different data types; these include geographical references, information about endangered or dangerous objects, personal data, information about organisations, contacts, possible extraordinary events, available resources, all this represented by an efficient database. The user can create its own views according to selected criteria, and define the desired outputs. Working with maps is an essential part of using the system – the interconnection of data and map components and accessibility of results for different units.

HKP modules:

- Administration
- Planning
- Model plans
- Crisis plans

8 Recommendations

A wide range of detection and monitoring devices are currently installed in tunnels all over Europe. However, data on reliability of existing detection and monitoring systems in tunnel application is scarce. This report tried to list the currently installed detection and monitoring equipment and make a reliability assessment.

As an aftermath of September 11th 2001 events, acquiring information about technology installed in tunnels and much more about technology installed outside tunnel has become a rather problematic issue as operators of large-scale structures are highly cautious in giving details about any respective structure and the installed technology. Related to already installed equipment this was especially to reliability data.

Therefore, the overall aim of this task to provide recommendations on reliable and cost-effective technology could not be reached. It was not possible to collect enough data in order to make any recommendation whatsoever.

For the purposes defined in this task, information about monitoring and detection systems could only be retrieved from Czech Republic, Germany, Greece, Slovakia, Spain and the United Kingdom.

What we can see from the investigation is that most of the installed equipment, where we were able to retrieve information, was quite reliable. The failure rates were acceptable. The only recommendation possible concerning equipment currently installed in tunnels is to carefully assess the situation within the tunnel and then choose the type of equipment that suits best to the requirements.

Some of the technologies used for monitoring of industrial facilities outside tunnelling are suitable to be used in tunnels. In view of the aforementioned inaccessibility of information about the actual monitoring technologies used in organisations it is not possible to draw a precise recommendation for specific equipment to be used as part of the tunnel technology.

The programs to be developed for safety & monitoring purposes in tunnels shall be similar to emergency information systems described in chapter 7.4 (example Czech Republic). The use of such programs during the action preparation phase, the actual intervention and the follow-up evaluation shall significantly increase tunnel safety and improve the intervention efficiency of rescue teams during extraordinary events.

Recommended target areas in developing SW for tunnels:

- Tunnel safety assessment
- Modelling of interventions for rescue teams and for the coordination of all parties involved in resolving extraordinary events
- Crisis management during extraordinary events
- Creation of intervention scenarios for rescue teams
- Resources management (persons, means, equipment)
- Simulations (for training and education purposes, coordination, testing, etc.)

9 Conclusions

The investigation on currently installed detection and monitoring equipment in tunnels was not as successful as expected. This was due to several reasons.

The composition of the consortium of partners allocated to the task and especially the allocated resources were not sufficient. Therefore, it was not possible to cover the field geographically from the start. Further the limited financial resources prevented from going too deep into detail.

However, the main reason for not being that successful was that the contacts refused from providing the desired amount of information necessary to successfully complete this exercise.

As an aftermath of September 11th 2001 events, acquiring information about technology installed in tunnels and much more about technology installed outside tunnel has become a rather problematic issue as operators of large-scale structures are highly cautious in giving details about any respective structure and the installed technology. Related to already installed equipment this was especially to reliability data.

For the further course of the UpTun project the failure in providing reliable recommendations on already existing reliable and cost-effective detection and monitoring equipment to be used in tunnels will nt cause serious damage. The main emphasis of the project is on new and innovative equipment which will mainly determine the success of the work package and contribute to the success of the entire project.

10 Annex

The annex gives an overview of the results of the investigations on detection and monitoring equipment installed in tunnels in Czech Republic, Slovakia, UK, Greece, Germany and Spain. These results cannot be understood as complete list of all different equipment installed. It only gives a limited view of what is installed in the mentioned countries.

10.1 Equipment installed in Czech Republic and Slovakia

Manufac-turer	Device	Description	Approx. cost	Service interval	Reliability	Manufacturer contact info	Notes
SICK, s. r.o.	3 pcs. – evaluation unit VICOTEC VCA 400,	evaluation unit	4 mil. Kč	yearly		SICK CZ, Nám. Osvoboditelů 1368, 153 00 Praha 5 - Radotín	www.sick.cz
	2 pairs of sensors – VCM 402, VCR 402 (CO),	CO measurement		bi-quarterly, cleaning as necessary			
	4 sensor pairs - VCM 404, VCR 404 (CO and opacity),	CO and opacity measurement		bi-quarterly, cleaning as necessary			
SICK, s. r.o.	3 pcs. - evaluation unit AWE 410,	evaluation unit	2,7 mil. Kč	yearly		SICK CZ, Nám. Osvoboditelů 1368, 153 00 Praha 5 - Radotín	www.sick.cz
	1 sensor pair – VCM 412, VCR 412	CO measurement		bi-quarterly, cleaning as necessary			
	2 sensor pairs - VCM 414, VCR 414	CO and opacity measurement		bi-quarterly, cleaning as necessary			
SICK, s. r.o.	2 pcs. - FLOWSIC 200 device	wind velocity measurement	1 mil. Kč	cleaning per request		SICK CZ, Nám. Osvoboditelů 1368, 153 00 Praha 5 - Radotín	www.sick.cz
	device for NOx concentration measurements (type not identified)	NOx measurement					
EUROLAB	EUROLAB device incl. scanners	stream measurement	136 t. Kč			-	
EUROLAB	2 pcs. - 2TD74 (EUROLAB device incl. scanners)	stream measurement	500 t. Kč	cleaning is part of the tunnel general cleaning		EUROLAB, laboratorní a měřicí technika, Praha 9, Chmelická 578, 190 16 Praha 9	firm isn't existed

Jes	400 JES EC 400 electro-chemical gas analyzer, VisGuard incl. an evaluation unit (2 measurement points, device types not described in more detail)	CO and opacity measurement		probably bi-quarterly, cleaning as necessary		JES Elektrotechnik GmbH, Davisstraße 7, 5400 Hallein, Austria, provider Siemens Gratz	www.jes-et.at
Siemens	device for stream velocity measurement (not defined in more detail)	stream measurement				Siemens AG Österreich, Siemensstraße 92, 1210 WIEN	www.siemens.at
NOVI-ANEMO	anemometer + evaluation unit	stream measurement	50 t. Kč	probably bi-quarterly, cleaning as necessary		Anemo s. r. o. Jana Masaryka 26 120 00 PRAHA 2	http://www.anemo.cz
VIDIS	Autoscan	detection of congestions	780 t. Kč	yearly		VIDIS s.r.o., Hvožďanská 3, 148 01 Praha 4	www.vidis.cz/videos.html
Traficon	2 pcs. - video detection case with power source 2 pcs. - configuration unit for video detection 9 pcs. - evaluation card for video detection	evaluation of a stationary vehicle				Traficon NV, Meensesteenweg 449/2, B-8501 Bissegem, Belgium. Tel: +32 (0)56 37 22 00. Fax: +32 (0)56 37 21 96	www.traficon.com
Image Sensing Systems, Inc.	AUTOSCOPE 2004	stationary vehicle and congestion detection	670 t. Kč	yearly		Image Sensing Systems, Inc. - Corporate/Global Headquarters E-Mail ISS Headquarters 500 Spruce Tree Centre, 1600 University Avenue West St. Paul, Minnesota, 55104-3825 USA	www.imagesensing.com
	Autoscope Solo® with 58 cameras.	stationary vehicle and congestion detection		yearly			http://www.bredar.ch/

Pepperl+Fuchs	23 pcs. – microwave sensors MW-VC-RS-RE1/EO, 23 pcs. – converters, 10 pcs. – APO 31 converter auxiliary boxes, 1 pc. - APO 41 converter auxiliary box	vehicle detection, speed measurement	2,5 mil. Kč	quarterly		Pepperl + Fuchs GmbH Königsberger Allee 87 68307 Mannheim Germany provider FFC Praha 8, U Slovanky 3 tel.: +420 266 052 098 fax: +420 286 890 252 e-m: praha@fccps.cz	http://www.pepperlfuchs.de, provider http://www.fccps.cz
Pepperl+Fuchs	3 pcs. – light barriers, production line F8, type indication OCS 5000-F8-UK, 3 pcs. – induction loop (below the light barrier)	vehicle height measurement at entry point	42 t. Kč	quarterly		Pepperl + Fuchs GmbH Königsberger Allee 87 68307 Mannheim Germany provider FFC Praha 8, U Slovanky 3 tel.: +420 266 052 098 fax: +420 286 890 252 e-m: praha@fccps.cz	http://www.pepperlfuchs.de, provider http://www.fccps.cz
DATAMER	2 pcs. MPR evaluation units, 4 pcs. DATAMER LD-1 detectors, 4 x - induction loops	traffic measurement	65 t. Kč	bi-quarterly		DATAMER, Bendlova 146/18 CZ - 613 00 Brno	
DATAMER	8 x - induction loops,	actual traffic state	112 t. Kč			DATAMER,	

	8 pcs. DATAMER LD-1 detectors	diagnostics				Bendlova 146/18 CZ - 613 00 Brno	
FCC	10 pcs. - microwave radar for vehicle speed and length measurement, homologated	vehicle travel speed measurement for the police		yearly		provider FFC Praha 8, U Slovanky 3 tel.: +420 266 052 098 fax: +420 286 890 252 e-m: praha@fccps.cz, RAMET C.H.M., a.s, Letecká 1110, 686 04 Kunovice	provider http://www.fccps.cz, http://www.rametchm.cz/
	SW for evaluation						
	1 pc. - server for homologated radars						
	4 pcs. - microwave radar for vehicle speed and length measurement	vehicle speed and length measurement					
	4 pcs. - data concentrator 3x input RS232 min. 9600Bd, 1x output						
Siemens	traffic measurement facility (evaluation device not identified in more detail) 8 x - induction loop	traffic measurement		quarterly		Siemens AG Österreich, Siemensstraße 92, 1210 WIEN	www.siemens.at
Siemens	2 pcs. - device for exceeded vehicle height diagnostics (evaluation device not described in more detail) 2 pcs. – light barrier, 4 pcs. – induction loop,	excess vehicle height diagnostics		quarterly		Siemens AG Österreich, Siemensstraße 92, 1210 WIEN	www.siemens.at
Boschung Mecatronic GmbH	GMA/SWIS device	icing detection				Boschung Mecatronic GmbH, Von Humboldt-Strasse 5, D-64646 Heppenheim	http://www.boschung.de
ELTODO POWER	SOS boxes	communication between persons in the tunnel and the control desk	240 - 300 t. Kč	yearly		ELTODO Power, Novodvorská 1010/14, 142 01, Praha 4	www.eltodo.cz

Halamek	MEANET device	icing detection		bi-quarterly		Halámek, Brno, ČR	
micKS	RWIS device	icing detection		bi-quarterly		micKS MSR GmbH, Alpgaustrasse 24, D-87561 Oberstdorf	http://www.micks.de
Boschung Mecatronic GmbH	AMS sensory station incl. a power supply unit and scanner - 2 sets TMS 2000 spraying system incl. 36 jets	detection and removal of icing	4 mil Kč	monthly -*), yearly - **), during carriage way repairs - ***)		Boschung Mecatronic GmbH, Von Humboldt-Strasse 5, D-64646 Heppenheim	http://www.boschung.de
SCHRACK SECONET GmbH	fire control panel BMZ MAXIMA (master, slave) - 2 pcs., evaluation unit ERICA - 4 pcs., press-button signalling box with parallel indicator 1702-PI - 70 pcs., optical smoke detector SLK-E - 216 pcs., ionization detector SIH-E - 214 pcs., linear detector SPA-E (8 pcs. in a set) automatic detectors rack with YBC-RL/4H3(H) addressing - 436 pcs., parallel indication PI - 10 pcs., air conditioning extension - 6 pcs.,	EFS system	7671 t. Kč	bi-quarterly		SCHRACK SECONET AG A-1122 Wien, Eibesbrunnergasse 18, stará adresa - Wienerbergstrasse 3,	http://www.schrack-seconet.com
ASTRA SECURITY	control panel EPS VEGA V 01 - 1 pc. emergency press-button EPS IP 67 4 pcs. and IP 42 - 13 pcs.	EFS system	650 t. Kč	bi-quarterly		ASTRA SECURITY, a.s. , Petrohradská 50, 101 00 Praha, Česká republika	http://www.astrasecurity.cz

	ionization smoke detector Hochiki - 21 pcs.						
Siemens Building Technologies	control panel EPS CI 1115-1 with EPROM CS 1115-CZ - 1 pc. smoke detector AnalogPlus, type DO 1131A - 14 pcs. heat detector AnalogPlus, DT 1131A type - 9 pcs. press-button signalling box DM 1132 - 4 pcs. detection cable FibroLaser II, 8 mm diameter - 780 m	EFS system		bi-quarterly		Siemens Building Technologies, s.r.o., divize Cerberus, Nuselská 116, Praha 4 - Nusle	http://www.cerberus.cz
Siemens Building Technologies	control panel EPS CI 1115-1 with EPROM CS 1115-CZ - 1 pcs. smoke detector AnalogPlus, type DO 1131A - 15 pcs. heat detector AnalogPlus, type DT 1131A - 2 pcs. press-button signalling box DM 1132 - 2 pcs. detection cable FibroLaser II, 8 mm diameter - 600 m	EFS system	2050 t. Kč	bi-quarterly		Siemens Building Technologies, s.r.o., divize Cerberus, Nuselská 116, Praha 4 - Nusle	http://www.cerberus.cz
Siemens	control panel Cerberus 1140 - 1pc. linear fire detector Mütec (not specified) emergency press-button (fire signalling box) 8 pcs. fire signalling box (not specified) 2 pcs.	EFS system		bi-quarterly		Siemens AG Österreich, Siemensstraße 92, 1210 WIEN	www.siemens.at
SCHRACK SECONET	fire detection control panel (not specified) - 1 pc.,	EFS system		bi-quarterly		SCHRACK SECONET AG	http://www.schrack-

GmbH	linear fire signalling box Mütec (not specified) emergency press-button (fire signalling box) 6 pcs. fire signalling box (not specified) 2 pcs.					A-1122 Wien, Eibesbrunnergasse 18, stará adresa - Wienerbergstrasse 3,	seconet.com
VEGACOM - Plettac	1 pc. device for video detection of queue stoppage in underpass	video detection	CCTV 4,9 mil. Kč, video detection 1,1 mil. Kč	bi-quarterly		VEGACOM - Plettac, Vegacom a.s. Šenovská 30/434 182 03 Praha 8	http://www.vegacom.cz
	1 pc. TV control panel					plettac electronic security GmbH, Würzburger Straße 150 - D-90766 Fürth - Germany	http://www.plettac-electronics.de

Kč - Czech crown

Boschung Mecatronic GmbH

icing measurement

***)** **monthly** - to verify the purity of NI sensor optical parts and absence of water in the sensor; removal of impurities and water if necessary.

****)** **yearly** - complex inspection and maintenance of the system, usually before winter season; includes complex checking and testing of the system functions, and fixing if necessary

*****) repairs of the carriage way - prior to cutting the road surface the BOSO and GT measuring probes have to be dismounted; the bases have to be carefully sliced out to make way for lifting the probes including their service cables that are integral parts of the probes.

10.2 Equipment installed the UK

Manufacturer	Part No. / Model	Description	Approx Cost	Service Intervals	Reli-ability	Manufacturer Contact Details	Notes
CODEL	TunnelMaster	CO, NO and Visibility Sensor	£9.000	Yearly		Codel International, Station Building, Station Road, Bakewell, Derbyshire, DE45 1GE, England. Tel: +44 (0)1629 814 351. Fax: +44 (0)8700 566 307	www.codel.co.uk
CODEL	TunnelMaster	CO and Visibility Sensor	£6.000	Yearly		As Above	TunnelMaster Sensors require a central control unit for power and PC interface
CODEL	TunnelMaster	Carbon Monoxide only Sensor	£4.000	Yearly		As Above	
CODEL	TunnelMaster	Visibility only Sensor	£2.600	Yearly		As Above	
CODEL	1000 Series	Visibility and Carbon Monoxide Sensor	N/A	Quarterly		As Above	Replaced by TunnelCraft Sensor
CODEL	2000 Series	Visibility and Carbon Monoxide Sensor	N/A	Quarterly		As Above	Replaced by TunnelCraft Sensor
CODEL	3000 Series	Visibility, Carbon Monoxide and Nitric Oxide	N/A	Quarterly		As Above	Replaced by TunnelMaster Sensor
CODEL	TunnelCraft	Visibility and Carbon Monoxide Sensor	£6.000	Yearly		As Above	TunnelCraft require a £350 48v / 100W PSU capable of powering two sensors
CODEL	TunnelCraft	Carbon Monoxide only Sensor	£5.800	Yearly		As Above	
CODEL	TunnelCraft	Visibility only Sensor	£2.500	Yearly		As Above	
CODEL	AFM	Bi-directional Air Flow Monitor	£2.600	Yearly		As Above	
ERWIN SICK	Flowsic 200	Air Flow and Direction Sensor		Clean As Required		Erwin Sick Ltd. Waldkirch House, 39 Hedley Rd, St. Albans, Herts. England. AL1 5BN Tel: +44 (0)1727 831121. Fax: +44 (0)1727 856767	www.sick.co.uk
ERWIN SICK	Vicotec 410	Visibility and CO Sensor				As Above	
ERWIN SICK	Visic 610	Visibility Distance measuring device				As Above	
ERWIN SICK	Hisic 450	Overheight Vehicle Detection upto 100kph		100,000 hours		As Above	
GOLDEN RIVER	Marksman 360	Eight Loop Traffic Counter	<£5000 / site	Approx. 3 Years		Golden River Traffic Ltd. Churchill Road, Bicester, Oxfordshire, England. OX26 4XT.	www.goldenriver.com

						Tel: +44 (0)1869 362800. Fax: +44 (0)1869 246858	
GOLDEN RIVER	M87X	Automatic Number Plate Reader / Traffic Management	Varies on Requirement Around £15k	Clean As Required		As Above	
GOLDEN RIVER	M803 / 812	Journey Time Monitoring System / Traffic Management	As Above	Clean As Required		As Above	
GOLDEN RIVER	Marksman 366	Eight Loop Traffic Classifier (CO & Temperature Monitor Optional)	£5000 / site	Approx. 3 Years		As Above	MicroTel Pollution Option (TPM) gives CO and Temperature Monitoring - available for Marksman 362 and 366 units
TRAFICON	VIP/I	Vehicle Flow and Incident Detection System				Traficon NV, Meensesteenweg 449/2, B-8501 Bissegem, Belgium. Tel: +32 (0)56 37 22 00. Fax: +32 (0)56 37 21 96	www.traficon.com Supplier of various indoor/outdoor vehicle detection systems
PEEK	N/A	PEEK provide intergratable systems such as; Automatic Incident Detection (AID), Variable Message & Lane Matrix Signs and Barriers	Varies on Requirement	N/A		Peek Traffic Ltd., Kings Worthy, Winchester, Hampshire, England. SO23 7QA Tel: +44 (0)1962 883200. Fax: +44 (0)1962 884026	www.peek-traffic.co.uk More of an intergrated system than a piece of equipment. Worldwide based company.
GE Sontay		Gas, Carbon Dioxide & Air Quality Sensors + Relative Humidity and Temperature Sensors				GE Sontay Ltd., Four Elms Road, Edenbridge, Kent, England. TN8 6AB UK Tel: 0845 345 7253. UK Fax: 0845 345 7353 Int. Tel: +44 1732 861225. Int. Fax: +44 1732 861226	www.sontay.com
SIEMENS CERBERUS		Fire and Linear Heat Detection				Siemens Building Technologies Ltd., Hawthorn Road, Staines, Middlesex, England. TW18 3AY Tel: +44 (0)1784 461616. Fax: +44 (0)1784 464464	www.cerberus.com

YORK SENSORS / SENSA		Fire and Linear Heat Detection				Sensa, Gamma House, Chilworth Science Park, Southhamton, Hampshire, England. SO16 7NS Tel: +44 (0)23 8076 5500. Fax: +44 (0)23 8076 5501	www.sensa.org
CROWCON	Flamgard	Flammable Gas Detector	£200	6 mths for calibration	3-5 Years before replacing sensor cell	Crowcon Detection Instruments Ltd, 2 Blacklands Way, Abingdon Business Park, Abingdon, Oxfordshire, England. OX14 1DY. Tel: +44 (0)1235 553057. Fax: +44 (0)1235 553062	www.crowcon.com
CROWCON	Cirrus	Infrared Flammable Gas Detector	£1.200	Clean As Required	10 Years MTBF	As Above	Crowcon also produces fixed/personal sampling and monitoring systems
CROWCON	Txgard	Toxic Gas & Oxygen Detector	£300	6 mths for calibration	3-5 Years before replacing sensor cell	As Above	IR Detection rate much higher than catalitic detectors without the need to replace sensor cell parts
CROWCON	Tcgard	Flammable & Toxic Gas Detector	£350	As Above	As Above	As Above	
CROWCON	Nimbus	Infrared Flammable Gas Detector	£750	Clean As Required	10 Years MTBF	As Above	
TYCO INTEGRATED SYSTEMS		Vehicle Incident Detection & Automatic Number Plate Recognition systems + others				Tyco Integrated Systems Limited, Bridge House, Saxon Way, Bar Hill, Cambridge, UK. CB3 8TY Tel: +44 (0)1954 784000. Fax: +44 (0)1954 784010	www.tycointsys.co.uk
CITILOG	MediaRoad	Automatic Incident Detection and Traffic Measurement				Citilog S.A., 5 Avenue d'Italie, 75013 Paris, France Tel: +33 153 94 53 95. Fax: +33 153 94 53 99	www.citilog.com
CITILOG	MediaTunnel	As Above including desicion making tools				As Above	

CITILOG	MediaCity	for Intersection control within urban environment				As Above	
CITILOG	VisioPaD	for Active Video Surveillance on PTZ cameras				As Above	
BIRAL	Windsonic	upto 60m/s Wind Sensor	£500-650	Clean as Required		Bristol Industrial & Research Associates Ltd, P.O. Box 2, Portishead, Bristol, UK. BS20 7JB Tel: +44 (0)1275 847787. Fax: +44 (0)1275 847303	www.biral.com
BIRAL	WindObserver	upto 65m/s 2-axis anemometer	£1095-1560	As Above		As Above	Windmaster Power Supply & Comms Unit available for £1150
BIRAL	WindMaster	3-axis anemometer	£2500-4445	As Above		As Above	Windmaster "Research" model available for £5k (greater accuracy)
BIRAL	VF-500	Visibility Sensor (analogue)	£6.235	As Above	upto 10 Years	As Above	
BIRAL	VPF-710	Visibility Sensor (digital)	£6.035	As Above		As Above	
BIRAL	VPF-730	Present Weather Sensors - Roadside measurement and classification of present weather including rainfall in mm/hr	£7.000	As Above		As Above	£295 for VPF-730 Heating Units
TYCO SAFETY PRODUCTS	MXF100	Fire and Linear Heat Detection				Tyco Control Systems	
ZELLWEGER	Apex	Gas Detector and Transmitter	£600	6 mths for calibration		Zellweger Analytics Limited, Hatch Pond House, 4 Stinsford Road, Nuffield Estate, Poole, Dorset, UK. BH17 0RZ Tel: +44 (0)1202 676161. Fax: +44 (0)1202678011	www.zelana.com
ZELLWEGER	Opus	Gas Detector and Transmitter	Version Dependant	Yearly		As Above	Zellweger provide a large range of fixed gas monitoring and detection equipment.
ZELLWEGER	Optima Plus	Infrared point flammable hydrocarbon gas detector certified for use in potentially explosive atmospheres		Clean As Required		As Above	IR Detection rate much higher than catalitic detectors without the

							need to replace sensor cell parts
ZELLWEGER	IR-148	Infra-Red Gas Monitor that detects solvents and gases, such as HCFCs, HFCs and PFCs		Yearly		As Above	
ZELLWEGER	SearchFlame 16	Optical flame detectors certified for use in designated hazardous areas		Clean As Required		As Above	
ZELLWEGER	SearchLine Excel	Detects the presence and build up of explosive concentration of hydrocarbon gas clouds in hazardous environments.		Clean As Required		As Above	
ZELLWEGER	SensePoint	Gas Detection Sensor	£200	6 mths for calibration	5-7 Years before replacing sensor cell	As Above	
ZELLWEGER	SignalPoint	Gas Detection Sensor Self-contained Unit	£150	As Above		As Above	
ZELLWEGER	780	High Temp Sensor for the detection of combustible gases		Yearly		As Above	
DRAEGER	Polytron IR CO_2	Carbon Dioxide Sensor	Version Dependant			Draeger Ltd, Ullswater Close, Kitty Brewster Industrial Estate, Blyth, Northumberland, NE24 4RG. UK. Tel: +44 (0)1670 352891. Fax: +44 (0)1670 356266	www.draeger.com
DRAEGER	Polytron IR N_2O	N_2O Gas Detector	Version Dependant			As Above	
DRAEGER	Polytron 1 / 2	Intrinsically Safe Gas Detector for continuous monitoring of toxic gases and oxygen in ambient air. Polytron 2 is ATEX approved	Version Dependant			As Above	
DRAEGER	Polytron TX	Explosion Proof Gas Detector for continuous monitoring of toxic gases and oxygen in ambient air	Version Dependant			As Above	

DRAEGER	Polytron 2 XP Tox	Explosion Proof Gas Detector for continuous monitoring of toxic gases and oxygen in ambient air	Version Dependant			As Above	
HAGNER	TLS-420	Tunnel Entrance Photometer	£2.650	Clean As Required	5-10 Years before re-calibration	Hagner Photometric Instruments Ltd, 6&7 Broadbridge Business Centre, Delling Lane, Bosham, West Sussex. PO18 8NF. UK Tel: +44 (0)1243 575723. Fax: +44 (0)1243 573238	www.hagnerlightmeters.com
HAGNER	ELV-741	Outdoor Illuminance Sensor	£900	Clean As Required		As Above	Washer Units approx £290
HAGNER	ELV-741 L	Indoor Illuminance Sensor	£780	Clean As Required		As Above	Wiper blades on washer units may need replacing every 2-3 years
HAGNER	EH-150	Road Tunnel Lighting control system using Hitachi EH-150 PLC and TLS-420 Photometer(s)	£2.700			As Above	

10.3 Equipment installed in 3 Greek tunnels

Country:	**Greece**
Name of the tunnel:	**Aktio – Preveza sub-sea tunnel**
Responsible Agency / Operator	**TEO – AKTOR Joint Venture**
Opening year:	**2001**
Fire alarm system (manual, automatic):	Yes – Automatic
Type of the fire detectors (trademark, type):	Sensor Cable-LD-40 Linear Heat detection system
Distance between fire detectors:	Linear – 400m zones
Extinguishing system (dry/water):	Both
Provide info for possible malfunctions:	None
Cameras inside the tunnel:	Yes – 19 in total
Type of the cameras (trademark, type):	PHILIPS LTC-0455/50
Distance between cameras:	Every 100m
Connection of the cameras with the control centre (cable, remote control):	Cable
Provide info for possible malfunctions:	None
Telephone devices inside the tunnel and their connection with the centre (cable, remote control):	Yes – every 50m
Connection of the telephone devices with the control centre (cable, remote control):	Cable
Provide info for possible malfunctions:	None
Red light inclusion (over fire extinguisher, telephone, fire detector, camera observation):	ACON Fire extinguishers Ltd.
Provide info for possible malfunctions / false alarms:	None
Does the radio signal exist in the tunnel (yes/no):	Yes
Does the mobile phone signal exist in the tunnel (yes/no):	No
Temperature measurement devices (trademark, type):	Temperature Sensor – Values through the seismic monitoring system
Provide info for possible malfunctions:	None
Carbon monoxide concentration measurement devices (trademark, type):	ACP – Tunnel craft
Provide info for possible malfunctions / false alarms:	None

Air speed measurement devices (trademark, type):	Internal: ACP Tunnel craft flow External: CombiSD Combined speed-direction anemometer
Provide info for possible malfunctions:	None
Vehicle speed measurement devices (trademark, type):	Inductive loops – SCADA SIEMENS
Provide info for possible malfunctions:	None
Traffic counter devices (trademark, type):	Inductive loops – SCADA SIEMENS
Provide info for possible malfunctions:	None
Lighting system (trademark, type):	THORN (Nah-T 400,250,100)
Is the tunnel lighting adaptable?	Automatic and manually
Provide info for possible malfunctions:	None
Ventilation in the tunnel (trademark, type):	HOWDEN APR-800/330-10
Ventilator system (automatic/manual)?	Automatic and manually
Provide info for possible malfunctions:	None
Does damage-informing system in the tunnel exist (electric bulbs, telephones, cameras)? Of what?	No
Drivers' information system:	Yes, through VMS and loudspeakers

Country:	**Greece**
Name of the tunnel:	**Patra Ring Road**
Responsible Agency / Operator	**P.A.TH.E.**
Opening year:	**2002**
Fire alarm system (manual, automatic):	Yes – Automatic
Type of the fire detectors (trademark, type):	-
Distance between fire detectors:	Linear – every 50m
Extinguishing system (dry/water):	Both
Provide info for possible malfunctions:	-
Cameras inside the tunnel:	Yes – 72 in total (52 fixed / 20 with remote control)
Type of the cameras (trademark, type):	-
Distance between cameras:	-
Connection of the cameras with the control centre (cable, remote control):	Cable
Provide info for possible malfunctions:	-
Telephone devices inside the tunnel and their connection with the centre (cable, remote control):	Yes – every 50m (114 public and 7 connected to the operator's room)
Connection of the telephone devices with the control centre (cable, remote control):	Cable and fibre optic
Provide info for possible malfunctions:	-
Red light inclusion (over fire extinguisher, telephone, fire detector, camera observation):	-
Provide info for possible malfunctions / false alarms:	-
Does the radio signal exist in the tunnel (yes/no):	Yes – 6 transmitters
Does the mobile phone signal exist in the tunnel (yes/no):	No
Temperature measurement devices (trademark, type):	No
Provide info for possible malfunctions:	-
Carbon monoxide concentration measurement devices (trademark, type):	Yes
Provide info for possible malfunctions / false alarms:	-

Air speed measurement devices (trademark, type):	No
Provide info for possible malfunctions:	-
Vehicle speed measurement devices (trademark, type):	Yes with inductive loops
Provide info for possible malfunctions:	-
Traffic counter devices (trademark, type):	Yes with inductive loops
Provide info for possible malfunctions :	-
Lighting system (trademark, type):	Yes
Is the tunnel lighting adaptable?	Yes with photometer
Provide info for possible malfunctions:	-
Ventilation in the tunnel (trademark, type):	Yes
Ventilator system (automatic/manual)?	Automatic and manually
Provide info for possible malfunctions:	-
Does damage-informing system in the tunnel exist (electric bulbs, telephones, cameras)? Of what?	-
Drivers' information system:	No

Country:	**Greece**
Name of the tunnel:	**S1N (2 bores) – EGNATIA ODOS**
Responsible Agency / Operator	**EGNATIA ODOS S.A.**
Opening year:	**2002**
Fire alarm system (manual, automatic):	Yes – Automatic & manually
Type of the fire detectors (trademark, type):	-
Distance between fire detectors:	Linear
Extinguishing system (dry/water):	Both
Provide info for possible malfunctions:	-
Cameras inside the tunnel:	Yes – 19 in total (17 inside stable and 2 outside with remote control)
Type of the cameras (trademark, type):	-
Distance between cameras:	Every 100 m
Connection of the cameras with the control centre (cable, remote control):	Cable
Provide info for possible malfunctions:	-
Telephone devices inside the tunnel and their connection with the centre (cable, remote control):	Yes – every 50m (17 in the right bore and 16 in the left one)
Connection of the telephone devices with the control centre (cable, remote control):	Cable
Provide info for possible malfunctions:	-
Red light inclusion (over fire extinguisher, telephone, fire detector, camera observation):	-
Provide info for possible malfunctions / false alarms:	-
Does the radio signal exist in the tunnel (yes/no):	No
Does the mobile phone signal exist in the tunnel (yes/no):	No
Temperature measurement devices (trademark, type):	Yes two, entering and exiting the tunnel
Provide info for possible malfunctions:	-
Carbon monoxide concentration measurement devices (trademark, type):	Yes – There are also measurement devices about visibility and Nitrogen
Provide info for possible malfunctions / false alarms:	-

Air speed measurement devices (trademark, type):	Yes in every bore
Provide info for possible malfunctions:	-
Vehicle speed measurement devices (trademark, type):	Yes with loops (every 100m)
Provide info for possible malfunctions:	-
Traffic counter devices (trademark, type):	Yes with loops
Provide info for possible malfunctions :	-
Lighting system (trademark, type):	Yes
Is the tunnel lighting adaptable?	Yes with photometer
Provide info for possible malfunctions:	-
Ventilation in the tunnel (trademark, type):	Yes
Ventilator system (automatic/manual)?	Automatic and manually (every 150m)
Provide info for possible malfunctions:	-
Does damage-informing system in the tunnel exist (electric bulbs, telephones, cameras)? Of what?	SCADA system
Drivers' information system:	Drivers are informed with sound alarms

10.4 Equipment installed in Germany

The investigation was to see in which tunnel in general fire safety equipment was installed. It was not on the specific type of equipment.

Tunnel name	City	Start of operation	Length (m)	No of CCTV	Distance between CCTV (m)	Fire alarm equipment manually	Fire alarm equipment automatic	No of extinguishers	Distance between extinguishers (m)
Laimer	München	1894	227	n.b.	n.b.	no	no	n.b.	n.b.
Schwab	Stuttgart	1896	125	n.b.	n.b.	no	no	n.b.	n.b.
Paul-Heyse	München	1902	216	n.b.	n.b.	no	no	n.b.	n.b.
St. Pauli	Hamburg	1911	426	11	n.b.	yes	no	8	400
Gildehof 1 (Alt)	Essen	1922	91	n.b.	n.b.	no	no	n.b.	n.b.
Kruiner Tunnel	Gevelsberg	1927	88	n.b.	n.b.	no	no	n.b.	n.b.
Eschenlohe-Nord	Eschenlohe	1936	223	n.b.	n.b.	no	no	n.b.	n.b.
Eschenlohe-Süd	Eschenlohe	1936	255	n.b.	n.b.	no	no	n.b.	n.b.
Lämmerbuckel	Hohenstadt	1956	624	n.b.	n.b.	no	no	4	300
Schloßberg	Harburg	1957	245	n.b.	n.b.	no	no	n.b.	n.b.
Wagenburg	Stuttgart	1957	824	n.b.	n.b.	yes	no	9	100
Rathenauplatz	Berlin	1958	212	n.b.	n.b.	no	no	n.b.	n.b.
Hagen-Vorhalle	Hagen	1960	121	n.b.	n.b.	no	no	2	n.b.
Leuchtenberg	München	1960	166	n.b.	n.b.	no	no	n.b.	n.b.
Flughafen	Echterdingen	1961	509	n.b.	n.b.	yes	yes	8	100
Rendsburg	Rendsburg	1961	640	7	114	yes	no	36	40
Deichtor	Hamburg	1962	133	n.b.	n.b.	no	no	6	50
Gaisberg	Heidelberg	1962	314	n.b.	n.b.	no	no	n.b.	n.b.
Billwerder-Moorfleet	Hamburg	1963	243	n.b.	n.b.	no	no	n.b.	n.b.
Hellberg	Kirn (Nahe)	1963	161	n.b.	n.b.	no	no	n.b.	n.b.
Engelberg	Leonberg	1964	319	n.b.	n.b.	no	no	n.b.	n.b.
Westring	Ulm	1964	385	n.b.	n.b.	no	no	3	n.b.
Innsbrucker Ring	München	1965	220	n.b.	n.b.	no	no	8	40
Krohnstieg	Hamburg	1965	420	n.b.	n.b.	no	no	5	75
Neubiberg	München	1965	327	n.b.	n.b.	no	no	n.b.	n.b.
Wallring	Hamburg	1965	541	n.b.	n.b.	no	no	10	100
Biederstein	München	1966	305	n.b.	n.b.	no	no	8	60
Komödienstrasse	Köln	1966	179	n.b.	n.b.	no	yes	3	50
Bundesplatz	Berlin	1967	281	n.b.	n.b.	no	no	n.b.	n.b.
Feuerbachstr.	Berlin	1968	260	n.b.	n.b.	no	no	n.b.	n.b.
Planie	Stuttgart	1968	400	n.b.	n.b.	yes	no	16	100
Schloßberg	Heidelberg	1968	918	n.b.	n.b.	no	yes	11	75
Alexanderplatz	Berlin	1969	300	n.b.	n.b.	no	no	n.b.	n.b.

Candidauffahrt	München	1969	252	n.b.	n.b.	no	no	5	50
Rheinallee 1	Düsseldorf	1969	650	8	200	yes	no	2	100
Schloßberg	Neuenbürg	1969	149	n.b.	n.b.	no	no	n.b.	n.b.
Wilmersdorf	Berlin	1969	175	n.b.	n.b.	no	no	n.b.	n.b.
Eigelstein	Köln	1970	94	n.b.	n.b.	no	no	2	30
Kiesberg	Wuppertal	1970	854	14	112	no	no	n.b.	n.b.
Peregrina	Stuttgart	1970	100	n.b.	n.b.	no	no	1	n.b.
Ruhrschnellweg	Essen	1970	1.005	24	100	yes	yes	36	50
Binsbarg	Hamburg	1971	158	n.b.	n.b.	no	no	n.b.	n.b.
Göppingen	Göppingen	1971	205	n.b.	n.b.	yes	no	10	30
Grenzstrasse	Köln	1971	318	n.b.	n.b.	no	yes	9	
Projensdorf	Kiel	1971	251	n.b.	n.b.	yes	no	12	44
Adenauerplatz	Berlin	1972	253	n.b.	n.b.	no	no	4	n.b.
Altstadtring	München	1972	608	3	n.b.	yes	yes	31	50
BAB-Zubr.Freihafen	Bremen	1972	110	n.b.	n.b.	no	no	n.b.	n.b.
Gildehof 2 (Neu)	Essen	1972	152	n.b.	n.b.	no	no	n.b.	n.b.
Gräfelfing	München	1972	280	n.b.	n.b.	no	no	n.b.	n.b.
Schwanenplatz	Stuttgart	1972	475	n.b.	n.b.	yes	no	12	n.b.
Hölzern	Weinsberg	1973	470	n.b.	n.b.	no	yes	12	133
Leuzetunnel	Stuttgart	1973	270	n.b.	n.b.	yes	no	2	n.b.
Rathaus	Lüdenscheid	1973	342	n.b.	n.b.	no	no	8	70
Saarburg	Saarburg	1973	185	n.b.	n.b.	no	no	n.b.	n.b.
Lehrertal	Ulm	1974	400	n.b.	n.b.	yes	no	5	80
Theater	Frankfurt	1974	415	8	70	yes	no	16	80
Elbtunnel	Hamburg	1975	2.653	54	300	yes	yes	82	100
Vogelsang	Esslingen	1975	106	n.b.	n.b.	no	no	n.b.	n.b.
Mühlberg Sigmaringen	Sigmaringen	1976	124	n.b.	n.b.	no	no	2	n.b.
Veringenstadt	Veringenstadt	1976	123	n.b.	n.b.	no	no	2	130
Adenauerallee	Aachen	1977	212	n.b.	n.b.	no	no	3	55
Echterdingen	Echterdingen	1977	150	n.b.	n.b.	yes	no	12	35
Pfaffenstein	Regensburg	1977	880	n.b.	n.b.	yes	no	18	90
Wilhelminenstraße	Darmstadt	1977	545	12	n.b.	yes	no	2	70
Barsbuettel	Barsbuettel	1978	164	n.b.	n.b.	no	no	3	60
Innsbrucker Platz	Berlin	1978	264	n.b.	n.b.	no	no	16	130
Schönbuch	Herrenberg	1978	606	n.b.	n.b.	yes	yes	20	150
Verkehrsring	Unna	1978	186	n.b.	n.b.	yes	no	n.b.	n.b.

Alt-Friedrichsfelde	Lichtenberg	1979	90	n.b.	n.b.	no	no	n.b.	n.b.
Butterberg	Osterode	1979	363	n.b.	n.b.	no	no	8	80
Flughafen Tegel	Berlin	1979	934	29	120	yes	yes	42	120
Johannesgraben	Stuttgart	1979	218	n.b.	n.b.	no	no	n.b.	n.b.
Lahneck	Lahnstein	1979	86	n.b.	n.b.	no	no	n.b.	n.b.
Landshuter Allee	München	1979	362	n.b.	n.b.	no	no	12	60
Schloßberg	Tübingen	1979	265	n.b.	n.b.	no	yes	18	30
Neuenlander Straße	Bremen	1980	126	n.b.	n.b.	no	no	n.b.	n.b.
Schlangenbader Str.	Berlin	1980	560	n.b.	n.b.	no	no	4	120
Hirschhorn	Hirschhorn	1982	356	n.b.	n.b.	no	yes	6	160
Rheinuferstrasse	Köln	1982	580	n.b.	n.b.	no	yes	3	170
Schiede	Limburg	1982	243	n.b.	n.b.	yes	yes	2	60
Blaubeuren	Blaubeuren	1983	330	n.b.	n.b.	yes	no	4	60
Okriftelerstraße	Frankfurt	1983	452	n.b.	n.b.	no	no	n.b.	n.b.
Universität	Düsseldorf	1983	1.026	n.b.	n.b.	no	no	26	80
Apollo	Bad Bertrich	1984	438	n.b.	n.b.	no	no	1	n.b.
Diana	Bad Bertrich	1984	193	n.b.	n.b.	no	no	n.b.	n.b.
Trappentreu	München	1984	522	11	n.b.	no	no	22	50
Westbahnhof	Aachen	1984	166	n.b.	n.b.	yes	no	n.b.	n.b.
Westtangente BO	Bochum	1984	565	10	100	yes	no	13	100
Birth	Velbert	1985	807	n.b.	n.b.	yes	no	18	90
Hugenwald	Waldkirch	1985	1.135	22	75	yes	yes	32	75
Oberdollendorf	Königswinter	1985	630	n.b.	n.b.	no	no	n.b.	n.b.
Oberkassel	Bonn	1985	540	n.b.	n.b.	no	no	n.b.	n.b.
Hohentwiel	Singen	1986	833	n.b.	n.b.	yes	yes	2	n.b.
Neugereut	Stuttgart	1986	415	n.b.	n.b.	yes	no	2	150
Pfarrwiesenallee	Sindelfingen	1986	110	n.b.	n.b.	no	no	n.b.	n.b.
Wersten	Düsseldorf	1986	860	n.b.	n.b.	no	no	25	80
Agnesburg	Aalen	1987	704	n.b.	n.b.	yes	yes	12	180
Beyschlagsiedlung	Berlin	1987	500	8	180	yes	yes	4	120
Ernststraße	Berlin	1987	154	n.b.	n.b.	no	no	4	n.b.
Essen-Huttrop	Essen	1987	340	n.b.	n.b.	no	no	4	110
Forstamt	Berlin	1987	208	n.b.	n.b.	no	yes	n.b.	n.b.
Schwarzer Berg	Eltmann	1987	710	6	200	yes	yes	12	200
Tegel Ortskern	Berlin	1987	753	15	150	yes	yes	15	130
Virngrund	Ellwangen	1987	468	n.b.	n.b.	yes	yes	12	150
Wendelberg	Melleck	1987	483	n.b.	n.b.	no	yes	10	200

Bismarckstraße	Stadtbergen	1988	214	n.b.	n.b.	yes	yes	12	65
Brudermühlstrasse	München	1988	803	13	80	yes	yes	32	15
Güterbahn	Karlsruhe	1988	152	n.b.	n.b.	no	no	8	150
Reifensteige	Schwäbisch Hall	1988	115	n.b.	n.b.	yes	no	2	90
Straßentunnel	Bruchsal	1988	110	n.b.	n.b.	no	no	4	100
Südtang.Edeltrud	Karlsruhe	1988	609	n.b.	n.b.	yes	yes	20	150
Dingolfing	Dingolfing	1989	157	n.b.	n.b.	no	yes (opacity !!)	n.b.	n.b.
Einhausung	Oberammergau	1989	106	n.b.	n.b.	no	no	n.b.	n.b.
Emstunnel	Leer	1989	945	7	250	yes	yes	22	93
Hahnerberger Str.	Wuppertal	1989	133	n.b.	n.b.	no	yes	2	n.b.
Osterbichl	Oberammergau	1989	278	n.b.	n.b.	no	no	n.b.	n.b.
Steinbis	Triberg	1989	142	n.b.	n.b.	no	no	n.b.	n.b.
Grünbrücke Aichelberg	Kirchheim	1990	100	n.b.	n.b.	no	no	n.b.	n.b.
Herfatz	Wangen	1990	440	n.b.	n.b.	yes	no	12	130
Himmelreich	Triberg	1990	162	n.b.	n.b.	no	no	n.b.	n.b.
Im Großen Busch	Wuppertal	1990	275	n.b.	n.b.	no	no	n.b.	n.b.
Michaelstunnel	Baden-Baden	1990	2.518	20	150	yes	yes	32	150
Rommelsbacher Str.	Reutlingen	1990	300	n.b.	n.b.	yes	yes (CO !!)	6	150
Schemmelsberg	Weinsberg	1990	680	n.b.	n.b.	no	yes	6	170
Utbremer Straße	Bremen	1990	122	n.b.	n.b.	no	no	n.b.	n.b.
Volkardey	Düsseldorf	1990	695	n.b.	n.b.	no	yes	5	160
Besigheim	Besigheim	1991	168	n.b.	n.b.	no	no	n.b.	n.b.
Gänsbühl	Saulgau	1991	134	n.b.	n.b.	no	no	n.b.	n.b.
Heidenäcker	Lauchringen	1991	160	n.b.	n.b.	no	no	n.b.	n.b.
Heilsberg	Gottmadingen	1991	483	n.b.	n.b.	yes	no	12	130
Heslach	Stuttgart-Heslach	1991	2.300	27	100	yes	yes	32	150
Hörnchenberg	Landstuhl	1991	511	n.b.	n.b.	yes	no	2	190
Kirchberg	Schiltach	1991	1.840	15	n.b.	yes	yes	30	150
Schloßberg	Schiltach	1991	830	7	n.b.	yes	yes	14	n.b.
Zuckerhut	Triberg	1991	196	n.b.	n.b.	no	no	n.b.	n.b.
Altenberg	Idar-Oberstein	1992	329	n.b.	n.b.	no	no	n.b.	n.b.
BAB-Zubringer	Echterdingen	1992	143	n.b.	n.b.	no	no	n.b.	n.b.
Flughafen	Düsseldorf	1992	1.070	n.b.	n.b.	no	yes	14	150

Kappelberg	Fellbach	1992	1.565	n.b.	n.b.	yes	yes	11	140
Nordwest-Umgehung	Rastatt	1992	1.021	8	120	yes	yes	14	120
Obernauerstraße	Aschaffenburg	1992	230	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Schürzeberg	Oberrieden	1992	530	n.b.	n.b.	yes	yes	12	240
Schwarzbach	Düsseldorf	1992	158	n.b.	n.b.	no	no	n.b.	n.b.
Tunnel	Uentrop	1992	200	n.b.	n.b.	no	yes	2	n.b.
Unterschweinstiege	Frankfurt	1992	90	1	n.b.	yes	yes	3	70
Berger	Stuttgart	1993	154	n.b.	n.b.	yes	no	2	n.b.
Bergkelter	Murr	1993	149	n.b.	n.b.	no	no	n.b.	n.b.
Einhausung Süd	Deggendorf	1993	310	n.b.	n.b.	yes	no	8	90
Mosel	Zwickau	1993	430	n.b.	n.b.	yes	yes	8	150
Reutherberg	Wolfach	1993	1.257	13	140	yes	yes	22	140
Rheinuferstrasse	Düsseldorf	1993	1.922	53	180	yes	yes	66	80
Steinbruch	Murr	1993	220	n.b.	n.b.	no	no	n.b.	n.b.
Fahrlach	Mannheim	1994	489	8	70	yes	yes	14	90
Heidberg	Braunschweig	1994	379	n.b.	n.b.	no	no	n.b.	n.b.
Herrlohtunnel	Winterberg	1994	168	n.b.	n.b.	no	no	n.b.	n.b.
Kohlberg	Erkheim	1994	598	n.b.	n.b.	yes	yes	3	150
Langenfirst	Schopfheim	1994	270	n.b.	n.b.	no	no	n.b.	n.b.
Ostwestfalendamm	Bielefeld	1994	535	n.b.	n.b.	yes	yes	4	115
Wambel	Dortmund	1994	1.420	n.b.	n.b.	no	yes	22	140
Wattkopf	Ettlingen	1994	1.950	16	140	yes	yes	15	140
Allach		1995	1.400	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Altstadttunnel	Arnsberg	1995	345	n.b.	n.b.	no	yes	8	150
Bärenkeller	Augsburg	1995	154	n.b.	n.b.	no	no	8	n.b.
Feuerbach	Stuttgart	1995	1.175	12	150	yes	yes	2	150
Hasselkopf	Braunlage	1995	220	n.b.	n.b.	no	no	n.b.	n.b.
Hirschweg	Stockach	1995	80	n.b.	n.b.	no	no	n.b.	n.b.
Sommerberg	Hausach	1995	1.045	13	n.b.	yes	yes	n.b.	n.b.
Weiherholz	Stockach	1995	80	n.b.	n.b.	no	no	n.b.	n.b.
Wernerhof	Ravensburg	1995	231	n.b.	n.b.	no	no	n.b.	n.b.
Bürgerwald		1997	1.435	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Gernsbach		1998	1.527	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Engelbergbassis	Stuttgart	1999	2.310	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Grötzingen		1999	1.108	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Königshainer Berge	Görlitz	1999	3.300	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Meistern	Bad Wildbad	1999	1.684	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.

Saukopf	Weinheim	1999	2.715	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Britz	Berlin	2000	1.700	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Farchant	Farchant	2000	2.326	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Einhausung Hösbach	Aschaffenburg	2001	2.101	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Einhausung Regensb.	Regensburg	2001	670	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Gäubahn	Stuttgart	2001	306	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Hochwald	Zella-Mehlis	2001	1.056	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Laufen	Laufen	2001	540	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Ursulaberg	Pfullingen	2001	1.180	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Viereichenhau	Stuttgart	2001	270	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Altfranken	Dresden	2002	345	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Elbtunnel 4. Röhre	Hamburg	2002	3.100	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Kappler	Freiburg	2002	1.187	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Langenberg	Velbert-Langenberg	2002	490	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Nollinger Berg	Rheinfelden	2002	1.268	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Petuelring	München	2002	1.738	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Rheinschlinge	Meerbusch	2002	870	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Schützenallee	Freiburg	2002	850	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Stadtberg	Bd. Reichenhall	2002	500	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Tunnel Strümp	Meerbusch	2002	640	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Weserauentunnel	Port. Westfalica	2002	1.730	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Wesertunnel	Dedesdorf	2002	1.636	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Alte Burg	Geschwenda	2003	866	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Bad Ems	Bad Ems	2003	1.522	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Berg Bock	Suhl	2003	2.750	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Bramschstr.	Dresden	2003	770	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Coschütz	Dresden	2003	2.353	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Dölzschen	Dresden	2003	1.080	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Dusslingen	Dusslingen	2003	457	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Einhausung Aubing	München	2003	1.455	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Lobeda	Jena	2003	600	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Rennsteig	Oberhof	2003	7.916	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Stadtstraße	Bremen-Hemelingen	2003	592	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.
Warnowtunnel	Rostock	2003	790	n.b.	n.b.	n.b.	n.b.	n.b.	n.b.

10.5 List of equipment manufacturers in Spain

Manufacturer/Supplier	Description	Manufacturer Contact Details	Notes
AGBAR MANTENIMIENTO, S.A. (MUSA)	Installation and maintenance of detection and monitoring equipment and systems	C/ Berguedà, 20-24. 08029 BARCELONA Tlf.: 93 494 97 50 Fax: 93 430 90 03 e-mail: madrid@musa.es	www.agbar.es
ANBER, S.A.	Manufacturer of fire fighting equipment and systems	Pq. Emp. Molino. Avda. Flores, 13 28970 HUMANES (MADRID) Tlf:91/6063711 Fax:91/6909561	anber@stnet.es
ALBERT ZIEGLER ESPAÑA, S.L.	Manufacturer of fire service vehicles, pumps and hoses	Balbino Marrón, 3, viapol, A, 4°-17 41005 SEVILLA Tlf:95/4643117 Fax:95/4661144	ziegler@zieglersl.com
AXIMA SISTEMAS E INSTALACIONES, S.A.	Design, execution, maintenance and operation of technical infrastructure in different areas of ventilation and automation systems	Pº Castellana, 163. 28080 MADRID Tlf.: 91 749 82 11 Fax: 91 749 83 02 e-mail: angel.gandara@axima.eu.com	www.axima.eu.com
CARANDINI	Manufacturer, Installation and maintenance of lighting equipment	Ronda Universidad, 31 08007 Barcelona Tlf.: 93 317 40 08 Fax: 93 317 18 90	www.carandini.com
DELESA SEGURIDAD	Installation and maintenance of detection and monitoring equipment and systems	C/ Fuente Forraje, 174. Pol. Ind. La Pahilla. 46370 Chiva - VALENCIA Tlf.: 96 252 13 10 Fax: 96 252 41 20 e-mail: delesa@ctv.es	www.ctv.es/USERS/delesa
EMMSA, S. A. (ESPAÑOLA DE MONTAJES METÁLICOS, S.A.)	Installation and maintenance of detection and monitoring equipment and systems	Torres y Amat, 7 - 11. 08001 BARCELONA Tlf.: 93 481 78 00 Fax: 93 481 78 01 e-mail: emmsa@emmsa.es	www.emmsa.es
ESES, S.A.	Installation and maintenance of detection and monitoring equipment and systems	C/ Antonio López, 249, 2ª Planta. Edificio Vértice. 28041 MADRID Tlf.: 91 379 82 00 Fax: 91 379 82 63 e-mail: pci.ingenieria@eses.es	www.eses.es
EXTINMAN, S.L.	Installation and maintenance of CCTV and fire fighting equipment	Polígono Juncaril, c/ D. Parc. 133-Ctra. Maracena 18220 Albolote - GRANADA Tlf.: 958 46 70 60 Fax: 958 46 56 90 e-mail: www.central@extinman.com	www.agbar.es

FIRE CONSULT, S.L.	Installation and maintenance of CCTV and fire fighting equipment	C/ Impresores, 12 Pol. Industrial Los Angeles. 28906 Getafe - MADRID Tlf.: 91 601 67 63 Fax: 91 601 67 64 e-mail: fireconsult@line-pro.es	www.extinman.com
FIREX, S.L.	Supplier installation and maintenancce of equpment for fire detection	C/ Santander, 36-local 12-F. Urb. Parque Roma. 50010 ZARAGOZA Tlf.: 976 34 33 00 Fax: 976 53 09 22 e-mail: fuego@firex.es	www.firex.es
GLOBE SPRINKLERS EUROPA, S.A.	Manufacture of sprinklers	Pq. Emp. Molino. Avda. Flores, 15 28970 HUMANES (MADRID) Tlf:91/6063711 Fax:91/6909561 anber@stnet.es	www.globesprinkler.com
HADASA, S.L.	Manufacturer, Installation and maintenance of lighting equipment	Avda. de la Industria, 15-17 28820 Coslada. Madrid Tlf.: 91 205 98 00 Fax: 91 205 98 01	General Electric branch
IASA INGENIEROS, S.A.	Manufacturer and supplier of systems for detection and fire fighting	C/ Taquígrafo Serra, 11. 08029 BARCELONA Tlf.: 93 321 11 48 Fax: 93 419 45 66 e-mail: iasa@iasa-es.com	www.iasa-es.com
IMES, S.A.	Design, installation and maintenance of detection and monitoring equipment	Avda. Ramón y Cajal, 107. 28043 MADRID Tlf.: 91 744 39 00 Fax: 91 744 39 01 e-mail: info@imes.es	www.imes.es
INCIPRESA	Installation and maintenance of detection and monitoring equipment and systems	Goya, 135 2°Izq. 28009 MADRID Tlf:91/3093636 Fax:91/3093488 comercial@incipresa.com	
MARIOFF HI-FOG S.A.	Hi-Fog system based on water mist technology	Avda. Espartero, 19. Pol. Ind. S. J. de Valderas. 28918 Leganés - MADRID Tlf.: 91 641 84 00 Fax: 91 641 84 01 e-mail: elia@vimpex.es	www.hi-fog.com
NORDÉS	Installation and maintenance of detection and monitoring equipment and systems	Polígono Pocomaco, 1ª Avenida B-1. 15190 A CORUÑA Tlf.: 981 17 36 99 Fax: 981 13 70 76 e-mail: correo@nordes.com	www.nordes.com

PACISA	Installation and maintenance of detection and monitoring equipment and systems	C/ Francisco Gervás, 3 - Pol. Ind. Alc. 28100 Alcobendas - MADRID Tlf.: 91 662 06 78 Fax: 91 661 23 43 e-mail: pacisa@pacisa.es	www.pacisa.es
PARSI, S.A.	Installation and maintenance of detection and monitoring equipment and systems	Del Textil, 4 - parcela 6. Polígono Industrial La Ferreria. 08110 Montcada i Reixac - BARCELONA Tlf.: 93 565 19 19 Fax: 93 565 19 18 e-mail: info@parsi-pci.com	www.parsi-pci.com
PEFIPRESA	Manufacture, design, installation, maintenance and training of fire fighting systems	C/ San Cesáreo, 22-24. 28021 MADRID Tlf.: 91 710 90 00 Fax: 91 798 57 56 e-mail: info.madrid@pefipresa.com	www.pefipresa.com
PROTEC-FIRE, S.A.	Installation and maintenance of detection and monitoring equipment and systems	C/ Galileo Galilei, 25. Pol. Ind. Garena. 28806 Alcalá de Henares - MADRID Tlf.: 91 878 17 22 Fax: 91 878 17 24 e-mail: protec-fire.compras@iturri.com	www.iturri.com
SABO ESPAÑOLA, S.A.	Installation and maintenance of detection and monitoring equipment and systems	P.I.Can Cuyas. C/Arquitectura, 14 nave 7 08110 MONTCADA I REIXAC Tlf:93/5650692 Fax:93/5648133 comercial@sabo-esp.com	www.sabo-esp.com
SAINCO ABENGOA	Highway and Vehicle Traffic Management § Heras Vehicle Location System § Interurban Traffic § Odyssey Freeway Management § Sicotie Tunnel Safety System § Urban Traffic Management	C/ Albarracín, 21 28037 Madrid Tlf.: 91 754 72 00 Fax: 91 754 72 02	www.saincotrafico.com

SICE	Traffic, SOS Posts and Tunnel Management Equipment · Traditional and LED traffic lights · Area Control Centres · Zone Centres · Dynamic and static signalling · Closed-circuit TV for surveillance · LED beacons... The MOT System traffic control	C/ Sepúlveda, 6 28108 ALCOBENDAS (Madrid) Tlf.: 91 623 22 00 Fax: 91 623 22 01	www.sice.com
SICK Optic Electronic, S.A.	Vicotec System Opto electronic system to manage tunnel control	C/ Constitución, 3 08960 Sant Just Desvern (Barcelona) Tlf.: 93 480 31 00 Fax: 93 473 44 69	www.sick.es
SIEMENS CERBERUS, S.A.	Manufacture and supply a complete range of systems to detect fire and explosion hazards	C/ Perú, 186. 08020 BARCELONA Tlf.: 902 353 363 Fax: 93 507 60 01	www.cerberus.com
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VIKING SPRINKLER, S.A.	Manufacturer of Fire Protection Sprinklers, Valves, Systems, and Devices.	P.San Fdo.I. C/Mar Cantabrico, 10 28830 SAN FERNANDO DE HENARES Tlf:91/6778352 Fax:91/6778498	www.vikingcorp.com
WATSEGUR GRUPO ISOLUX	Installation and maintenance of detection and monitoring equipment and systems	C/ Alcocer, 41. 28021 MADRID Tlf.: 91 467 90 00 Fax: 91 796 58 75 e-mail: watsegur@isolux.es	www.isolux.es
WORMALD MATHER + PLATT ESPAÑA S.A	Installation and maintenance of detection and monitoring equipment and systems	C/ Gran Vía de les Corts Catalanes, 322-324. 08004 BARCELONA Tlf.: 93 325 26 00 Fax: 93 424 65 04 e-mail: rdurany@tycoint.com	www.tfs.com