



AUTOMATIC FIRE EXTINGUISHING and VISUAL GUIDE SYSTEMS for TUNNEL PROTECTION

Generals

Caccialanza & C. developed in the last years some technologically very innovative products, aimed to provide a very important contribution to increase the safety in railway and highway tunnels.

Automatic Fire Extinguishing System For Tunnel

Innovating fire extinguishing system for tunnel fires for fully automatic intervention or for remote operation from a remote Control Room.

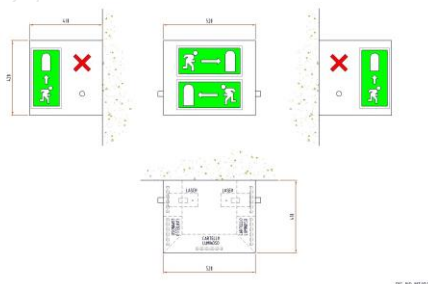
The system is based on the proven technology of fire fighting remote controlled monitors.



Depending on the length of the tunnel (long tunnels ≥ 1 km. or short tunnels < 1 km.), two different versions of the automatic fire extinguishing system with remote controlled monitors are available.

Automatic Interactive Signalling and Visual Guide System for Escape Paths in Tunnels

During emergencies it is very important that people inside tunnels (especially in long ones) are able to orientate themselves and move in the right direction (opposite to the accident one) in order to reach the accessible tunnel exit or the safety zones depending on the emergency in progress.



The innovative proposed system shows along the entire tunnel the evacuation route for the existing emergency, with continual, univocal optical signs that can be seen and followed continuously even in case of smoke, that may develop and spread inside the tunnel in case of fire emergencies.



AUTOMATIC FIRE EXTINGUISHING SYSTEM for TUNNEL PROTECTION with REMOTE CONTROLLED MONITORS

Generals

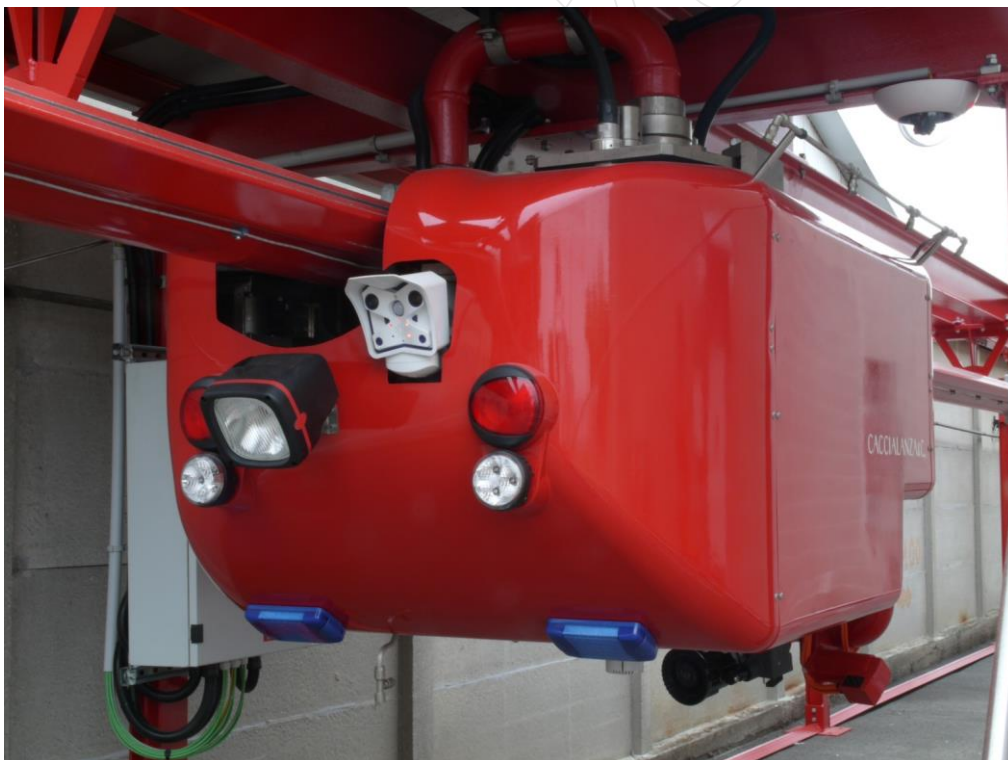
Innovating fire extinguishing system for tunnel fires for fully automatic intervention or for remote operation from a remote Control Room.

The system is based on the proven technology of fire fighting remote controlled foam/water monitors, worldwide utilized and appreciated for the fire protection in heavy risk plants.



Depending from the length of the tunnel (long tunnels ≥ 1 km. or short tunnels < 1 km.), two different versions of the automatic fire extinguishing system with remote controlled monitors are available.

The 1st version with mobile remote controlled monitors on overhead trailer (TUDEM-CAR), the system consists in a fixed structure (overhead rail), installed at the ceiling along the tunnel, and in a number of mobile units (trailers) equipped with foam/water monitors moving along the fixed structure.



The fixed structure is equipped with the main water (or foam premix) supply pipe (working pressure ~ 10 bar).

In the same fixed structure are integrated the main electric power supply line, the serial bus for data transmission and the heat sensing cable for the fire detection.

At regular intervals (typically 42 meters) along the tunnel, docking and control stations are provided for stop and connection of the mobile units.



The docking and control stations are additionally equipped with the infrared flame detectors for the fire detection.

Each mobile unit (trailer) is equipped with the electric remote controlled fire fighting monitor with flow rate 1.000 lt./min., two IP / TV cameras for visible and infrared light, the motors for the linear movement of the unit along the rail and the electric panel with command and control devices.

The 2nd version of the system with remote controlled fixed monitors uniformly spaced along the tunnel (TUDEM-LEGIO) consists of monitors directly installed along the tunnel at regular intervals of 42 m.

The main water supply line and the monitor flow rate are the same as for the 1st version (see above).

Following, the working pressure of the main water (or foam premix) supply pipe is of about 10 bar and the flow rate of the remote controlled monitors is of 1.000 lt./min.



Also in this case, the data are transmitted and the monitors are operated by means of a serial bus, and the fire detection is provided by heat sensing cable and infrared flame detectors.

Each monitor is equipped with 2 IP / TV cameras for visible and infrared light pointed at both directions along the tunnel.

Optionally for both versions, flammable gas detectors and toxic gas detectors for monitoring dangerous situations can be provided.

The fire protection system is integrated with a water pressurizing unit and with a foam proportioning system, consisting of a pumping station (normally with electric pump and Diesel motor pump) and a displacement liquid foam proportioner.

Alternatively to the displacement liquid foam proportioning unit, a balance pressure foam proportioner with related foam concentrate pump can be used.

The dimensioning of the foam storage and proportioning system depends on tunnel length and features. Usually, for short and medium length tunnels, the same foam supply system can be used for the 2 barrel vaults of the tunnel or for 2 adjacent tunnels.



It is important to consider that in both versions of the proposed automatic extinguishing system with remote controlled monitors the extinguishing system with fire hydrant cabinets as required by law can be easily integrated.

The fire hydrant cabinets are directly connected to the monitors main water supply line with regular intervals of 126 or 252 meters (with a step multiple of the distance of the docking and control stations) and are usually equipped with a pressure reducing valve to reduce the water pressure at the manually operated branch pipes at about 4÷5 bar.

In this case the pumping station is additionally equipped with a jockey pump to maintain the main water supply line permanently at a pressure of 5 bar for the hydrant cabinets.

Automatic operation of the system

The automatic operation of the system is performed through a centralized main command and control panel installed in the Control Room of the tunnel or in any other technical room. For the automatic intervention, the extinguishing system is combined with a double technology fire detection system with linear heat detectors and infrared flame detectors installed along the whole length of the tunnel.

In the system with mobile remote controlled monitors on overhead trailer (1st version), in case of detection of a fire, the two nearest mobile units with monitor (which, in stand-by condition, are positioned with constant step of about 800 m. along the tunnel) move along the rail and reach the docking and control stations closest to the fire zone.

The 2 monitors automatically connect to the main water (foam premix) supply line through a special patented coupling and start spraying water or foam with a step-less adjustable jet from full jet (for maximum throw and extinguishing power) to narrow cone and wide cone fog jet (for maximum cooling effect).

The connection of the mobile units to the coupling of the docking and control station automatically connect also the electric power supply and the data transmission between the mobile unit and the fixed system.

In case of longer tunnels with more than 2 mobile units, the two mobile units positioned immediately upstream and downstream the 2 units involved in the fire extinguishing intervention move to the next closer docking and control stations, connect to the feeding line and start spraying water with a wide cone fog jet (with spray angle 120°) with cooling effect to drop the temperature inside the tunnel and for containing the fire smoke.

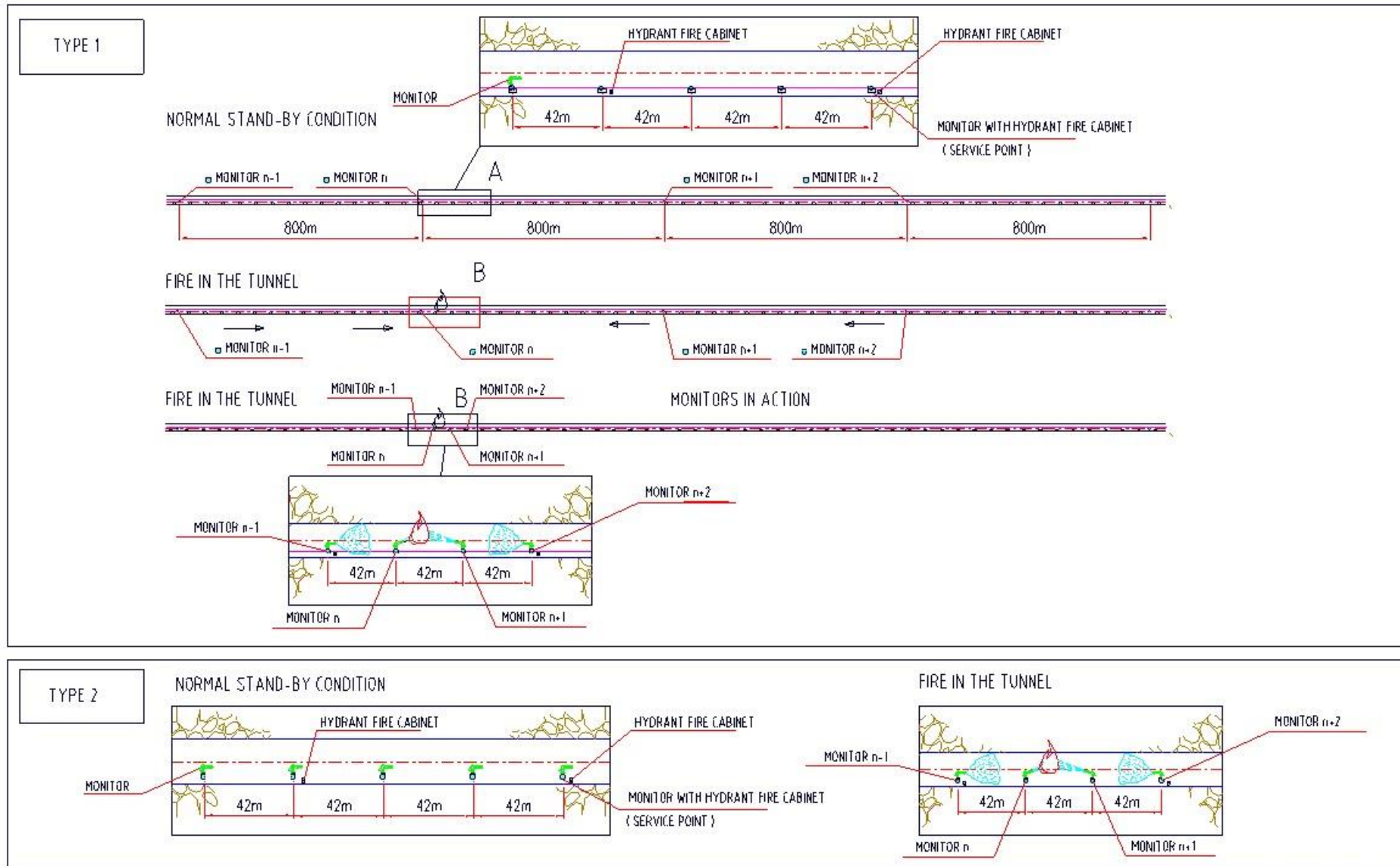
The complete typical process is reported in the scheme on page 5, showing the monitors in "stand-by" position, their translation to the nearest docking and control stations in case of fire and their operation for the extinguishing intervention, for cooling the heat and for containing the smoke of the fire.

In the system with remote controlled fixed monitors uniformly spaced along the tunnel (2nd version), the intervention procedure is exactly the same as for the 1st version.

In this case, however, the monitors are fixed and uniformly installed with the required interval of 42 m. along the tunnel. The fire detection system automatically selects the two monitors closest (upstream and downstream) to the fire and alarm area and starts the extinguishing intervention.

Contemporarily, the two monitors positioned immediately upstream and downstream the 2 units involved in the fire extinguishing action are selected to start the operation with wide fog jet for cooling the heat and for containing the smoke of the fire.

Obviously, all the other monitors are in stand-by and their on-off valves remain closed.



Typical procedure operating system

DIS NR MT001759



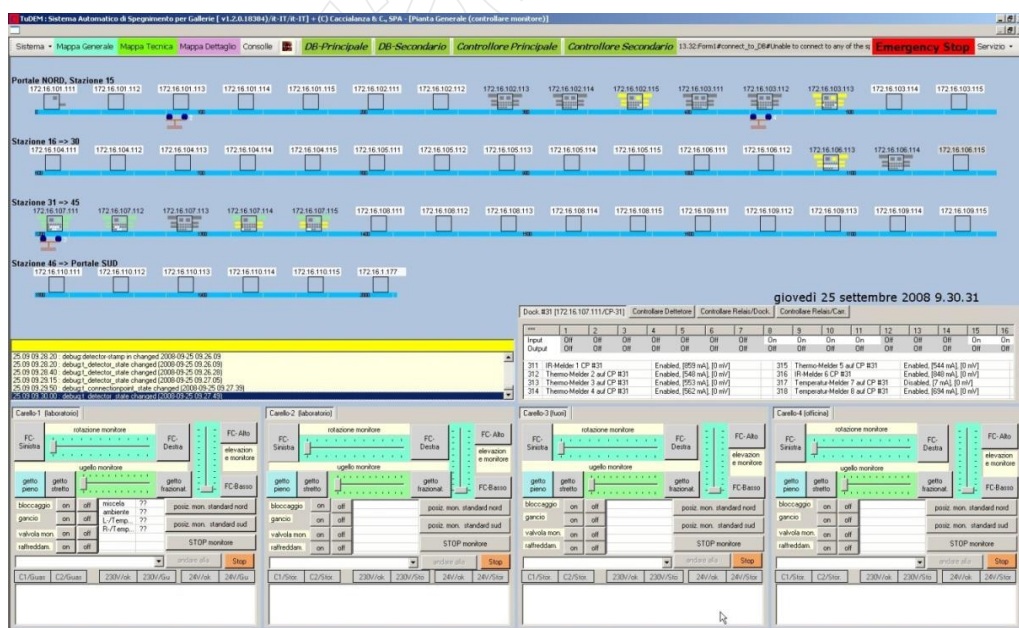
Manual remote control of the system with joy-sticks from the panel in the Control Room

From the main command and control panel in the Control Room it is possible to control the situation in the tunnel by means of high sensibility IP / TV cameras for visible and infrared light mounted on the mobile units or on each fixed monitor, and to operate the monitors from remote with the joy-stick controller, aiming the jet of the monitors exactly on the fire.



This operation can be performed as final tuning of the automatic intervention of the system or on autonomous decision of the operator in the Control Room.

In this case it is sufficient to click with the mouse the exact point on the screen where the extinguishing operation is required in order to activate immediately the positioning procedure of the mobile units and their connection to the water supply line and to the electric power and signal transmission line (1st version), or to activate immediately the automatic selection procedure of the involved monitors (2nd version).



The IP / TV cameras for visible and infrared light allow the monitoring of the tunnel from the Control Room, with visible light or infrared technology depending on the local conditions and on the size of the objects to be observed.



Finally the system allows to best coordinate the operations of the fire brigades, showing continuously the situation of the fire area and of the surrounding.

Dimensioning logic of the system

Studies on the behaviour of fire development in tunnels performed by Research Institutes and Fire Brigades Laboratories are available in the literature, both supported by real tests and by mathematical models based on semi-empiric relations.

These studies, specially focussed on the time / temperature curves depending on the heating power of the different ignition sources, show that the maximum temperatures in a tunnel fire are reached after about 10 minutes, and that for the first 5 minutes the temperature inside the tunnel does not significantly differ from the temperatures reached by similar fires in open space.

When proper extinguishing actions start, the temperature increase stops almost immediately.

Following to the above, for tunnel fires an efficient extinguishing system must be activated in less than 5 minutes. Of course, above indicated parameters are average values, and the specific value for each single tunnel must be determined with a risk analysis.

The dimensioning of the automatic fire extinguishing system with remote controlled monitors for tunnels protection (in both versions) must consequently assure an intervention time of less than 4 minutes from the start of the fire to the beginning of the automatic extinguishing action.

A time of less than 2 minutes is considered for the fire detection and the validation procedures.

For the system with mobile remote controlled monitors on overhead trailer (1st version), the translation of the mobile units to reach the nearest docking station for connection to the water feeding line and start automatically the extinguishing operation requires less than 1 minute.

The translation speed of the mobile unit along the overhead rail is ≥ 10 m./sec.

Therefore, the mutual distance of the single mobile units (trailer with monitor) in "stand-by" condition (when not working) is ≥ 500 m. up to 1 km (typical step 800 m.).



In less than 1 minute the monitors are activated and positioned and the extinguishing operation can start.

In case of remote joy-stick operation of the system directly from the operator in the Control Room, the time of intervention can be further reduced.

Indeed, when the operator in the local or remote Control Room individuates a fire, he can immediately activate the extinguishing procedure (eliminating the time of automatic fire detection and validation), starting the extinguishing operation in less than 2 minutes.

The same happens if the operator decides to activate the extinguishing operation based on an alarm from a single fire detector, after checking the situation via the IP / TV cameras for visible and infrared light, without waiting for the redundant signal of the heat sensing cable (which is normally slower).

System reliability

The world wide proven extinguishing capacity of the automatic fire fighting system with remote controlled monitors is combined with the highest reliability of its components, considering the particular conditions where the fire fighting intervention must be performed. To assure the highest reliability, redundancy has been applied to all critical parts of the system, for which not only the best materials and components available on the market have been selected, but also the most updated and reliable technology of monitoring, communication and check procedures have been adopted.

In particular for the data transmission a TCP/IP system has been selected, in order to allow the direct use of already existing communication structures or future structures to be realized for the remote transmission of alarms, commands and controls to the centralized Control Rooms of the tunnel without additional costs.

The system is therefore designed to be redundant in all its features:

- extinguishing operation by means of 2 monitors on the 2 sides of the fire (1 monitor is sufficient for extinguishing the fire),
- the power supply of the docking and control stations is performed in a loop; therefore it is possible to supply separately and independently the two sides of any area involved in the fire,
- the data transmission (both via optical fibre and copper cable) is performed in a twin loop, separately and independently for the two sides of any area involved in the fire,

The extinguishing operation can work continuously without time limitation, as there are no components or resources of the system subject to exhaustion.

Applications of the system for ordinary monitoring and maintenance activities in the tunnel

Beside the main fire protection function, the automatic system with remote controlled monitors can be utilized also for different purposes, such as monitoring and maintenance activities during the ordinary operation of the tunnel.

The mobile units equipped with IP / TV cameras for visible and infrared light can be moved along the tunnel to any docking and control station by means of the remote control system from the Control Room or, alternatively, additional fixed cameras can be mounted along the tunnel in proximity of the docking stations without any extra cost for signal transmission, feeding and management of these cameras, as such functions are already provided in the proposed fire extinguishing system.



The monitors can be used for cleaning activities (washing of the internal tunnel surfaces) or anti-pollution activities (dilution of dangerous liquids spills) by moving the overhead trailers wherever required along the tunnel by means of the remote control system and by spraying specific detergent or solvent liquids properly admixed to the water.

Both the docking and control stations and the mobile units can be equipped with sensors for check of the air pollution (CO, etc.) or for check of explosive atmospheres in the tunnel, for continuous working and monitoring both during ordinary traffic conditions and in emergency conditions.

Technical features of the system

The detailed description of the technical features of the automatic fire extinguishing system for tunnels protection with mobile remote controlled monitors on overhead trailer (1st version) and with remote controlled fixed monitors uniformly spaced along the tunnel (2nd version), is reported in the chapter relevant to each system.

- **AUTOMATIC FIRE EXTINGUISHING SYSTEM for TUNNEL with REMOTE CONTROLLED MONITORS on OVERHEAD RAIL**
- **AUTOMATIC FIRE EXTINGUISHING SYSTEM for TUNNEL with SPREAD REMOTE CONTROLLED MONITORS**



The pictures in the tunnel show the extinguishing tests performed in the Test Tunnel of the Italian Fire Brigades' Training Centre in Montelibretti (Roma).

Caccialanza & C. reserve the right to change at any time, without prior notice, any specification or feature of the system in order to continuously improve the product.

The Automatic Extinguishing System for Tunnels with Remote Controlled Monitors on Overhead Rail is protected by the following Patents: Italian Patent MI2007A 000584 and MI2008A 000735, International Patent PCT/EP2008/002153.

Automatic Interactive Signalisation and Visual Guide System for Escape Routes in Tunnels and Confined Areas

Description and technical data of the system

Innovating system for signalisation and visual guide along evacuation routes to be installed in tunnels and confined areas for fully automatic interactive intervention. The system can operate in a fully automatic and interactive way.

During emergencies it is very important that people inside tunnels (especially in long ones) are able to orientate themselves and move in the right direction (opposite to the accident one) in order to reach the accessible tunnel exit or the safety zones depending on the emergency in progress.

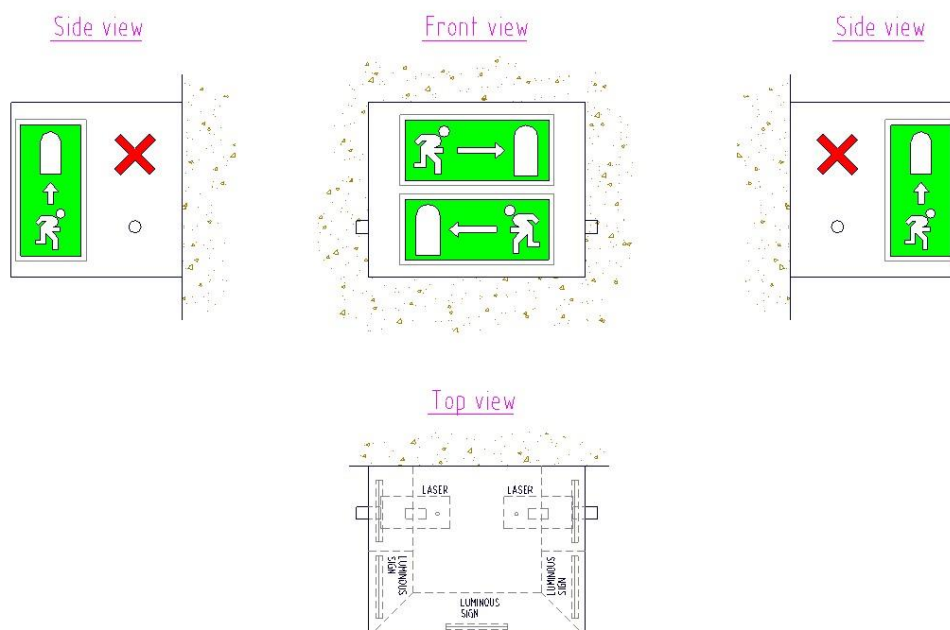
This system shows along the entire tunnel the evacuation route for the existing emergency, with continual, univocal optical signs that can be seen and followed continuously even in case of smoke, that may develop and spread inside the tunnel in case of fire emergencies.

In particular the system is designed to be combined with TuDEM, the automatic fire extinguishing system for tunnel protection with remote controlled monitors designed by our Company in two versions with mobile remote controlled monitors on overhead rail and with fixed remote controlled monitors spread along the tunnel.

Through a proper interface the signalisation and visual guide system for evacuation routes can work also with any fire detection and alarm management system already existing in the tunnel.

The system can be manually operated too.

The typical structure of each module is reported in the following picture:



DIS. NR. MT001781



The interactive signalisation system for evacuation routes therefore consists of modules spread along the tunnel at regular intervals of 40/50 meters.

Each module is equipped with the following light beacons:

- two light signs with 2 green pictograms showing opposite evacuation directions, parallel to the tunnel axis,
- two other light signs with two green pictograms showing the opposite tunnel exits and two light signs with red pictograms showing the dangerous direction placed on the sign sides perpendicularly to the tunnel axis,
- two green laser ray transmitters inside the module in opposite directions along the tunnel axis,
- a permanent optical signal of the system operation condition.

Each laser ray is aimed to a special target placed at the basis of the side pictogram of the nearest module.

Thus it is possible, through a special logical controller inside the module, to operate the instructions related to an evacuation direction or the instructions for the opposite direction.

In both cases in each module the following will be operated:

- one of the two light signs with 2 green pictograms parallel to the tunnel axis,
- the laser ray hitting the target of the closest module in the evacuation direction,
- the sign with frontal green pictogram opposite to ray in operation (showing the evacuation route and the target of which will be hit by the ray of the preceding module), and
- the sign with frontal red pictogram on the side of the ray in operation (therefore in the direction opposite to the evacuation route).

On the next page the above is schematically shown.

It is therefore possible, controlling each module properly with two digital signals, to create two continuous signals of evacuation routes in opposite directions from any area of the tunnel where the dangerous situation occurs.

The rays visually guide people inside the tunnel, depending on the cases, to an exit or to a safe area (shelter).

System operation

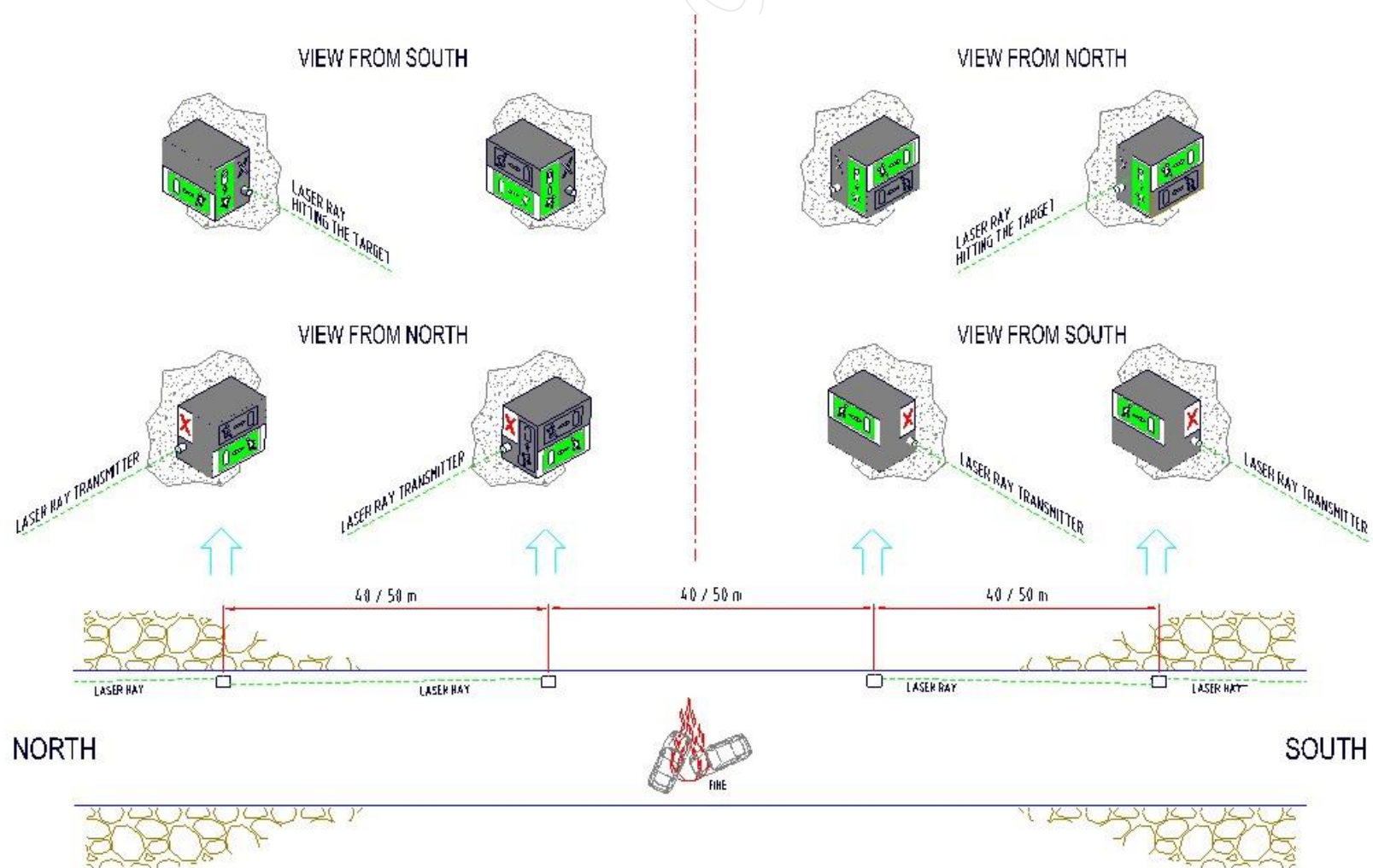
The fundamental peripheral unit of the system of signalisation and visual guide consists of the above briefly described module, of which there is a picture on page 9.

Distance among modules is 40/50 meters.

In a tunnel with Caccialanza fire extinguishing system with remote controlled monitors both in mobile execution on overhead rail and in fixed execution with spread monitors, modules are integrated in the docking or intervention stations already existing.

From these station panels modules are provided with electric power supply and commands to their local internal logic, controlling selection of the evacuation direction to visualize on the specific module depending on the received signal.

On the contrary the logic controlling selection of the evacuation direction for each area of the tunnel is managed interactively by the fire extinguishing system, based on the signals of the single fire detectors installed inside the tunnel or based on the direct commands by the operator in the control room.



DIS. NR. MT001780



The evacuation route visualization system can be used even without Caccialanza fire extinguishing system TuDEM.

In fact the system for visual guide and evacuation route visualization, as it is equipped with a standard digital interface, can be combined with any other plant for fire detection, fire extinguishment or emergency management already existing inside the tunnel.

In addition manual operation is always possible both from a panel installed in the tunnel Control Room or in any other technical room, and from points for emergency management at the tunnel entrances.

System reliability

The world wide proven capacity of this system is combined with the highest reliability of its components, considering the particular conditions where the emergency intervention must be performed.

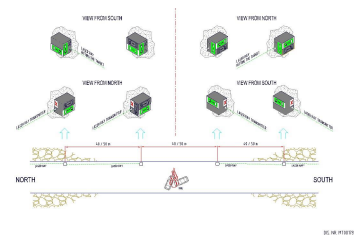
To assure the highest reliability, redundancy has been applied to all critical parts of the system, for which not only the best materials and components available on the market have been selected, but also the most updated and reliable technology of monitoring, communication and check procedures have been adopted.

In particular for the data transmission a TCP/IP system has been selected, in order to allow the direct use of already existing communication structures or future structures to be realized for the remote transmission of alarms, commands and controls to the centralized Control Rooms of the tunnel without additional costs.

Technical features of the system

The detailed description of the technical features of the system is reported in the chapter

Automatic Interactive Signalisation and Visual Guide System for Escape Routes in Tunnels and Confined Areas



The Signalisation and Visual Guide Interactive System for Evacuation Routes in Tunnels and Confined Areas is protected by the following Patents: Italian Patent MI2008A 002113,
International Patent pending.

Caccialanza & C. reserve the right to change at any time, without prior notice, any specification or feature of the system in order to continuously improve the product.