SIGNALISATION AND VISUAL GUIDE INTERACTIVE SYSTEM for EVACUATION ROUTES in TUNNELS and CONFINED AREAS

Generals

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

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 not 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.
In both versions of the fire extinguishing system TuDEM, at regular intervals of 42 meters along the tunnel there is a docking station equipped with a module of the signalisation and visual guide system for evacuation routes.

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 picture of page 2.

Description and technical data of the system

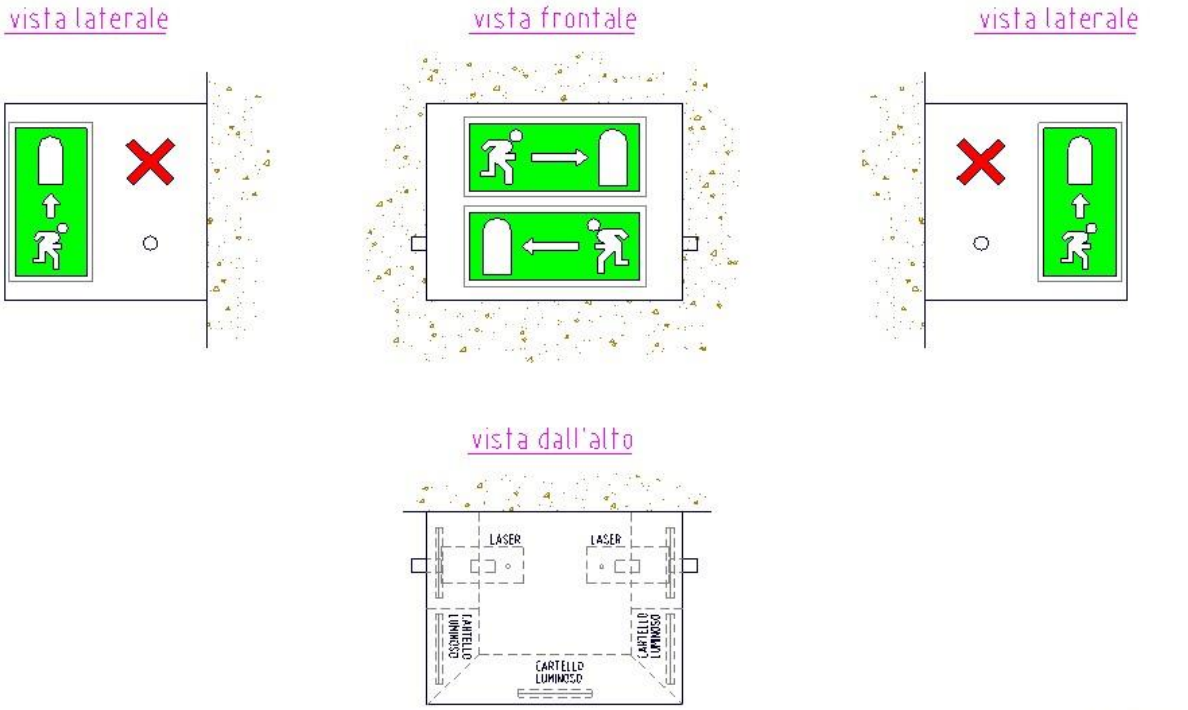
The interactive signalisation system for evacuation routes therefore consists of modules spread along the tunnel at regular intervals of 40/50 meters.

In those modules are concentrated all the operational and visualisation elements which constitute the system, with the exception of the command central unit which is installed in a technical room.

Each module is equipped with the following light beacons:

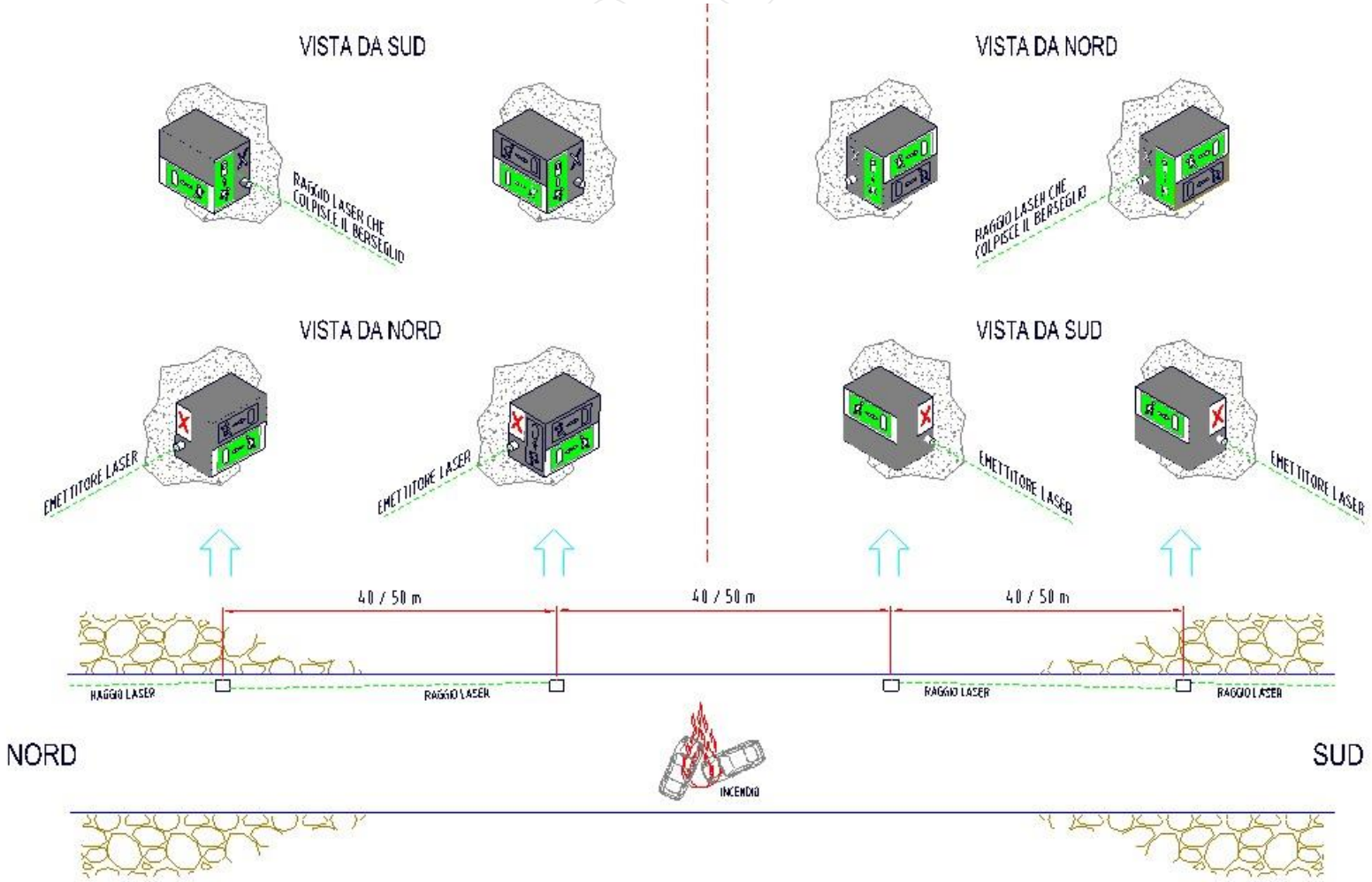
- two light signs with 2 green pictograms showing opposite evacuation directions, parallel to the tunnel axis,
- two other light signs with two green pictograms showing the opposite tunnel exits and two light signs with red pictograms showing the dangerous direction placed on the sign sides perpendicularly 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 page 3 the above is schematically shown.

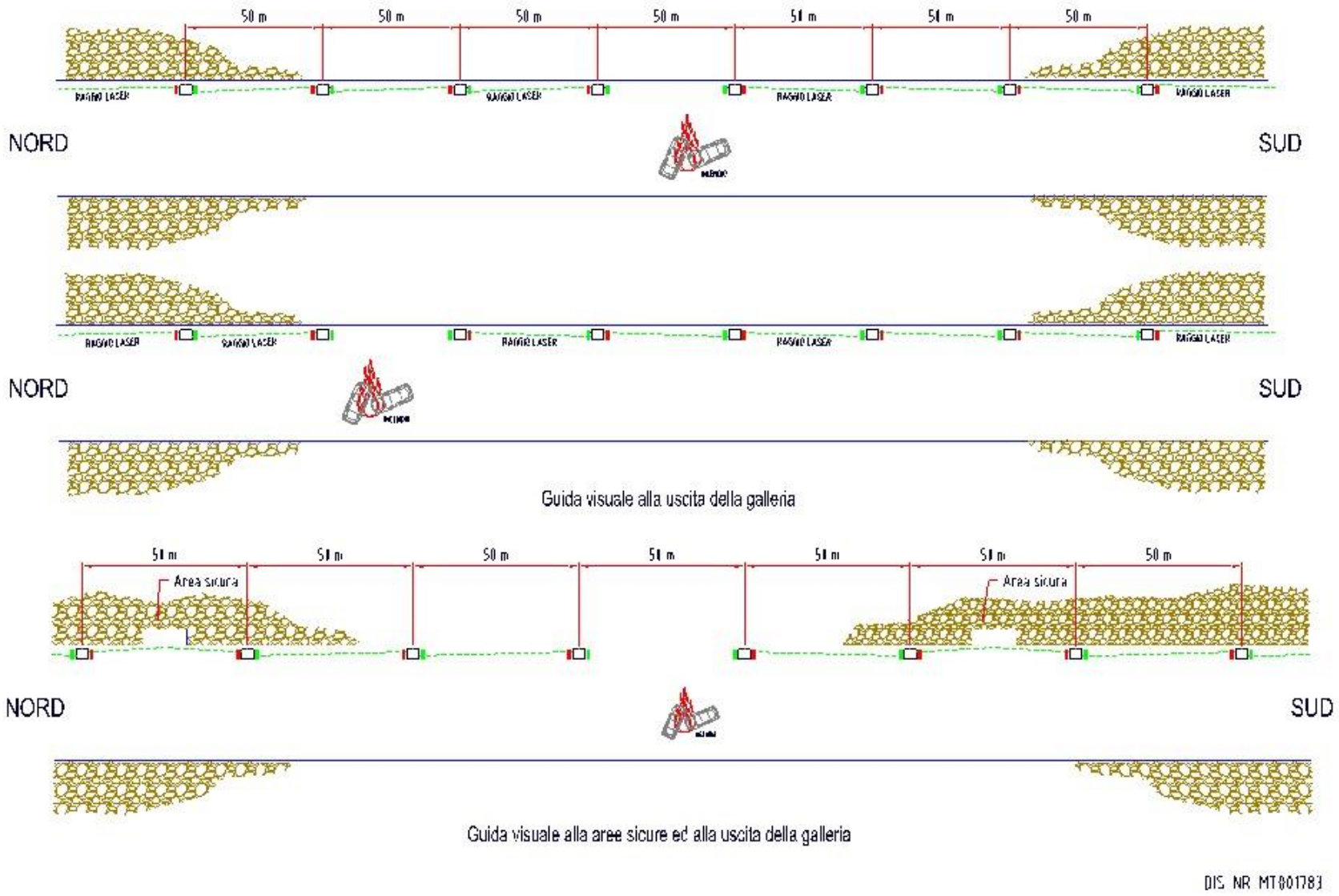


DIS NR MT001789

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).
In scheme on page 6 there are some examples of visual guide for different danger situations, both in case evacuation routes are directly outside the two tunnel exits and in case along the tunnel there are safe areas.
Of course the schemes are only indicative; the thorough modularity and reliability of the visual guide system combined with the possibility of interactive command/control of all its functions make possible any guide configuration, fitting it, if required, to the changing operating conditions.

In the system design phase, particular attention has been paid to safety and easy understanding of the system even by the unskilled operator when the system is both in stand-by and in operation.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RAGGIO LASER
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Guida visuale alla uscita della galleria
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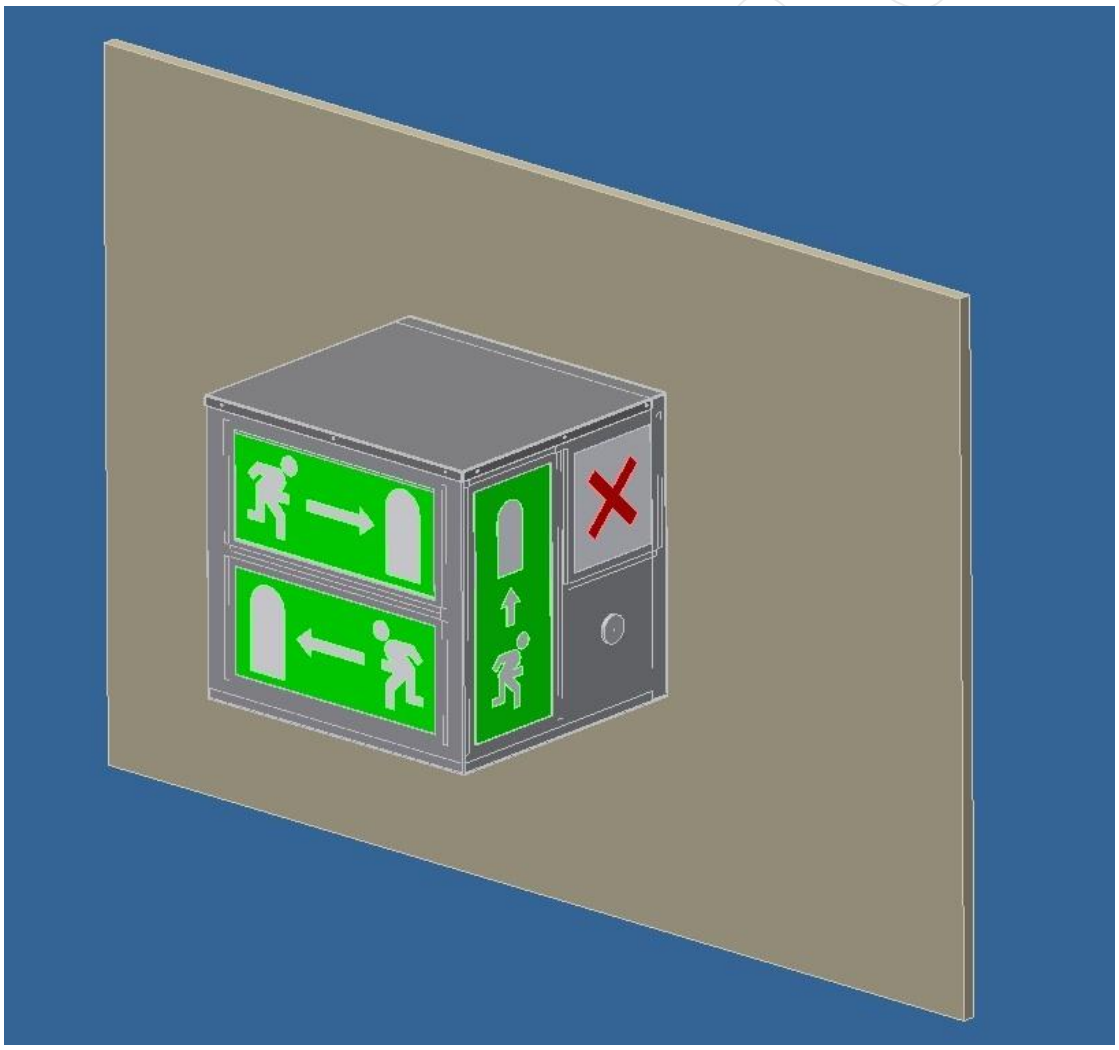
System operation

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.



Signalisation and visual guide module
(in the picture all the pictograms, that in actual operation are never all in function at the same time, are highlighted)

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.

Intervention 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.

Also smoke development, strictly depending on the tunnel characteristics and the existing venting plants, during the first minutes from the beginning of the fire does not increase too much and starts then to increase and spread in the tunnel.

Based on the above considerations, the signalisation and visual guide system has to fulfil two main requirements, valid also for emergencies not directly in connection with a fire:

- To allow people inside the tunnel to understand easily, quickly and univocally the direction to follow, without a specific training or particular knowledge about safety. Should the first decision about the evacuation direction be wrong, recurrent warnings have to inform people inside the tunnel about the mistake so that it can be corrected.

- To provide people inside the tunnel with a continuous guide easy to follow along the entire way to cover inside the tunnel, that can be seen even in case of very thick smoke.

Technical data of the system

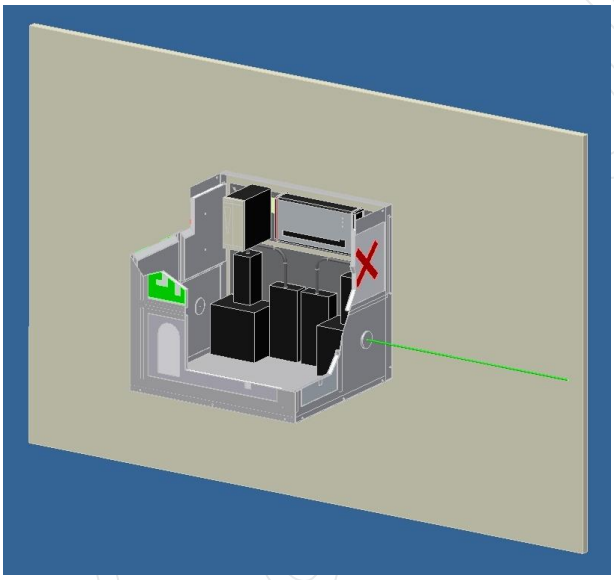
The distance of 40/50 meters for the positioning of the single units is highly conservative and mainly considers two factors which are very important in the interactive management of an emergency:

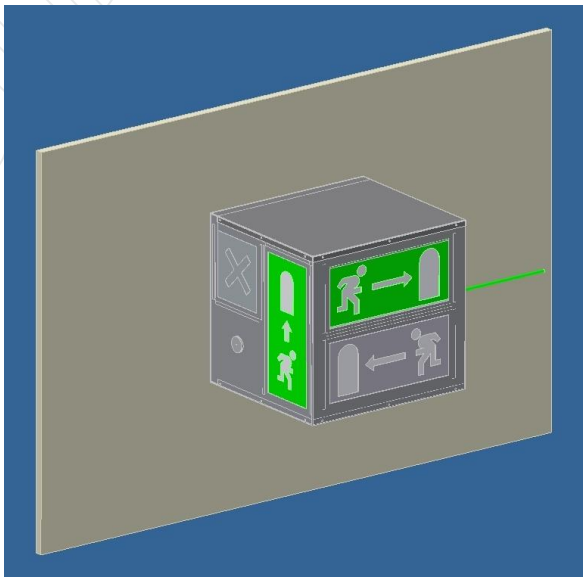
- The need to define each time and with a small distance the right evacuation direction to choose for any person in any place of the tunnel.
  The choice has to be supported by visual, absolutely univocal elements (shape of a person running to the tunnel exit with green light) allowing, in case of wrong direction, people to realize the mistake in short time and change the evacuation direction.

In order to make signals easily recognizable, they are lighted by a diffuser supporting the signals and the dimension of the pictograms seems bigger with respect to the typical identification distance.
In addition, the wrong direction is explicitly highlighted by a symbol (X lighted up in red) familiar and known by all car drivers, people travelling on the roads even with public means of transport.

- The need for escaping people to have a continuous, visible, never stopping visualization even in eventual complete darkness, that has not to become invisible because of fire smokes.
For this reason the system uses very powerful (330 m W) laser rays producing a green ray with power spectrum in the 532 nm.
Each laser ray (that in normal conditions could cover the entire tunnel length) hits a target in the next station and therefore has to cover about 50 m. only.
The procedure is the same for each station.
This means that the system can work even if 90% of the ray is absorbed by smoke.
Furthermore, as smoke increases the green heat of the ray, it is perfectly visible in any condition.

Power supply of each unit is performed in a loop, in order to ensure operation even in case of power grid failure.
A redundant bus foreseen for command/control data transmission assures the highest reliability of the system; the units are equipped also with local digital inlets for additional direct operation.





System reliabilty

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.
The system is therefore designed to be redundant in all its features:
- visualization of each unit is always ensured by at least two different signs for each direction,
- the power supply of the units is performed in a loop; therefore it is possible to supply separately and independently the two sides of any area involved in the fire or in the emergency,
- 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.

Easy system installation

This system can be easily installed in new or in existing tunnels, without need to stop the tunnel traffic during the installation works of the system.
It can be installed in motorway tunnels, railway tunnels and in underground lines.

Maintenance

Like any safety system (as required by law), this system needs periodical maintenance.
The maintenance activities on our system are particularly easy because all system components are permanently monitored by the central control panel with immediate signalisation and record of any problem. Furthermore, most of the components are installed in the docking and control stations, so that the maintenance can be easily carried out without stopping the tunnel traffic.
Finally, the system does not include any component with a limited service life (requiring periodical replacement).

The pictures in the gallery have been shot during extinguishing tests performed in the Test Tunnel in the Training Centre of the Italian Fire Brigades in Montelibretti (Roma).

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.

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