THE FUTURE OF ROAD GUIDANCE IN TUNNELS
Mario Goldbrich
D. Swarovski & Co Swareflex Division, Austria

1. INTRODUCTION
The risk analysis of road tunnels is currently an important topic for university faculties in this field of expertise. Quantitative risk assessments help to determine individual risk characteristics for tunnels. Determining factors are the gravity of an accident as well as the probability of its occurrence. The security risk is calculated using these two factors (Baltzer, 2009).

2. OPTICAL GUIDANCE SYSTEMS
Guidance systems based on LED technology in tunnels play a key role because they are used both as a preventative measure as well as in case of an emergency. Nevertheless, the optical guidance system has not yet been defined as a separate parameter for the risk analysis. Currently the optical guidance system only is defined as one of many parameters reducing the probability of accidents.

Figure 1: Optical guidance systems reduce the risk of accidents among older car drivers

An optical guidance system makes especially older car drivers feel more safely, when driving through a tunnel, and therefore helps to reduce the risk of accidents. Several international studies have shown that the driver much better recognizes the road edge and therefore dangerous "encounters" near the middle lane can be avoided (Bartenbach, 2004). In case of emergency or fire, the guidance system serves as a warning sign that leads the fleeing pedestrians safely and quickly to the nearest emergency exit or tunnel portal. In the Netherlands, this is reinforced by the installation of green LED modules.
Optical guidance systems using LED modules have become a standard in the equipment of modern road tunnels. Different national policies require different designs, LED colors, and spacing of the modules (see RABT 2006 for Germany and Austria for RVS 9.282). The following technical functions are in use: on / off, different modes of operation (German RABT), brightness control in up to 8 levels and blinking.

Computer and LED technology are offering many new product ideas. Easily LED modules may become intelligent. These microprocessor-controlled modules offer many new functions! The modules are individually addressed and can be controlled separately. New features are chaser lights, group chaser lights in a certain speed according to the speed limit (km/h) and chaser lights leading to the next or the best emergency exit. New modules can collect additional information and report back to the operation room. This may be a simple status information (module works / does not work) or the signal may contain environmental data such as temperature and traffic information. Intelligent modules will be able to detect a fire, count the number of vehicles, measure the speed of passing vehicles, and more.

3. TECHNICAL DESCRIPTION OF OPTICAL GUIDANCE SYSTEMS

Different requirements for the installation technique in a tunnel have lead to two different systems that are available in the market: the multi-system with a direct cable connection, and the inductive system transferring power through an inductive system of coupler and LED module (Goldbrich, 2009).
3.1. Multi-system
The Swareflex multi-system consists of the following components:

- Multi-controller with power supply of 24 or 48V and 2.5 or 5A
- * Appropriate interface to the operation room
- * Direct connection using a cable or strands 2 x 2,5 mm2
- * Various module designs (Swaroline multi, LeveLite multi).
- * HD-connector IP68

![Figure 3: Tunnel Gousselerbierg, Luxemburg, Multi-system](image)

The control unit powers the multi-modules and establishes the interface to the tunnel operation. Information is transmitted in both directions. Energy supply and control signals are sent via a simple cable or strands. The intelligent modules are microprocessor controlled and can send and receive data. Each control unit can drive up to 255 separate modules. The control signals trigger different functions such as different levels of brightness, separate control of both sides of the module, 2 different color conditions (eg: green or red), chaser light, group chaser light and blinking light. The modules can return a variety of signals including various operating conditions and other data like the temperature or the number of vehicles passing.

3.2. Inductive system
The Swareflex inductive system consists of the following components:

- IHP control unit, resonant circuit 38,5 kHz, 5A current and voltage up to 200V
- Appropriate tunnel interface
- Power supply of the modules via induction coupler
- Compensator to maintain the resonant circuit
- System cable 2x6 mm2.
Figure 4: Basic configuration system inductive

The inductive system consists of one or more control units (depending on the length of the tunnel and the location of the power supply), which operate LED modules wirelessly via inductive energy transmission. An induction coupler generates the energy transfer. The modules are best mounted onto or near to the kerbstone. The brightness of the modules is adjustable via the control unit. Daytime and nighttime intensity are triggered by an external signal or by a brightness sensor.

4. INTERNATIONAL TEST PROJECTS

4.1. Chain of tunnels - Packssattel, Styria, Austria

The chain of tunnels is located on the A2 between Graz and Klagenfurt. The section Mooskirchen - Pack covers a length of 32 km at 338 to 1050 m above sea level. The tunnel was at a poor technical standard before the renovation. Since the renovation in 2007 the tunnel chain fulfills the highest standards. The optical guidance system (Swareflex Swaroline IHP) is an important part of the security and the traffic control.

Figure 5: Tunnel chain Pack, Styria

The following features have been tested:
- indication of middle lane in conjunction with variable message signs in temporary traffic displacements
- influence average speed via group chaser lights
  - optimal speed
  - speed reduction
- escape route signalization with chaser light indicating the nearest exit
4.2. Tunnel River Elbe - Hamburg, Germany

The city of Hamburg has commissioned a study on optimizing the traffic flow in the Elbe tunnel (Study optimization of traffic flow in the Elbe Tunnel, 1998). Different traffic scenarios were simulated using a special computer program. The effects of flashing lights and chaser lights were tested on the “Companion” system. Here a brief summary:

"The combination of flashing lights and chaser lights have a significant effect on improving the traffic flow. Speed profiles and average travel times show dramatic improvements. The formation and resolution of traffic jams can be effected very positively by optical guidance systems – with the effect of a general reduction of traffic jams. Flashing lights and chaser lights help to more evenly distribute the traffic flow and support the resolution of traffic jams, resulting in a quicker end to jams. The effects of the simulation based on different hypothesis need to be proven in reality.”

"Another advantage of the system is the possibility of warning drivers. On the most sensitive road section in the Elbe tunnel early warnings can be realized over a long road distance.”

4.3. Gousselerbierg Tunnel, Luxembourg

The tunnel Gousselerbierg with 2.695 meters is the second longest tunnel in Luxembourg and is part of the A7. Both tubes are equipped with 2 lanes and a hard shoulder. The official opening of the tunnel was on 24.1.2008.

Figure 6: Tunnel Gousselerbierg, Luxembourg
The optical guidance system was realized using the system multi (Swareflex multi-system) (Osch, 2007).

The following features have been tested:

- group 4 chaser light to influence the average speed
- group 4 chaser light with basic brightness
- modules one side continuous light and flashing light on the other side

5. CONCLUSION

New technical possibilities open a wide field of additional applications for optical guidance systems. Now the same modules can be used to influence the driving speed, to indicate the escape route, to indicate traffic delineations, and other applications. At the moment the lack of guidelines and scientific studies limit the possible application of new technologies. We need to better study possible applications and establish the necessary regulations.

The socio demographics are changing and the population ages – older people driving cars is a fact. Especially for those drivers an optical guidance system can help improving traffic safety.

LITERATURE


G. Osch (2007); Verkehrssicherheitsstudie Tunnel A7 Gousselerbierg; Demonstrationsvideo; Luxemburg 2007.


A. Waltl (2008); Sicherheitstechnische Sanierung der Tunnelkette Pack; 4th International Conference TU Graz; Demonstrationsvideo.