

UPTUN - Tunnel Safety Research



United Kingdom Mines Rescue Service (MRSL)



European 5th Framework Research Programme – “UPTUN”

(Cost-effective, Sustainable and Innovative Upgrading Methods for Fire Safety in Existing Tunnels)

30+ Research Partners, 11 Million Euro Total Budget



**MRS� research area –
“Human Response” (WP3)**

Task 3.1: State of the Art
Review

Task 3.2: Research on
Evacuation Support Systems



Risks have increased



EU tunnels are aging

Most tunnels have been built to specifications that have become outdated: their equipment is obsolete, traffic conditions have substantially changed since their opening, there is no general legal mechanism to improve safety once the tunnels are put into service.



EU tunnel users have changed

- insufficient coordination combined with a growing number of international trips has increased risks in congested tunnels
- non-native users are at greater risk of becoming a victim due to the lack of harmonisation of safety information, communication and equipment.

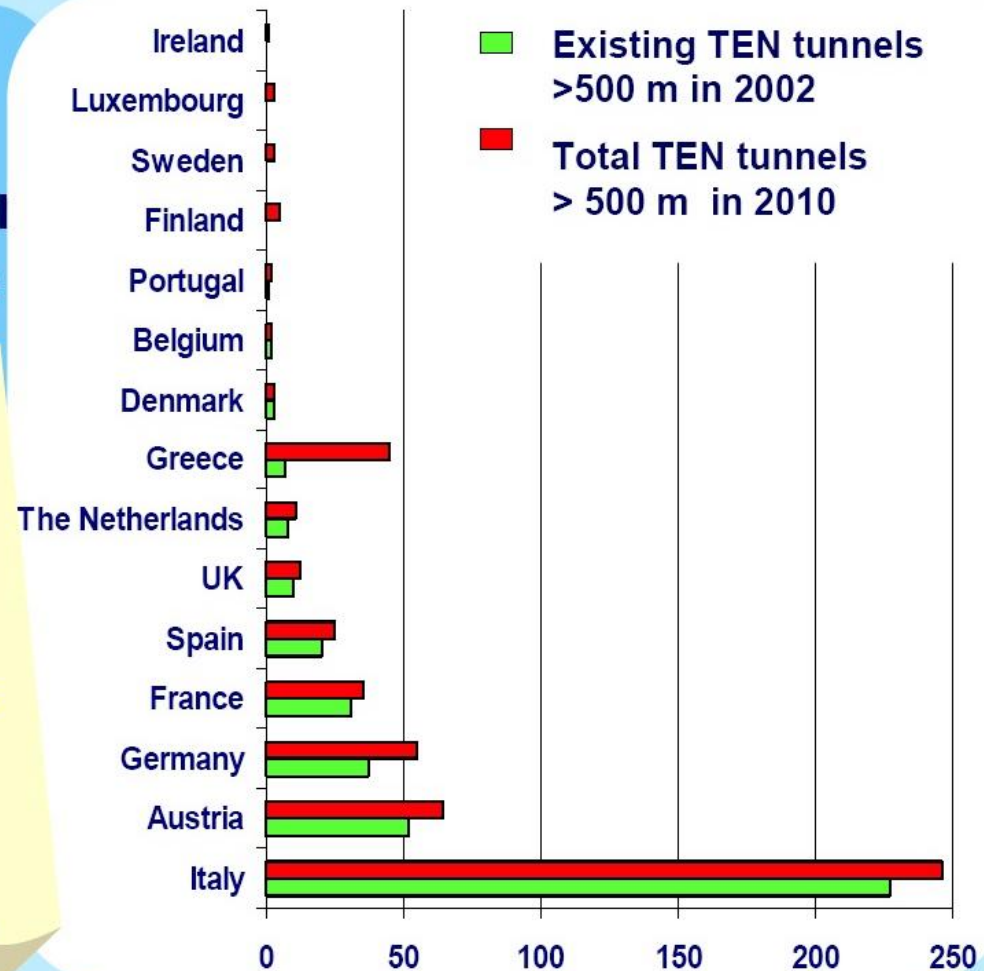




Targeted tunnels

Tunnels of the **Trans European Network** longer than **500 meters** in **operation** under **construction** or at the **design stage**.

The density of tunnels in **Italy** and **Austria** exceeds by far the density of tunnels in the EU
Greece will add the largest number of targeted tunnels
Three candidate countries have tunnels that fall in this category: **Bulgaria, Slovenia and Slovakia**.
Norway is the only EEA country with tunnels over 500 meters, 130 of them!





Fire Accidents in the World's Road Tunnels

Year	Tunnel / Length	Location / Country	Injuries/Fatalities
1949	Holland 2 550 m	New York USA	66 injured smoke inhalation
1974	Mont Blanc 11 600 m	France-Italy	1 injured
1976	Crossing BP - A6 430 m	Paris France	12 light injuries (smoke)
1978	Velsen 770 m	Velsen Nederland	5 dead 5 injured
1979	Nihonzaka 2 045 m	Shitzuoka Japan	7 dead 1 injured
1980	Kajiwara 740 m	Japan	1 dead
1982	Caldecott 1 028 m	Oakland USA	7 dead 2 injured
1982 3. Nov.	Salang 2 700 m	Mazar-e-Sharif - Kabul, Afghanistan	> 200 dead
1983	Pecorila Galleria 662 m	Gênes Savone, Italy	9 dead 22 injured
1986	L'Arme 1 105 m	Nice France	3 dead 5 injured
1987	Gumefens 343 m	Berne Switzerland	2 dead
1990	Røldal 4 656 m	Røldal Norway	1 injured
1990	Mont Blanc 11 600 m	France-Italy	2 injured

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1993	<u>Serra Ripoli</u> 442 m	<u>Bologne-Florence</u> Italy	4 dead 4 injured
1993	<u>Hovden</u> 1 290m	<u>Høyanger</u> Norway	5 injured in the collision.
1994	<u>Huguenot</u> 3 914 m	<u>South-Afrika</u>	1 dead 28 injured
1995 10 Apr.	<u>Pfander</u> 6 719 m	<u>Austria</u>	3 dead in the collision 4 injured
1996 18 Mar.	<u>Isola delle Femmine</u> 148 m	<u>Palermo</u> Italy	5 dead 20 injured
1999 24 Mar.	<u>Mont Blanc</u> 11 600 m	<u>France-Italy</u>	39 dead
1999 29 May	<u>Tauern</u> 6 401 m	<u>A10 Salzburg-Spittal</u> Austria	12 dead 49 injured
2000 14 Jul.	<u>Seljestad</u> 1 272 m	<u>E 134 Drammen –</u> <u>Haugesund, Norway</u>	6 injured
2001 28 May	<u>Prapontin</u> 4 409 m	<u>A 32 Torino –</u> <u>Bardonecchia, Italy</u>	19 injured by smoke
2001 6 Aug.	<u>Gleinalm</u> 8 320 m	<u>A 9 near Graz</u> Austria	5 dead 4 injured
2001 24 Oct.	<u>St. Gotthard</u> 16 918 m	<u>A 2</u> Switzerland	11 dead

Source: http://home.no.net/lotsberg/artiklar/brann/en_tab.html



ACCIDENTS IN RAIL AND METRO TUNNELS

Date/ Location	Tunnel length	Fatalities/Injured:
2001 Baltimore, USA	2.5 km	0 / 0
2000 Kitzsteinhorn, Austria	3.4 km	155 fatalities of total 167 passengers
2000 Notre Dame -de-Lorette, Paris, France	Underground station	0 fatalities 24 injured, 10 seriously
1999 U-bahn line 15, Cologne, Germany	Underground station	0 fatalities 67 injured, 7 seriously
1999 Minsk Metro, Russia	Underground station	52 fatalities 150+ injured of total 2000 passengers
1999 Salerno, Italy	10 km	4 fatalities 9 injured of total 1100 passengers



1996 Eurotunnel, UK - France	50 km	0 / ?
1995 Baku Metro, Aserbadjan	Metro	289 fatalities 265 injured
1994 Summit Tunnel, UK	2.6 km	0/0
1991 Severn Tunnel, UK	6.8 km	0/100? of total 291passengers
1991 Hirschen-graben Tunnel, Zürich, Switzerland	1.3 km	0 / 0?
1988 Gare de Lyon, Paris, France	Metro station	59 fatalities 32 injured
1987 King's Cross Station, London, UK	Underground station	31/?

Source: http://home.no.net/lotsberg/artiklar/andersen/en_table_1.html

+ ... Meeting requirements for increased resilience of response to terrorist attacks in transportation tunnels?



Task 3.2: Development of an Evacuation Support System

Tunnel Safety - "Cascade" of steps by importance:

1. Prevention of accidents
2. Mitigation of incident impacts
3. Provide "fair chance" of escape
4. Facilitate rescue by third parties

Research Objective: Research and develop proof-of-principle systems for guidance and evacuation through smoke.

Provide at least a fair chance of self-escape.



Behavioural and physiological issues

- Low frequency of high severity events
- Assume naïve subjects
- Delays in subject response a major problem
- Anticipate disorientation and panic
- Critical toxicity and thermal tolerance limits





Introduction of tunnel evacuation support systems ...

- Ø Will depend on standardisation, effectiveness and cost (unless prescribed by legislation).
- Ø Enhanced functionality could increase take-up.

Hence, MRSL system will support dual roles of:

1. Wayfinding and guidance through smoke
2. Tunnel environmental monitoring and fire detection

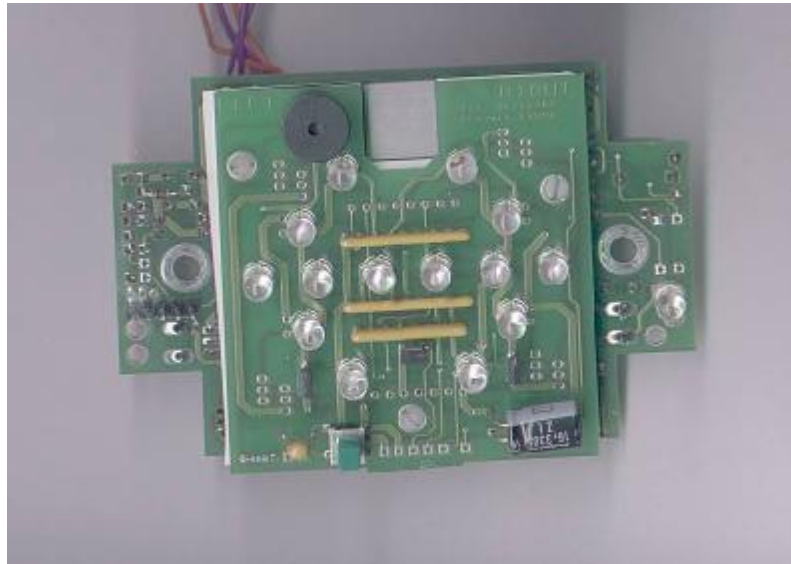
System to be independently powered, easy to install and maintain, fail-safe design, low ownership cost.



- **Single wire, no connectors or contacts**
- **Simple to install and maintain**
- **Line inductively charges internal battery**
- **Audio-visual evacuation guidance + local CO / temp. measurement**
- **Telemetry of readings using same wire**
- **Arrow can be dynamically reassigned**



Concept of
MRSL
evacuation
support
system



1



2



3

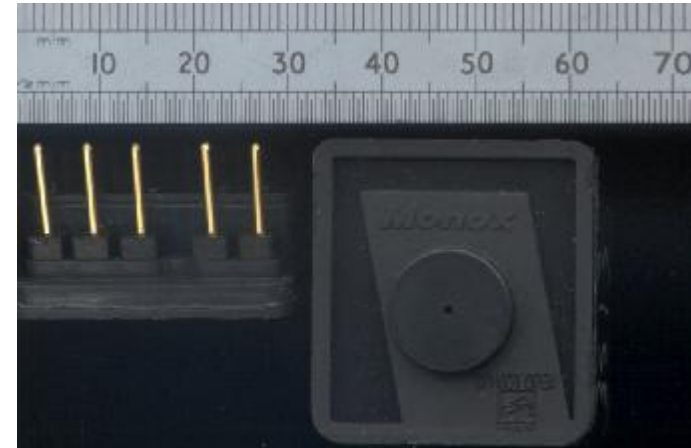
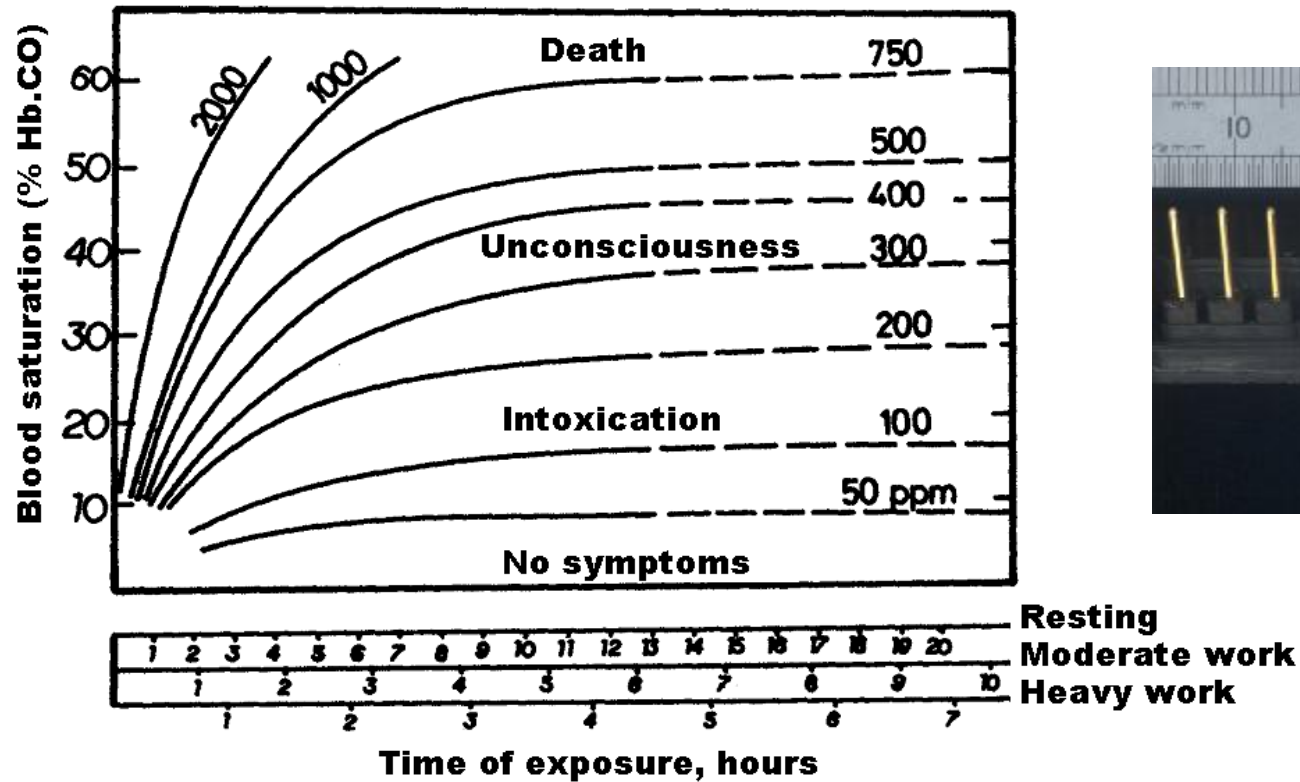
Evacuation Beacon

PCB Detail (above)

Quiescent - 1

Arrow Left - 2

Arrow Right - 3

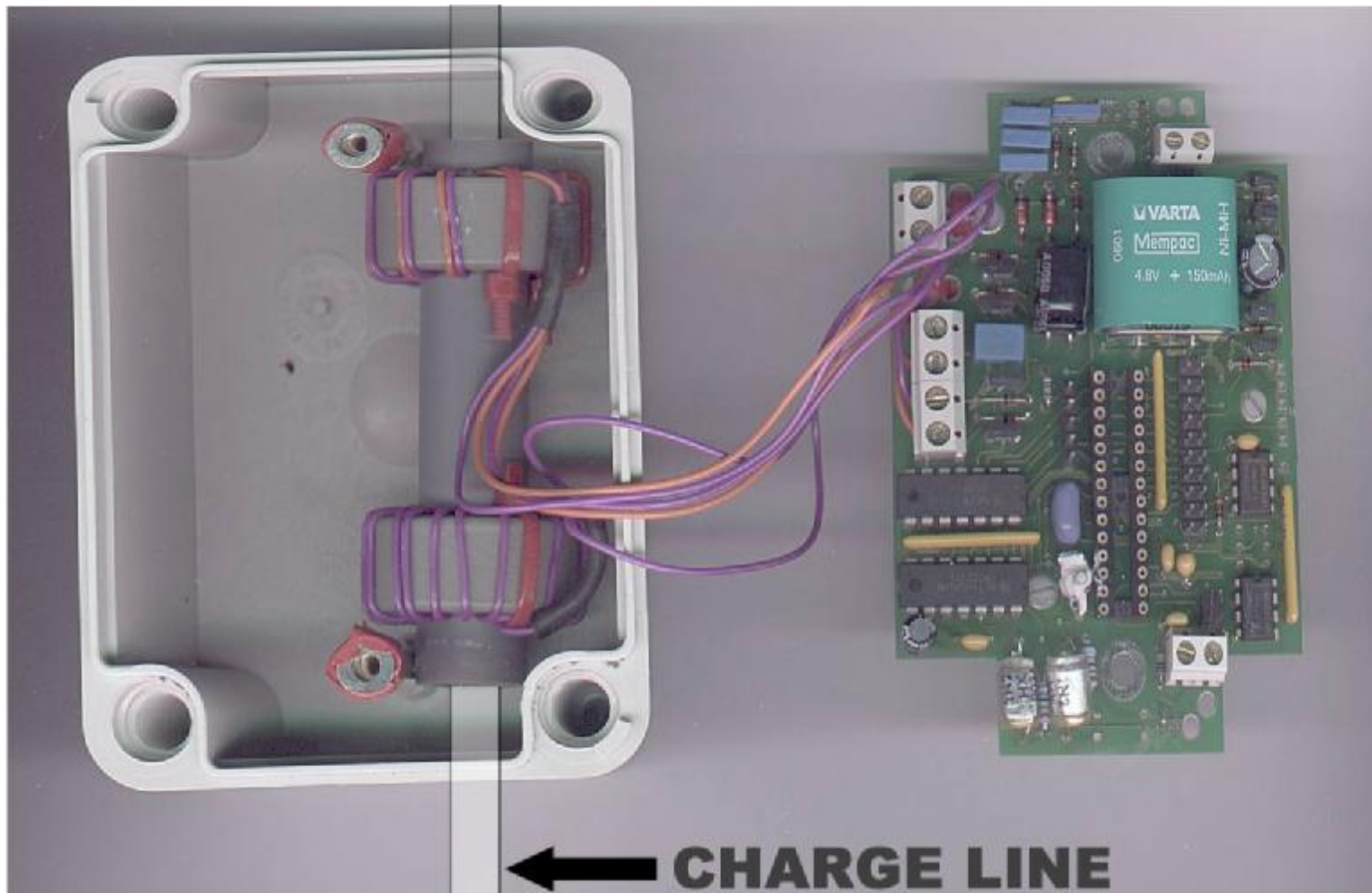


Physiological effects of carbon monoxide exposure

Inbuilt dual-range CO sensor for:

- 1. Fire / anomaly detection and**
- 2. Exposure monitoring of tunnel occupants**

Inductive charge and telemetry subsystem in early prototype





Scope to use new ‘ultra-high brightness’ LEDs for increased smoke penetration and visibility.



**Luxeon
high power
emitters**



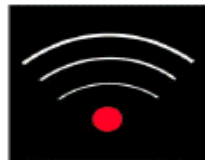
**Chip
form**



Scope to use sound localisation and voice instruction:



Directional Sound Evacuation - Tunnels



What is Localizer[®] technology?



Localizer[®] directional sound is a broadband, multi-frequency (“white noise”) sound. The sound source is easily and quickly located by our ears, making it ideal for rapid evacuation guidance. Technology details are on the web site www.soundalert.com

Developed at Leeds University, the technology is patented in the EU, Canada, UK, USA, Australia and Hong Kong, with applications being processed in Japan.

Conventional fire alarm sounders efficiently warn people in the event of a fire that evacuation is necessary, but give no indication of exit routes. Illuminated exit signs, which are often ignored as part of the everyday visual clutter, will help only if visible and not obscured by smoke. PA/VA systems can advise where to go, but cannot actually guide people along the route. Localizer-equipped audible exit signs that use directional sound properties can identify evacuation routes even in dense smoke and are complementary to all the above systems. Localizer was recently awarded the Fire Industry Council’s product innovation award.

Tunnel Evacuation

Fatalities in fires are often caused by inhalation of poisonous smoke. Rapid evacuation of the smoke-filled areas is critical to save lives.

Directional sound technology, fitted in addition to the normal bells or sounders and PA systems, offers a way to draw people to exit doors routes even in perfect visibility – however they are without equal in smoke. Triggered by existing Fire Detection systems, Localizer directional sound beacons positioned adjacent to or integrated within illuminated exit signs immediately identify their location – making them easy to locate even in smoke.



Current Position:

Novel contactless
'single-wire' power
transfer and telemetry
system now proven.



Proof-of-concept
system to be trialled in
Mines Rescue Service
test gallery, mid 2004
onwards.



Thank You