

Human behaviour influencing tunnel safety.

*Ir. Evert Worm. Dutch Ministry of Transport, Public Works and Water Management.
Head of Centre for Tunnel Safety. Member of the PIARC C3.3 Committee. Chair of
the PIARC C3.3 working group 3 on human behaviour.*

Ir. E.W. Worm
Centre for Tunnel Safety
Rijkswaterstaat Bouwdienst
Ministry of Transport, Public Works
and Water Management
Tunnelling Department
PO Box 20.000 / room 1-21b
3502 LA Utrecht
tel. +31 (0)30 285 7903
fax +31 (0)30 285 7306
e-mail: e.w.worm@bwd.rws.minvenw.nl
website: <http://www.tunnelsafety.nl>

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ABSTRACT**Human behaviour influencing tunnel safety.**

Ir. Evert Worm. Dutch Ministry of Transport, Public Works and Water Management. Head of Centre for Tunnel Safety. Member of the PIARC C3.3 Committee. Chair of the PIARC C3.3 working group 3 on human behaviour.

Considering safety of tunnels it turns out, that in spite of good design (infrastructure) and use of safe vehicles, accidents still happen, often due to human behaviour.

In this lecture some issues will be shown on human behaviour of road tunnel users and results will be presented from human behaviour tests.

Recommendations will be given to improve the behaviour of the user in normal circumstances as well as in cases of emergency.

RESUMEN**Comportamientos humanos que influyen sobre la seguridad de circulación en túneles carreteros**

Ing. Evert Worm, Ministerio de Transportes, Obras Públicas y Gestión de Aguas de Holanda. Director del Centro para la Seguridad en Túneles. Miembro del Comité C3.3 de la AIPCR, y responsable del grupo de trabajo sobre "Comportamiento humano" en dicho Comité.

Del análisis de la seguridad en los túneles surge claramente que, aún contando con buenos diseños de infraestructura y el uso de vehículos seguros, los accidentes siguen ocurriendo, a menudo debido al factor humano.

En este artículo se presentan algunos aspectos del comportamiento humano en túneles carreteros, y se muestran resultados de pruebas realizadas para verificar dichos comportamientos.

Se indican algunas recomendaciones para mejorar el comportamiento de los usuarios, tanto bajo circunstancias normales como en situaciones de emergencia.

1. Framework.

Safety is a big issue, whether we are speaking about industrial safety, social safety or transport safety. We especially experience this when we are confronted with the negative side of it: unsafety. Concentrated on transport safety and especially tunnel safety I only have to mention the disasters of 1999 and 2001 in Europe (Mont Blanc-, Tauern- and Gotthard tunnel fires) and everyone should know what I mean.

In analysing causes and effects of accidents, some basic principles might help us in doing that in a structured way.

We first might look along the so called safety chain, as follows:

- pro-action (avoid unsafety)
- prevention (diminish chances and reduce consequences)
- correction (create opportunities for self rescue)
- repression (offer help from the emergency services)

In this *self-rescue* means:

- action of others present at the scene, immediately after occurrence of the incident
- bringing oneself and others out of danger without the aid of professional emergency services.

Emergency services include:

- actions taken by the tunnel operator/manager
- actions taken by the police, fire brigade and ambulance services.

Measures can subsequently be targeted at the main components of the total system, namely:

- the infrastructure: the tunnel including all the technical systems and its approach roads
- the vehicles
- the users of the tunnel system
- the organisation; especially the operation of:
 - the tunnel operator, and
 - the emergency services

This results in the following table of possible measures, distinguished into process phasing and components of the traffic system:

Measures focusing on:	pro-action	prevention	correction (self rescue)	repression
infrastructure	x	x	x	x
vehicles		x	x	
tunnel users	x	x	x	
organisation:				

operator		x	x	x
emergency services				x

Table 1: Points of application for measures

Concentrating on human factors, we have to focus on the last two rows in the table. Despite all efforts aimed at the first two component systems (infrastructure and vehicles), serious accidents happen from time to time, whereby 'the human factor' in particular gives evidence of points for improvement. This is exactly the area at which the terms of reference of the PIARC C3.3 working group 3 are aimed.

The following deals with this human factor in greater detail, with the discussion being limited to *road tunnels*, although a number of items also apply to train and metro tunnels.

The scheduled outputs of the working group consist of:

- understanding of the road user behaviour
- "technical" safety measures derived from that (design, signs and signals)
- "organisational" safety measures derived from that (especially educational measures)
- understanding of behaviour of the emergency services
- recommendations for fire brigades, ambulance service and police, based on the behaviour knowledge.

In this lecture I limit myself to the road users in particular. This is due firstly to the state of affairs within working group 3 (activities on road-user behaviour made the most progress) and secondly to the limited time available for this lecture.

At first aspects of interest and experiences concerning human behaviour will be given (section 2) and then possibilities for influencing that (section 3).

2. Where can things go wrong with respect to the behaviour of the tunnel user?

A car driver approaching a tunnel aims to drive through it under conditions as normal as possible and to continue his journey without inconvenience.

How does he approach the tunnel?

- fit or tired
- calm or stressed
- with or without a dangerous or not so dangerous cargo
- concentrating or occupied by other matters
- as a professional driver or otherwise
- under quiet traffic conditions or in heavy traffic
- under what weather conditions
- as a frequent user or a once-only user

The situation in which the road user is, also determines his driving.

He must:

- maintain his direction
- keep his distance to the vehicle in front
- maintain the correct speed
- pay attention to the signs
- pay attention to the other traffic

Subsequently he drives into the tunnel. Driving in tunnels has a number of special characteristics.

Apart from normal driving, a number of specific effects can be evoked:

- feelings of constriction or confinement
- fear of walls
- fear of getting stuck
- visibility reduced by the darkness
- monotonous visual surroundings
- lack of orientation
- lack of connection with the outside world

Infrastructural measures must prevent or limit these feelings as much as possible.

And then suddenly something goes wrong, with fire breaking out in the worst case. Realize that this requires an enormous change in behaviour of the people involved. If this mental turnaround is not made adequately, valuable time is lost and wrong decisions are made with all the related disastrous consequences of that, as is unfortunately shown all too clearly by the mentioned tunnel disasters.

For the user involved applies:

- What is happening?
- What do I have to do?
- How do I get out as quick as possible?
- Where do I have to go?

The kind of behaviour that can actually be observed in this type of situation:

- passivity, an initial response of disbelief and people continuing their original behaviour. Realize that people not directly in the neighbourhood of a fire might think being in a “normal” queue
- people are not sure what to do. Information comes over insufficiently and/or is not followed up immediately.
- people don't like to evacuate from their vehicles (in several accidents it was shown that people died in their vehicles as a result of suffocation, although there must have been enough time to escape)
- the dangers of smoke, heat and toxic substances are evidently not perceived by the road users
- if people escape, they often look for the way along which they have come, whether in their vehicle or not
- if fleeing people orientate along the wall or road surface often missing the emergency doors, because the escape facilities are often not recognized as such (ignorance and/or lack of clarity)

In addition several ancillary effects might occur:

- frequently a fire is not detected immediately
- a fire in its early stages can often still be extinguished with fire-extinguishing equipment available on the spot. This, however, requires quick action with equipment, which must be very simple to use. Complicated directions for use turn out to be useless; in situations of stress they are of no use at all.
- it regularly turns out that available fire-extinguishing equipment is not used
- people are not familiar with the situation
- people are under time pressure and emotional pressure
- people get incomplete, incorrect or contradictory signals
- from human behaviour tests it was derived that passivity very quick changes in activity when people are ordered to escape. So it is of extremely great importance that accurate information is given as quick as possible.
- A good example will be followed in a correct way: If some tend to flee, others will follow. But also: bad example causes bad consequence. If the ones nearest at the scene don't flee, all the others tend to wait

3. Influencing people's behaviour.

People's behaviour might be improved by:

- information (general and for each tunnel)
- education (driver training)
- legislation
- enforcement

Of course those resources will not be the same for the different groups of human beings. The following table 2 indicates the possibilities.

	information	education	legislation	enforcement
tunnel user	x	x	x	x
operator	x	x	x	x
emergency services	x	x	x	x

Table 2: Resources for influencing human behaviour of different groups

As already stated before I only focus on the tunnel user and herein especially on the information he gets when passing through a tunnel.

Approaching the tunnel:

Approaching the tunnel its user should be helped with information.

That information¹ should be:

- homogenous
- uniform
- concentrated
- continuous

Information that has to be thought of for instance:

- indicating an alternative route
- permitted height
- tunnel category with respect to the allowance of dangerous goods
- the tunnel length (if longer than 500m)
- toll regulations
- route information (if one has to choose inside)
- radio broadcasting frequency
- if necessary, early guiding the road user on special lanes

and always realise, that the user has to see, to understand en to react. That all takes time. So:

- start early enough before entering with giving the information
- if necessary do it on both sides of the road
- repeat most important signs
- search for self explain ability as much as possible
- beware of overload

In the tunnel:

- avoid boring situations (especially for extreme long tunnels)
- provide the escape doors with a standard green colour and apply good visible pictograms of a fleeing person
- take care of sufficient lighting of the spot

¹ See: PIARC publication on directional signing PIARC 2006)

- consider the application of extra attention grabbers like f.i. a LED lighting around the escape door (only to be used in crisis situations)
- consider orienting light lines on the step barrier or elsewhere low near the ground
- consider providing (large) signs with the text: ALARM only burning in case of an emergency
- apply pictograms (fleeing person) every 25m on both sides of the wall and mention the distance to the nearest escape door
- also apply a sign opposite of the escape door in order to warn fleeing persons when they are on the wrong side of the road
- consider the application of an extra warning sign (spoken word and sound) above the escape doors in order to guide as much as possible
- apply arrows on the road surface (based on the knowledge that people often try to find their way with their face to the road surface)
- when people arrive in a separate escape tube also guide them further to the exit

In order to improve human behaviour in tunnels the European Union produced two leaflets which general recommendations; one for the normal road user and one for the professional driver.

This leaflet in short describes the essentials of the most important safety measures:

- ventilation systems
- emergency exits
- emergency lanes or lay bys
- emergency stations
- tunnel lighting
- traffic surveillance
- traffic radio

and gives recommendations on how to behave:

- when entering a tunnel
- in traffic congestion
- in the event of breakdown or accident
- if a car is on fire

Other information can be provided by:

- specific leaflets for each tunnel.

Many tunnel managers in many countries use information leaflets for their specific tunnel. Critics could say that such leaflets are of little use, because many put them aside unread. However, it is just like advertising: its power is in repetition.

Continuous information increases the chance that when occasion arises exemplary behaviour is prompted which is followed by others.

- All these sources of information, however, do not in themselves guarantee that the message will be sufficiently disseminated. There is therefore a lot to be said for well-directed information campaigns drawing extra attention to this, for example via newspapers, radio and television. It is of great importance that they point out the specific dangers of fire, and that swift and adequate action in such situations is of vital importance.

4. Conclusion.

The human factor in particular often is one of the most serious causes of accidents in spite of good designed infrastructure and safe vehicles. In order to reduce this risk factor as much as possible influencing human behaviour with proper design, signals and signs is urgent.

In my opinion it is very important that we internationally try to standardize these measures as much as possible. The world is becoming smaller and smaller and people travel everywhere. They will be helped very much when meeting everywhere about the same system. That's where PIARC working for in this field by formulating recommendations.