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Research on facilitating evacuation. Norwegian Public Roads Administration

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Tunnel and concrete



Norwegian road tunnels

- Ca. 1130 road tunnels, total length 1131 km
- Predominantly hard rock tunnels
- Mostly short tunnels: < 1 km
- Longest road tunnel: 24,5 km
- 525 $<$ 500 m
- 602 $>$ 500 m
- Annual average daily traffic
 - AADT $<$ 1000 for 50 %
 - AADT $>$ 5000 for 20 %
 - Oslo tunnels up to 95 000



Photo: Olav Handeland



Main reasons for road tunnelling in Norway

- Strait crossings
- Connecting rural areas
- Protecting the road from avalanches and rock falls
- Solving urban environmental challenges



Photo: Tomas Rolland, NPRA



Subsea tunnels

- 35 subsea tunnels
 - Longest subsea tunnel: 7,9 km
 - Deepest tunnel: 287 m below sea level
- First subsea tunnel opened in 1981
- Steep gradients, up to 10 %

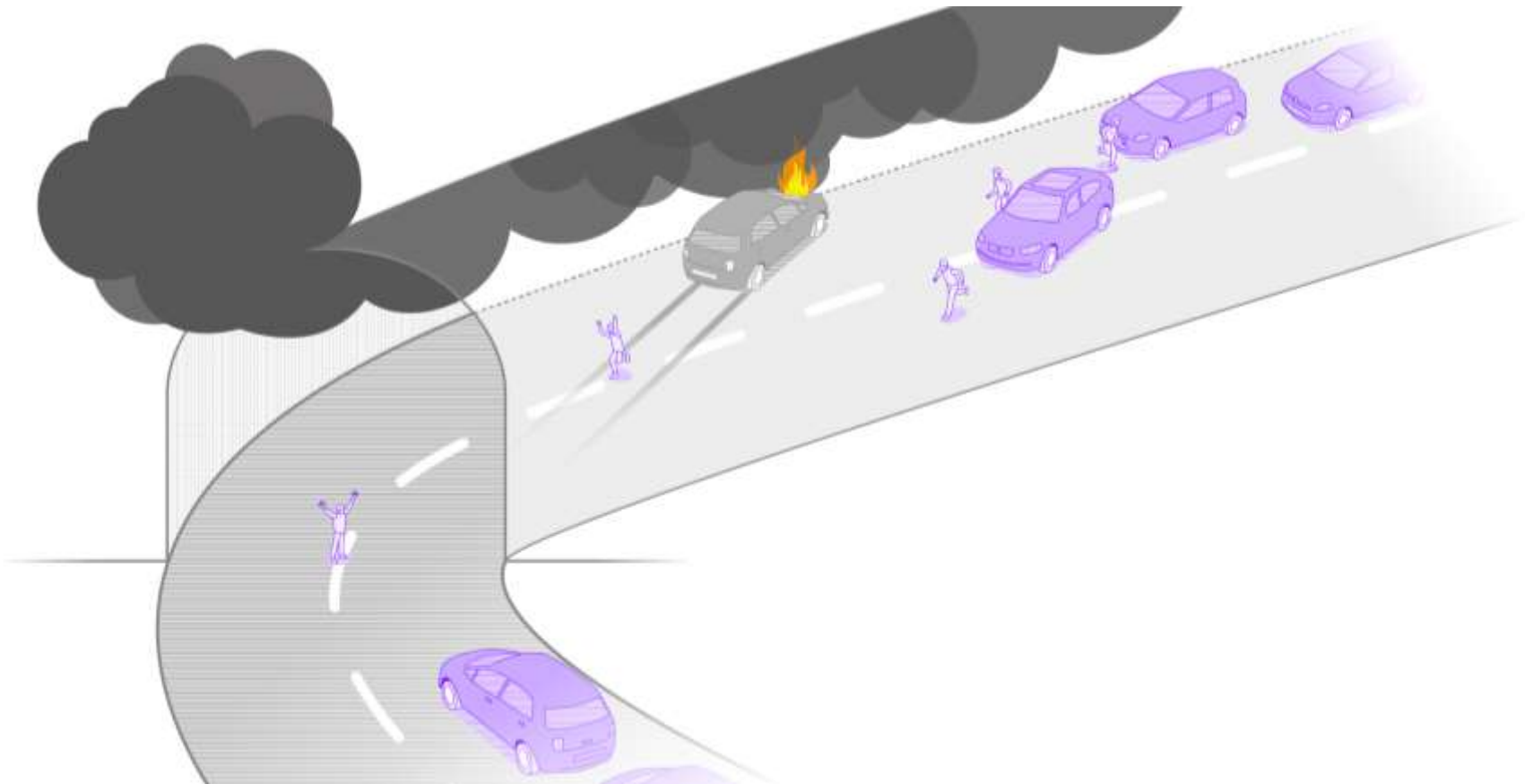


Photo: Henriette Erken Busterud



The connection between tunnel design and human behavior

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Research on human behavior in fire in tunnels

- At present, understanding human behavior in fire in tunnels is limited compared to other areas of fire safety engineering
- European experiments have mainly been performed in two-tubes tunnels
- Motorists tend to ignore tunnel signs, emergency doors, or even the tunnel walls when driving through tunnels (Boer & van Zandten, 2007)
- Social influence impact increases with uncertainty and reduced visibility (Nilsson & Johanson, 2009, Boer & van Zanten, 2007)



- Participants who received safety information prior to driving in tunnels showed better and quicker safety behavior (Muhlberger et al., 2015, Kinateder et al. 2013), Gandit et al. 2007)
- Characteristics of those who feel safe when driving through tunnels: Men, 18–28 years, drive often, never been involved in accidents, knowledge about safety, trust in authorities (Vatsvåg, 2016)
- Motorists tend to think there is a normal traffic jam, waiting for congestion to dissolve, ignoring the threat (Boer & van Zanten, 2007)



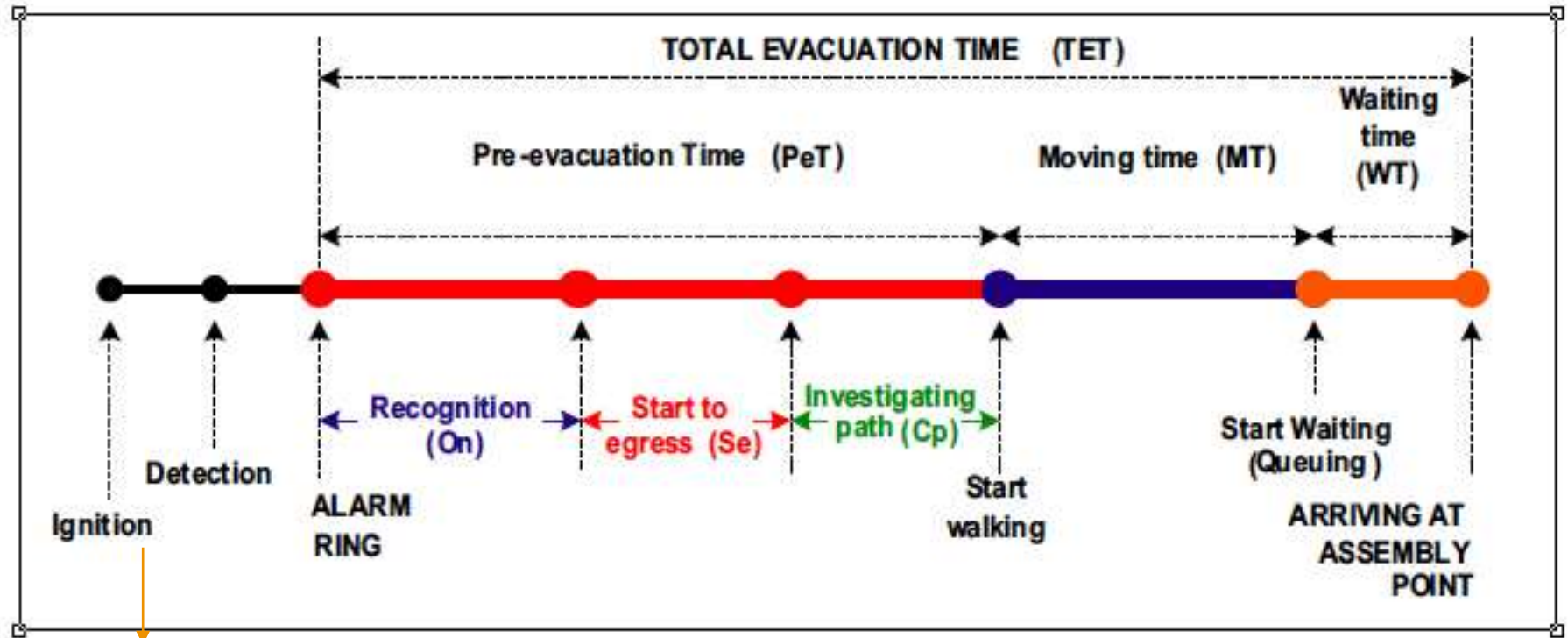
Behavioral sequence model (Canter et al., 1980)

- Three phases of evacuation:

Interpretation – preparation – action



The explanatory time line model (Frantzich, Nilsson & Rød, 2016), based on RSET model (Proulx, 2008), Rahman et al., 2008)



Pre-accident conditioning (risk comm.)



Strategy for PR campaign and driving education to ensure safe behavior during tunnel incidents

- PR campaign to the public:
 - what to do when incident happens in tunnel (self rescue)
 - what are the most important messages?
 1. You are responsible for your own safety; listen to the radio
 2. Don't enter the tunnel on red light
 3. Use the emergency phone on the tunnel wall to get in touch with the Traffic control center
 4. A fire extinguisher is available on the tunnel wall
 5. Follow the signs to evacuate
- Education of heavy-goods vehicle drivers

Safety management of road tunnels

Fundamentals for self rescue



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Safety management of road tunnels

Aim of project

- Use of rescue chambers inside the tunnels. Dimension criteria – guiding directions – safety equipment – surveillance. A study will explore whether safety is provided
- Develop technology to promote solutions that may help the motorists perform self rescue and assist the emergency services
- Develop risk accept criteria and a risk analysis model for fire in tunnels
- The innovation partnership project (supported by Innovation Norway), for safety in tunnels, will be launched medio 2020.

The project is searching for a solution to discover and provide information about what happens, what has happened, and what to do when an incident occurs in a tunnel

Self rescue – evacuation

Self rescue in thick smoke,- How can we find rescue rooms?

Simulation of self rescue in a road tunnel

- Full scale laboratory simulation
- Virtual Reality (VR) in combination with walking platform
- 3D modeling of fire evacuation in a long tunnel .




Self rescue – evacuation

- Aim:

Will safety be provided by using rescue chambers without an exit to the outside? Is it easy to find the exit doors? How much time is needed?

Method



Simulated tunnel incident. Screenshot from VR modell




Figure 1: These stages in people emergency behaviour have four observable behaviour

- A test of wayfinding
 - Not a test of hesitation time
- Fire and smoke
 - Visible when road users were in the start position
- Priming video
 - drive towards fire incident shown initially

SINTEF



Self rescue – evacuation

Variables in simulation

- Using alarm signal about fire in tunnel
- Using loudspeaker/sound signal directing the public to rescue chambers
- Using LED lights or illuminating bands
- Using personal communication media, such as the vehicle's info. system, or mobile phone



Self rescue – evacuation

Results to be explored:

- How many persons will be engulfed in smoke??
- What is the most useful aid in finding the rescue chambers?
- What proportion of the tunnel occupants find the rescue chambers?
- What variables influence decision making in evacuation?
- May personal communication medium, such as cell phone, be useful?



Self rescue – evacuation – the next step

- Functional and psychological demands to rescue chambers is simulated through eye-tracking, studying what tunnel occupants look at when evacuating. This will give increased depth information on the cognitive load when perceiving and understanding the situation
- What does it take for tunnel occupants to enter a rescue chamber inside a tunnel – and stay there until rescued?
- Tender specification published early August (see announcement on Doffin, database for public procurement)
- Simulation will be performed in the fall 2018



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Thank you 😊