Real life experience on evacuation, specializing in fire & tunnels, fire safety from simulation to real life

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https://doi.org/10.4224/20374790

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Real Life Experience on Evacuation Specializing in Fire & Tunnels Fire Safety from Simulation to Real Life

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September 27, 2010

National Research Council Canada | Conseil national de recherches Canada

Canada

Presentation Outline

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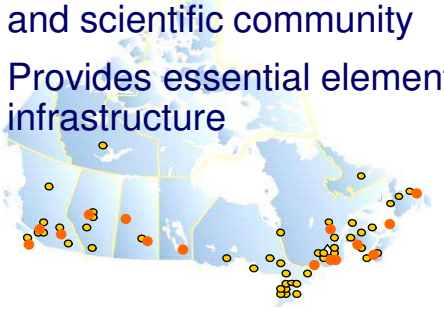
- National Research Council
- Building Information Modeling
  - Background
  - Fire Simulation and Evacuation in buildings
- Fire safety issues in tunnels
  - Integrated safety policy
  - Fire development &Egress time model
  - Human response
- Case studies

National Research Council

- National organization, federal government agency
- Over 4,200 full-time employees; over 1,446 guest workers
- Labs and facilities across Canada
- Dissemination of S&T information to industry and scientific community
- Provides essential elements infrastructure



The Canadian Construction Sector

12% of GDP
$146.1 billion capital expenditures
Over $5.5 trillion built assets*
Largest employer > 1M
Low R & D expenditures

*Source: NRC-IRC Advanced Asset Management: Tools and Techniques

Facilities account for 35-40% of national energy consumption
Generates 25% of Canada's solid waste
Consumes >50% of primary natural resources
Long product life means enduring impact
Generates 30% of total GHGs

Source: Athena Sustainable Materials Institute, Natural Resources Canada

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Institute for Research in Construction

Established 1947
Guided by industry advisory board
and 2 Commissions
$33 million budget,
238 employees, 40 visiting workers
Ottawa, Regina and London

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Fire Research Program

Centre for Computer-assisted Construction Technologies

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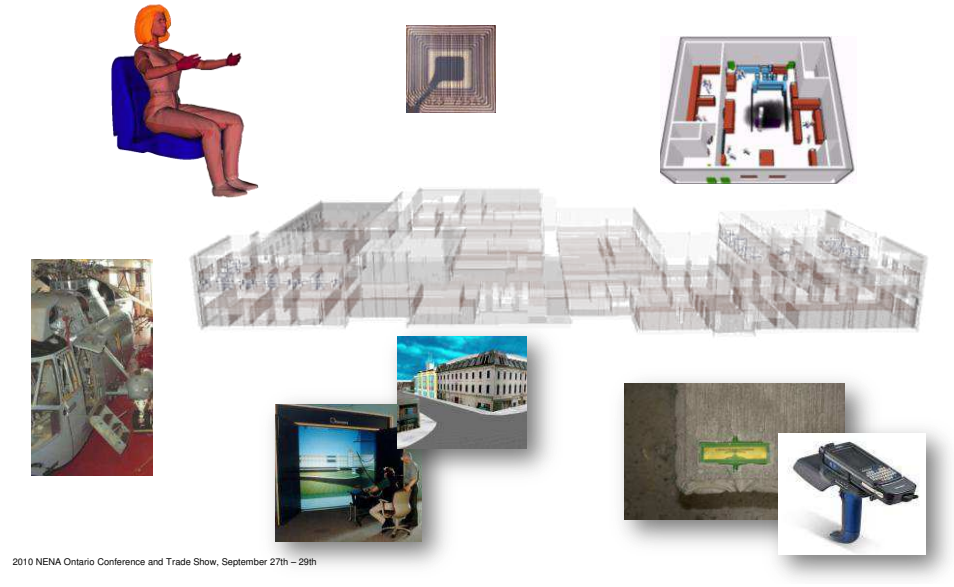

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Building Information Modeling

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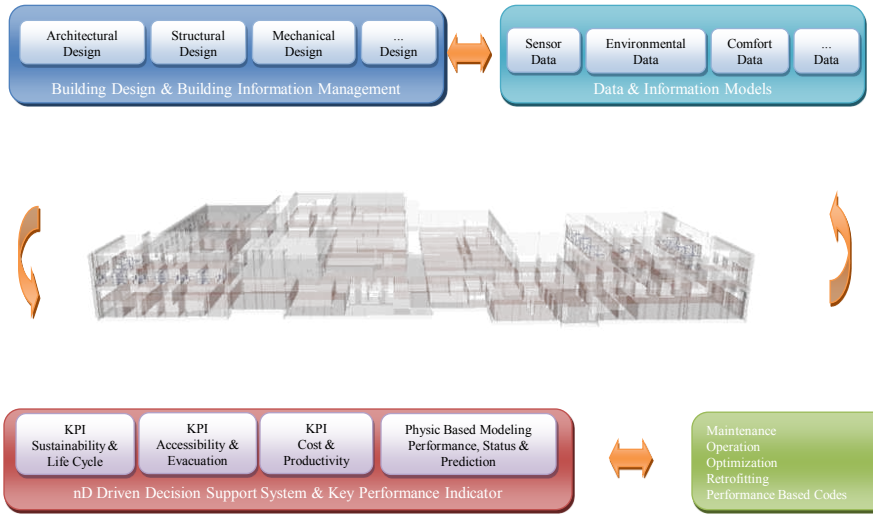
- What it isn't:
  - process, software, standard
- What it is:
  - Use of BIM
    - **Communication Collaboration and Data Reuse**
  - For all aspects of a facility
  - Over entire life-cycle of a facility

Autodesk ©

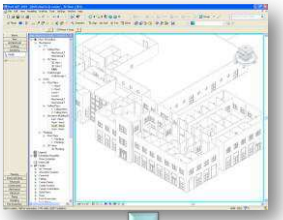
Dynamic Building Information Modeling

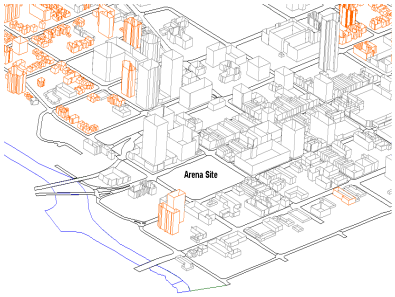


BIM & Fire Safety

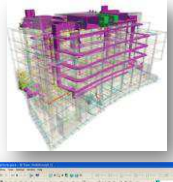
- Code & Standard
- Fire resistant rated construction
- Sprinklers, type strength angle
- Alarms
- Fire Extinguisher
- Evacuation
- Dangerous materials

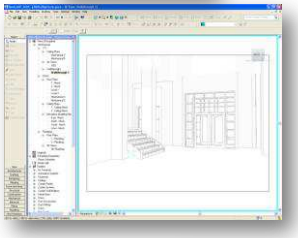
Geographical Rendering and Neighbourhood Impact





Building Information Modeling Walk through & Evacuation





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Building Information Modeling As Built

- Large Data for Building Scans
  - As built, As Design Philosophy
    - Virtual sites
    - Accurate Data capturing, Surface parameters computation
  - Sectional and Feature Contours
    - Building layouts, Feature and Section Identification
    - Partial model surface can be created where required
  - Handling Large Data
    - Data Simplification, Segmentation
  - Measurements
    - Dimensions, Angles, Areas, Volumes etc

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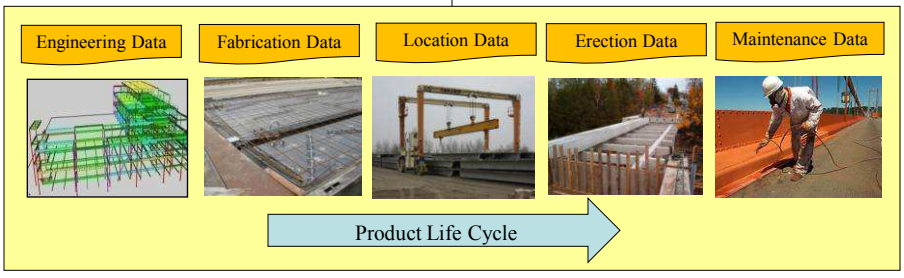
Product Life Cycle Traceability of Structures

RFID Reader



Building Information Modeling
Fire Simulation and Evacuation

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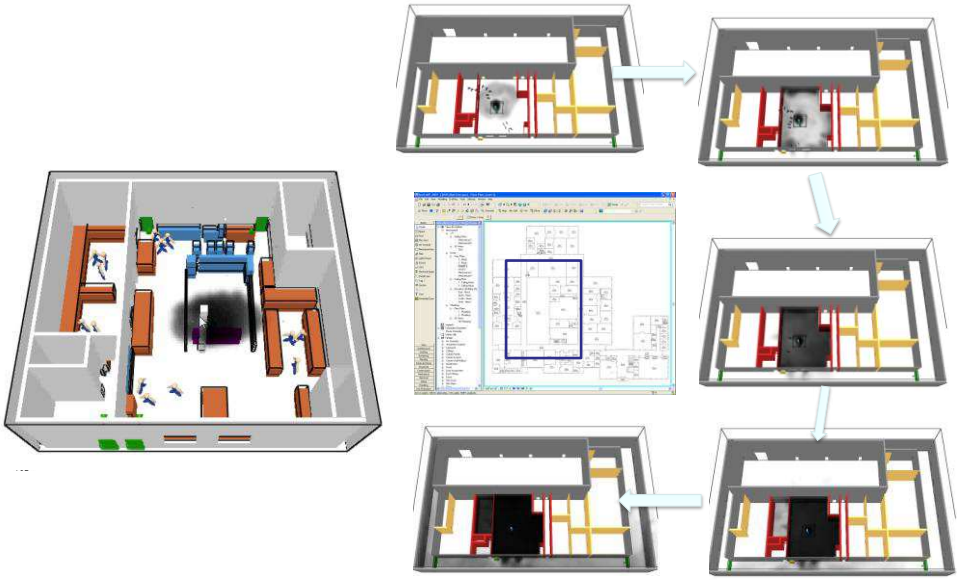

Building Information Modeling
Fire Simulation and Evacuation

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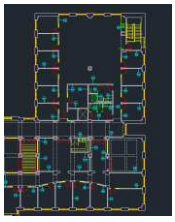

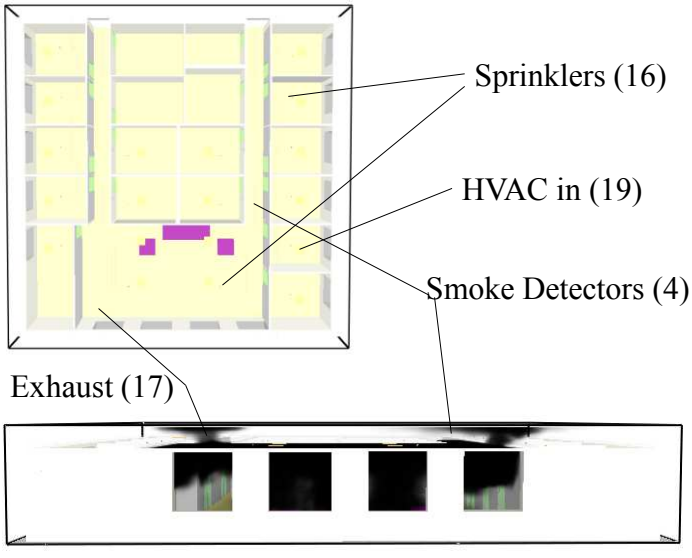

Building Information Modeling Evacuation

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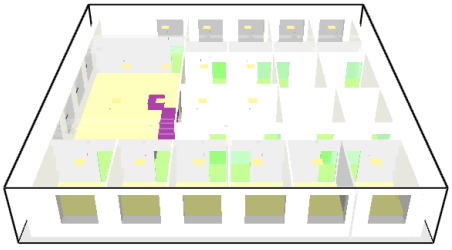

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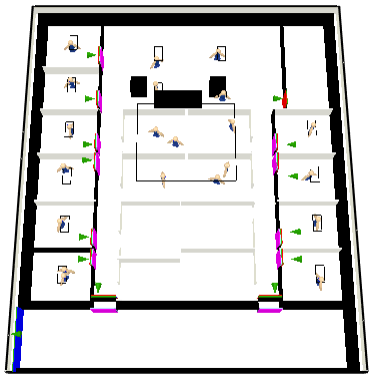

simulators

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FIRE SAFETY ISSUES IN TUNNELS

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BACKGROUND

- Fires in tunnels have caused significant risk to human life and damage to property and economy
  - Direct costs are extremely high
    - Large number of deaths and injuries over last decade;
    - Damage to tunnel structure and facilities (annual cost of tunnel fires in Europe estimated at €210 Million);
  - Indirect costs are very high
    - Significant economy and political impact;
    - Loss of confidence in using tunnels.

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BACKGROUND

Fires within confines of underground systems are among the most difficult to extinguish because:

- fire fighters have limited room in which to operate
- limited access points for fire personnel
- emergency exits locations
- availability of water supply
- ventilation capabilities

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TUNNEL INCIDENT

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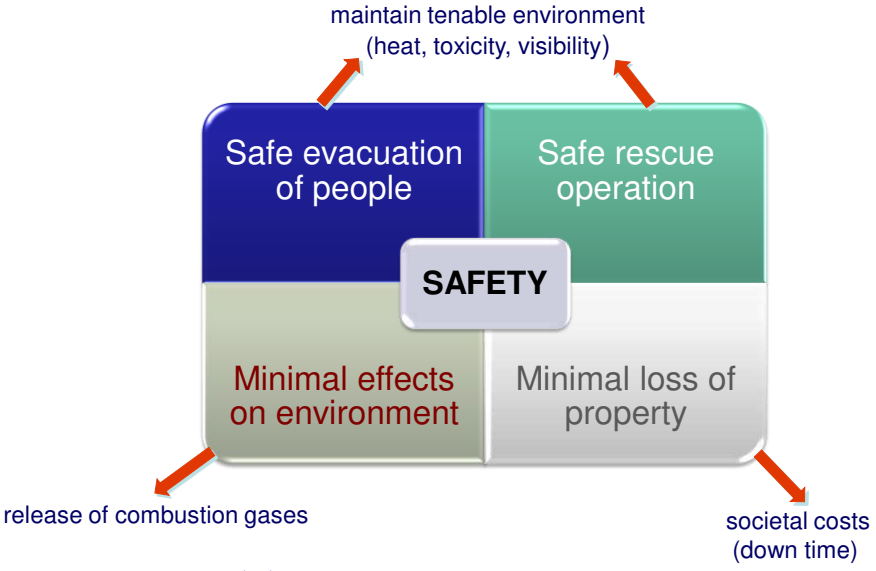
FIRE SAFETY ISSUES IN TUNNELS



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INTEGRATED SAFETY POLICY

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DESIGN

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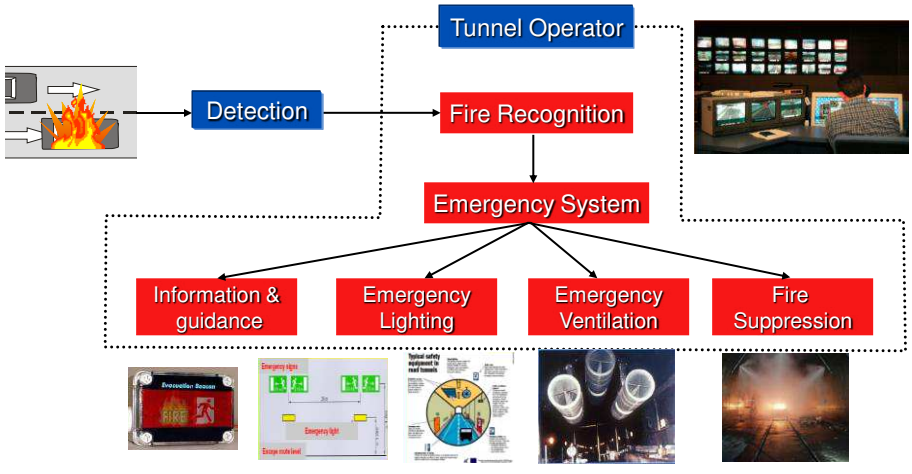
FIRE PROTECTION MATRIX



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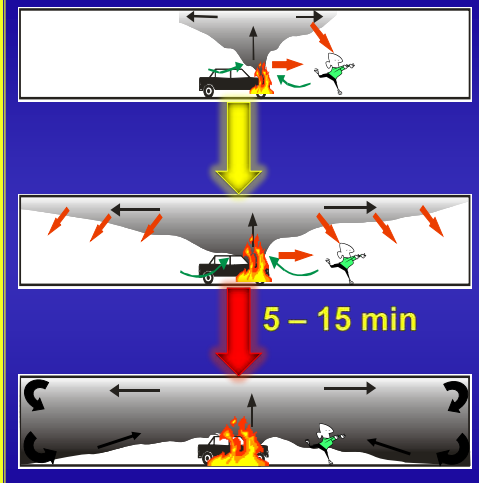
FIRE DEVELOPMENT



Fire produces high temperatures, heat radiation, smoke, low visibility, lethal toxic gases

As fire grows, smoke travels away from fire releasing its heat at tunnel ceiling and walls and cools down (smoke stratification)

As a result, smoke layer drops down and starts to fill the tunnel causing a much lower visibility (loss of stratification)

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DESIGN CRITERIA

- Air Temperatures Criteria
- Air Carbon Monoxide (CO) Criteria
- Smoke Obscuration Criteria – Visibility
- Radiation Heat Flux Criteria

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- Air Temperatures Criteria
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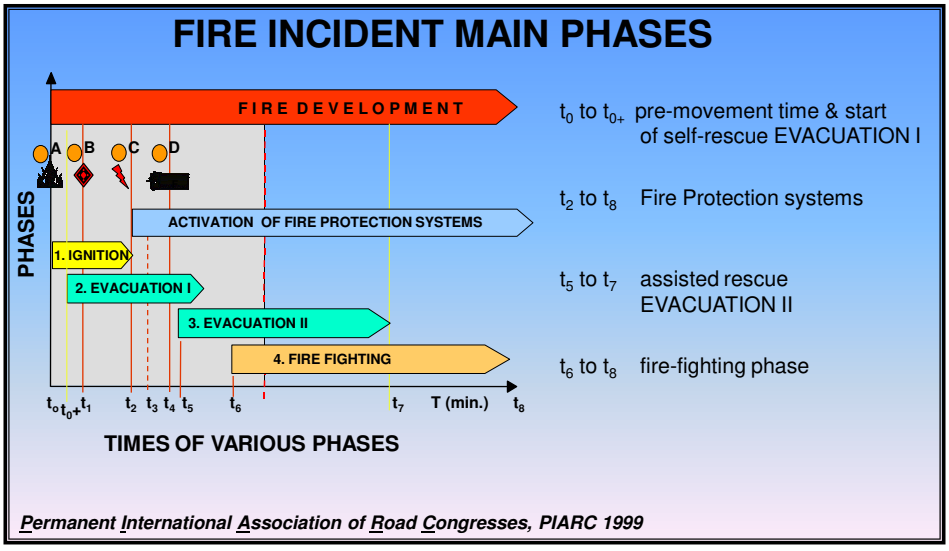
FIRE DEVELOPMENT



TERMINOLOGY

RSET (Required Safe Escape Time)

Time necessary between ignition of a fire and time at which all occupants can reach an area of safety.

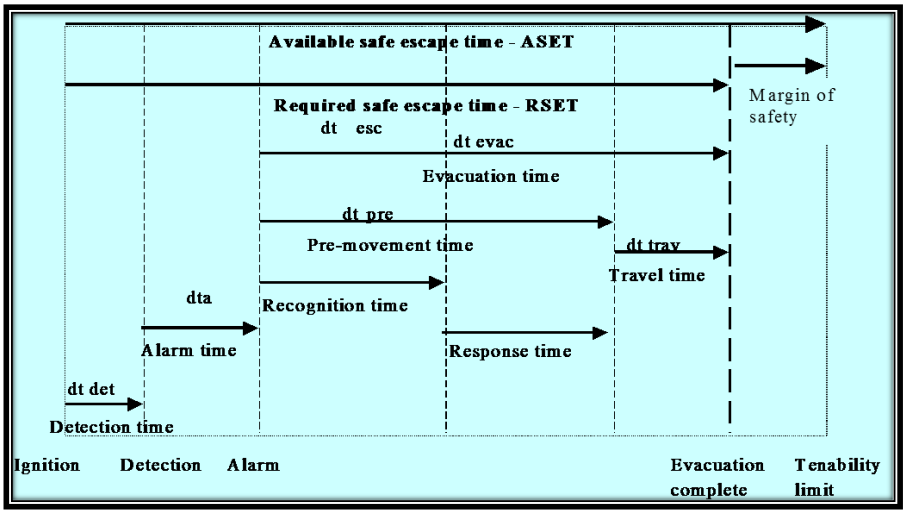
ASET (Available Safe Escape Time)

Time available between ignition of a fire and time at which tenability criteria are exceeded in means of egress.

***RSET** should be shorter than **ASET** by an acceptable Margin of Safety.*

EGRESS TIME MODEL

Model divides up time available for evacuation into several stages:



MAIN FACTORS THAT ACCELERATE OR DELAY OCCURRENCE OF EGRESS BEHAVIOURS

(SOCIETY OF FIRE PROTECTION ENGINEERS, SFPE)

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	Main factors that can accelerate the occurrence of egress behavior
Phase 0: onset of the event	▪ Proximity of hazard source. ▪ Familiarity with environment. ▪ Experience/training.
Phase 1: Perception and recognition of the alert signals.	▪ Proximity of hazard source. ▪ Intensity of alert. ▪ Clear messages on risk level. ▪ Credibility of information given/perceived. ▪ Collective move towards emergency exits.

MAIN FACTORS THAT ACCELERATE OR DELAY OCCURRENCE OF EGRESS BEHAVIOURS

(SOCIETY OF FIRE PROTECTION ENGINEERS, SFPE)

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	Main factors that can accelerate the occurrence of egress behavior
Phase 2: To make a decision about hazards reality and to evacuation preparation	▪ Clear messages on risk level. ▪ Information on emergency exits & what to do. ▪ Credibility of information given/received. ▪ Emergence of leader organizing evacuation. ▪ Collective move towards evacuation. ▪ Good visibility.
Phase 3: Move towards getting safe	▪ Smoke well controlled. ▪ Lighting and good visibility. ▪ Information on emergency exits & what to do.

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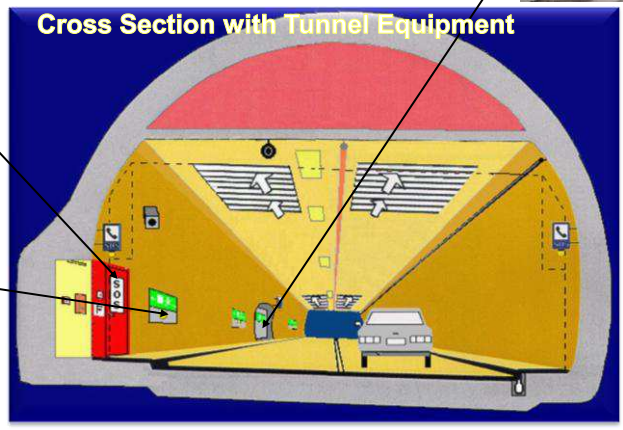
MAIN FEATURES OF THE SELF-RESCUE CONCEPT

Emergency station with Fire–exstinguishers and push button
at least every 150 m (250 m)

Emergency exit
at least every 500 m



Escape route markings and emergency lights
every 25m at a height of 1,0 to 1,5 m above escape route level

EU leaflet

What to do when you are entering a tunnel

- **Listen to the radio** station indicated by the sign
- Switch on your **headlights.** Take off your **sunglasses**
- **Obey traffic lights** and **signs**
- **Keep** a safe **distance** from the vehicle in front
- **Do not overtake** if there is only one lane in each direction
- **Do not turn** or reverse. **Do not stop**, except in an emergency

What to do in the event of breakdown or accident

- Switch on your **warning lights**
- Try to **move your vehicle** to an **emergency lane** or **lay-by** or at least to the hard shoulder
- **Switch off the engine**
- **Leave your vehicle**
- If necessary and possible, give **first aid** to **injured people**
- **Call for help** from an emergency station

What to do in traffic congestion

- Switch on your **warning lights**
- **Keep your distance**, even if you are moving slowly or have stopped
- **Switch off your engine**, if the traffic has come to a halt
- **Listen to** messages on the **radio**
- **Follow the instructions** given by tunnel officials or **obey variable message signs**

Remember: Check fuel and turn on radio before entering a tunnel!

What to do if your or another vehicle is on fire

- If your vehicle is on fire, if possible **drive out of the tunnel**
- If that is not possible, **pull over** to the side, **switch off the engine** and **leave the vehicle** immediately
- **Call for help** from an emergency station
- If you can, **put out the fire** using an **extinguisher** available in the tunnel
- If you can, **give first aid** to injured people
- **Go**, as soon as possible, to an **emergency exit**

Remember: Fire and smoke can kill - save your life, not your car!

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HUMAN RESPONSE

Who is the human in Human Response?

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Tunnel user

INTERACTION !!

Tunnel operator

Emergency response teams

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MOST COMMON BEHAVIOUR

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- Panic
- Absence of response
- Commitment

➥How long will this inertia last?

THE INITIAL MOMENT

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- Investigating ambiguous cues
- Fire fighting
  - Unlikely to take place
- Milling with others to discuss situation
  - Provide information to help passengers make decisions

WARNING USERS (CUES)

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- Auditory alarms
  - Location
  - Intensity (background noise)
  - Signal type
- Other cues
  - Smoke
  - Heat

QUESTIONS

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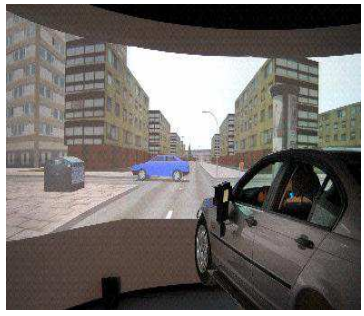
- What do people think when getting involved in accident?
- Do they understand what is going on?
- When do they understand and based on what cue?
- Idea is that providing information would help, but…..
- Is this the case?
- Do people know how to apply this?
- And….. is it enough?

DRIVING SIMULATOR STUDY

DRIVING SIMULATOR STUDY

SCENARIO – Altogether 60 drivers, 20 per group (no prior information, leaflet, Leaflet and operator voice):

- Busy traffic
- Traffic slows down due to accident 1 km upstream
- Entering the tunnel it gets to a stop
- 3.5 min after accident, smoke enters the tunnel
- Gets thicker and thicker



- After 10 min without action, experiment stopped
- If people indicate to get out and ….. Stopped.

CONCLUSIONS

- Did not reach 100% stated evacuation !!
- EU leaflet helps but is not enough
- Even with operator voice still doubt (smoke)
- Radio is not often used as information channel
- People still indicate they don't know how to handle
- People also want to know what is going on
- Enough information from a designer's point of view is not always enough for the tunnel user.

REAL LIFE EVACUATION STUDIES

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REAL LIFE EVACUATION STUDIES

- No instruction about possible accident
- Smoking truck stops in tunnel and blocks lanes
- 193 cars in 7 tests, 1 person per car
- 5 minutes: operator voice
- 7 minutes another.

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CONCLUSIONS

- People need between 5 to 15 minutes to decide whether they should do anything at all and finally what to do.
- New information vital to inform people they are no longer in normal situation.
- During anxiety a person's focus becomes very narrow – only allowing processing of most obvious elements of environment.
- In case of emergencies all communications should be simple, brief, and obvious.
- To avoid panic and stampede, people must think escape routes open or accessible and escaping time is adequate.
- Moderate level of stress required to motivate appropriate human response.

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EVACUATION STUDY
TUNNEL STUDY CENTRE (CETU)

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TUNNEL STUDY CENTRE (CETU)

Evaluation experiment were performed with ten users faced with a situation of coming to stop in the tunnel and the triggering of all the devices foreseen to favor their self evacuation

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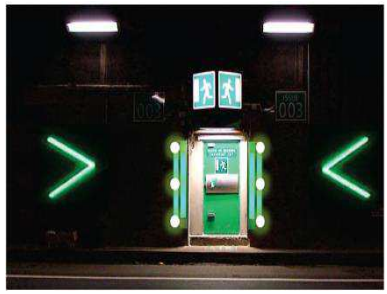
TUNNEL STUDY CENTRE (CETU)

- Light smoke: dynamic and static visual devices remain visible
- Thick smoke: static devices not seen and chevrons remain faintly visible
- Flashing light are last visible elements up to 25 m
- Audio devices remain audible, in spite of forced ventilation operation
- All users detected various devices (visual and audio) and understood their roles (induced necessity of evacuation)



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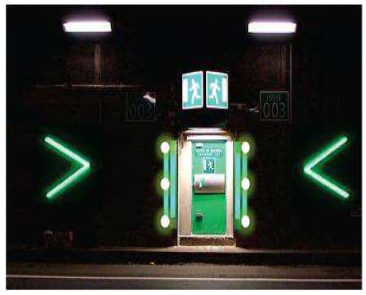
TUNNEL STUDY CENTRE (CETU)

- Alarm function of siren was well understood (danger signal)
- Audio beacons give indication of action and place
- Dynamic visual device (chevrons) show and guide to the place where it is necessary to go
- All users self-evacuated in less than two minutes. It is the whole of the device, the combination of audio and visual, which triggered the self-evacuation by the users



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