

**Fire brigade perspective for suppression of tunnel accidents with batterypowered electric cars or hydrogen fuel cell cars**

# Institute for Safety

## Lectureship on Transport Safety

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# Presentation

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- b. IFV and Lectureship Transport Safety

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# 1. Introduction



# Safety regions in The Netherlands



# Tasks of the IFV / Lectureship Transport Safety

The IFV is a national knowledge and education centre, which supports safety regions for:

- fire service
- medical assistance in incidents
- disaster and crisis management.

The Lectureship transport safety is part of the IFV

- ▶ Goal is to improve safety transport of
  - goods on the road, water, rail and through pipelines
  - passengers on the road, water and rail
- ▶ Special attention for tunnelsafety and alternative fuels
- ▶ Emphasis on risk management and emergency response



## 2. Tunnel safety and emergency response



# Tunnels in The Netherlands

- ▶ 24 road tunnels managed by Rijkswaterstaat
- ▶ 22 road tunnels managed by local or provincial government
- ▶ 11 rail tunnels managed by ProRail
- ▶ (Increasing numbers of) light rail and metro tunnels



# Legislation on tunnel safety

## ► Construction

- Legislation: Building Act
- Requirements: 1 hour fire resistance for land tunnels / 2 hours for underwater tunnels

## ► Installation

- Legislation: Law on Tunnelsafety (based on European guidelines for tunnelsafety)
- Requirements: standard technical equipment for (national) road tunnels / QRA for tunnelsafety

## ► Organisation

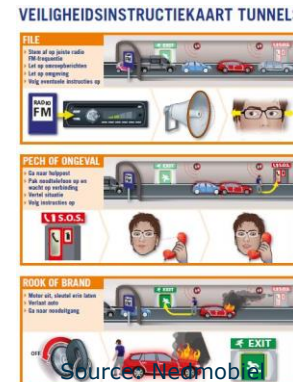
- Legislation: Law on Safety Regions – crisis management on governmental and operational level
- Requirements: emergency response possibilities for fire brigades and crisis health care



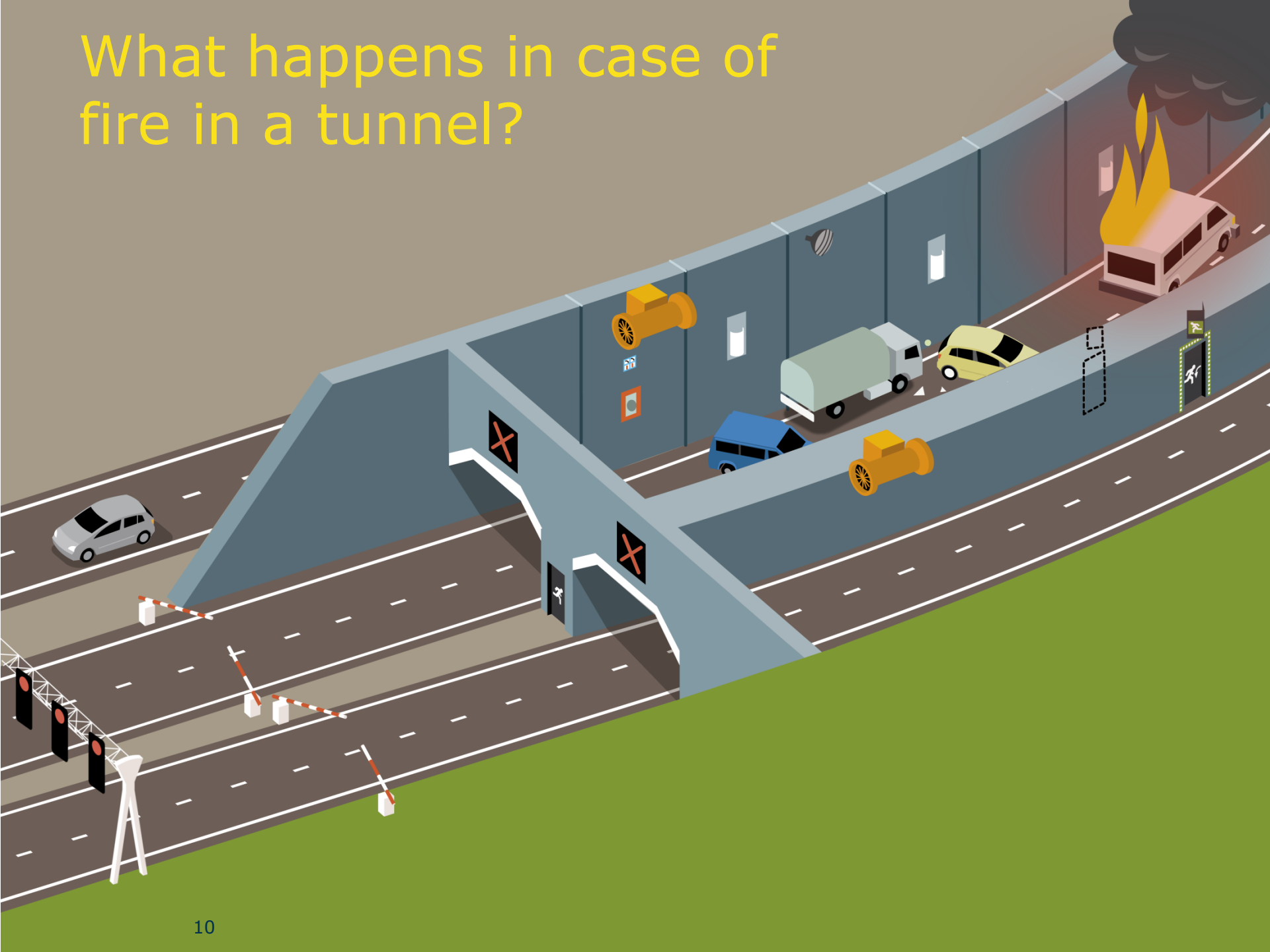


# Key safety factors

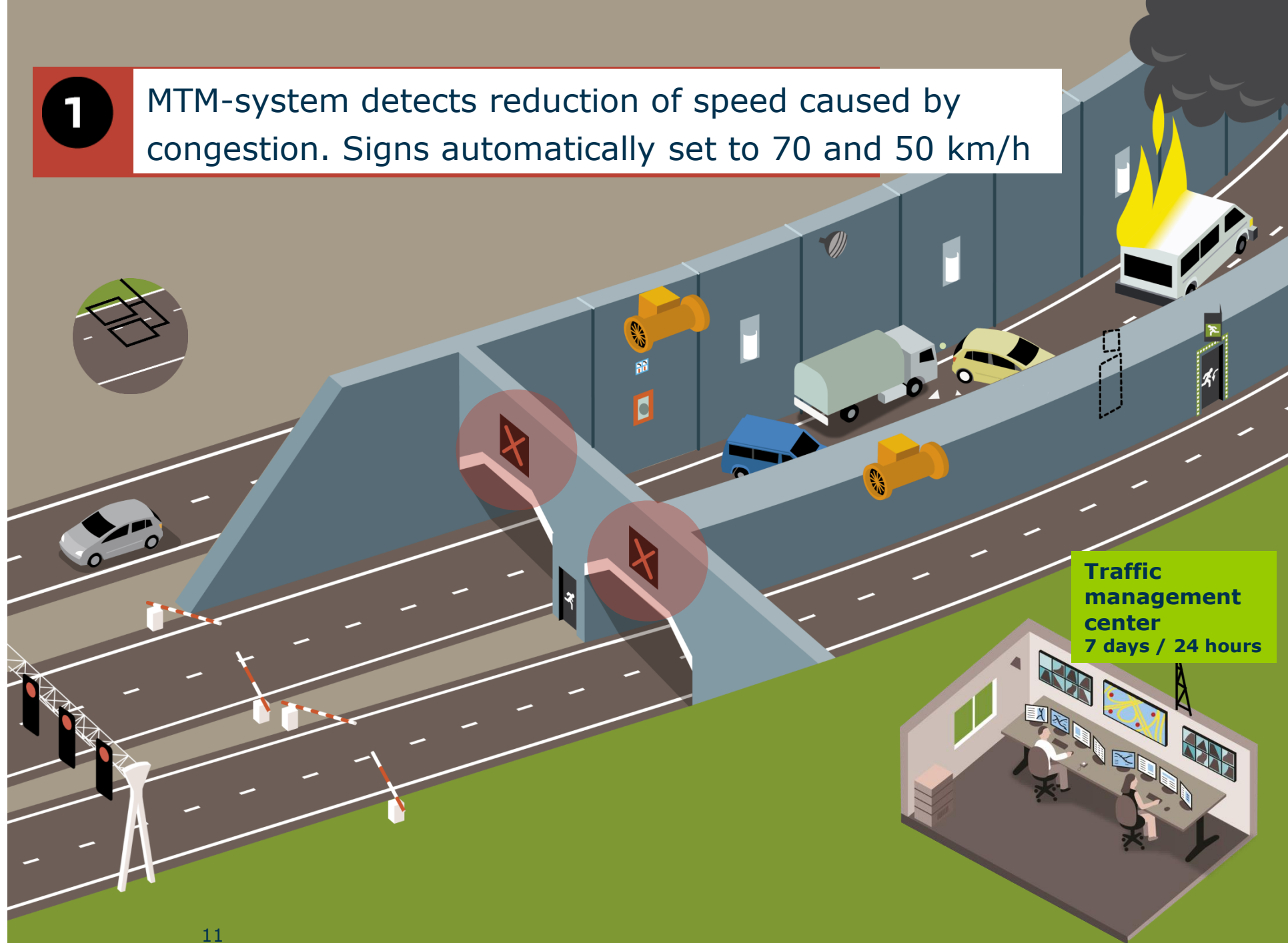
- ▶ Only one way tunnel tubes (no two way traffic in 1 tube)
- ▶ Ventilation system
- ▶ Measures for self-reliance / evacuation: short distance between emergency exits (100m) & 24 h traffic control which can give instructions for tunnel users
- ▶ Effective emergency response



# What happens in case of fire in a tunnel?

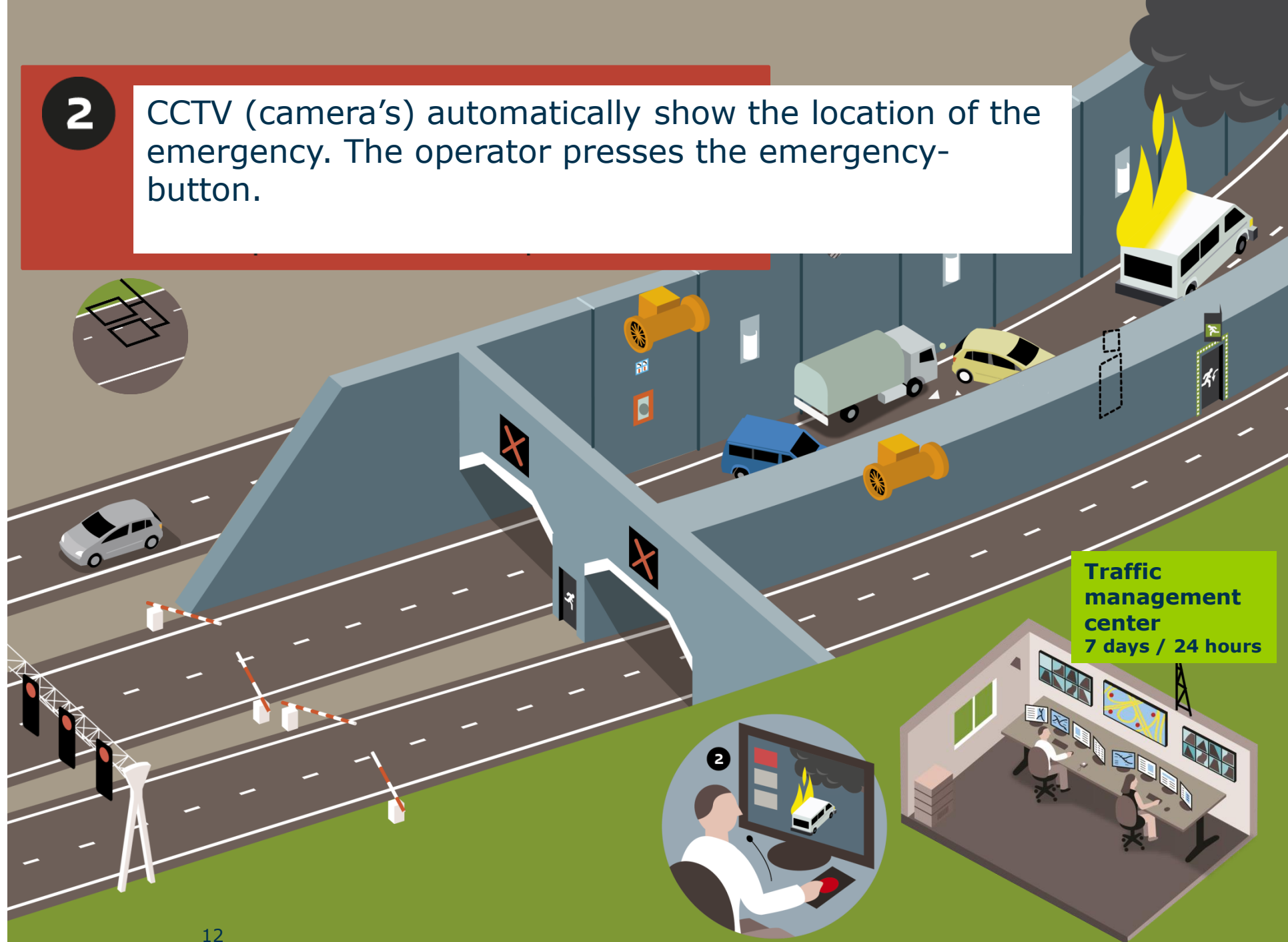


**1** MTM-system detects reduction of speed caused by congestion. Signs automatically set to 70 and 50 km/h



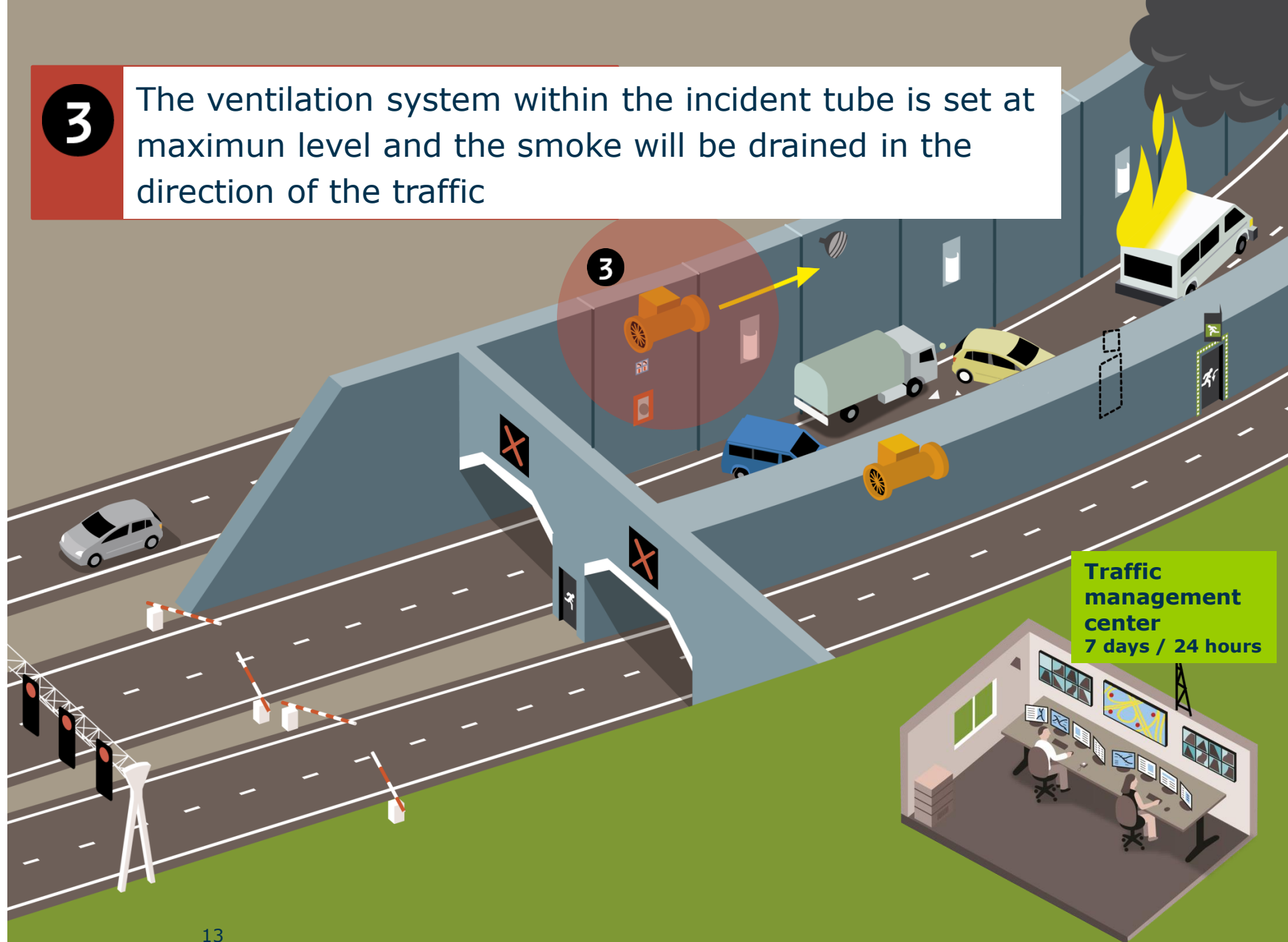
2

CCTV (camera's) automatically show the location of the emergency. The operator presses the emergency-button.



3

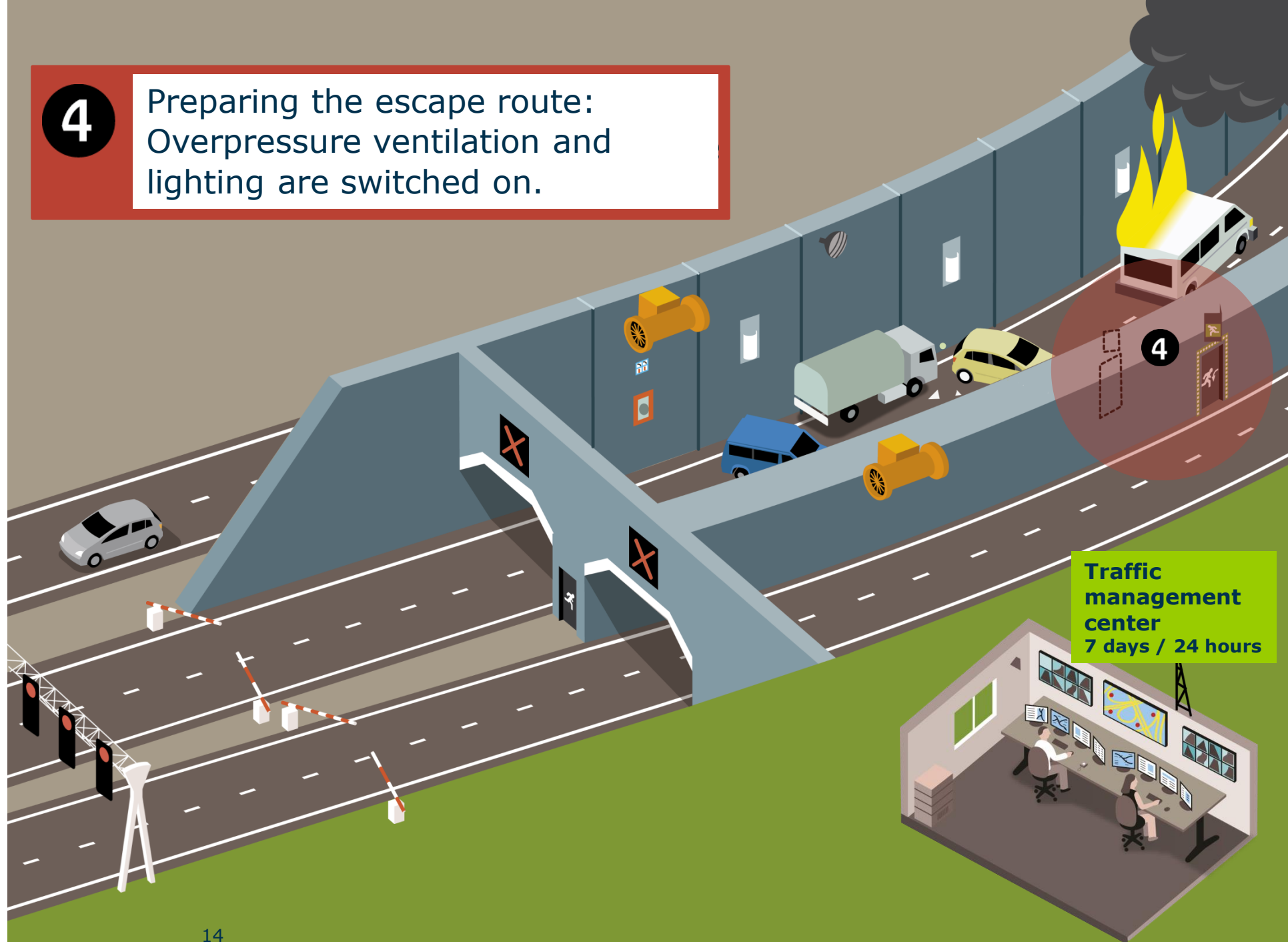
The ventilation system within the incident tube is set at maximum level and the smoke will be drained in the direction of the traffic





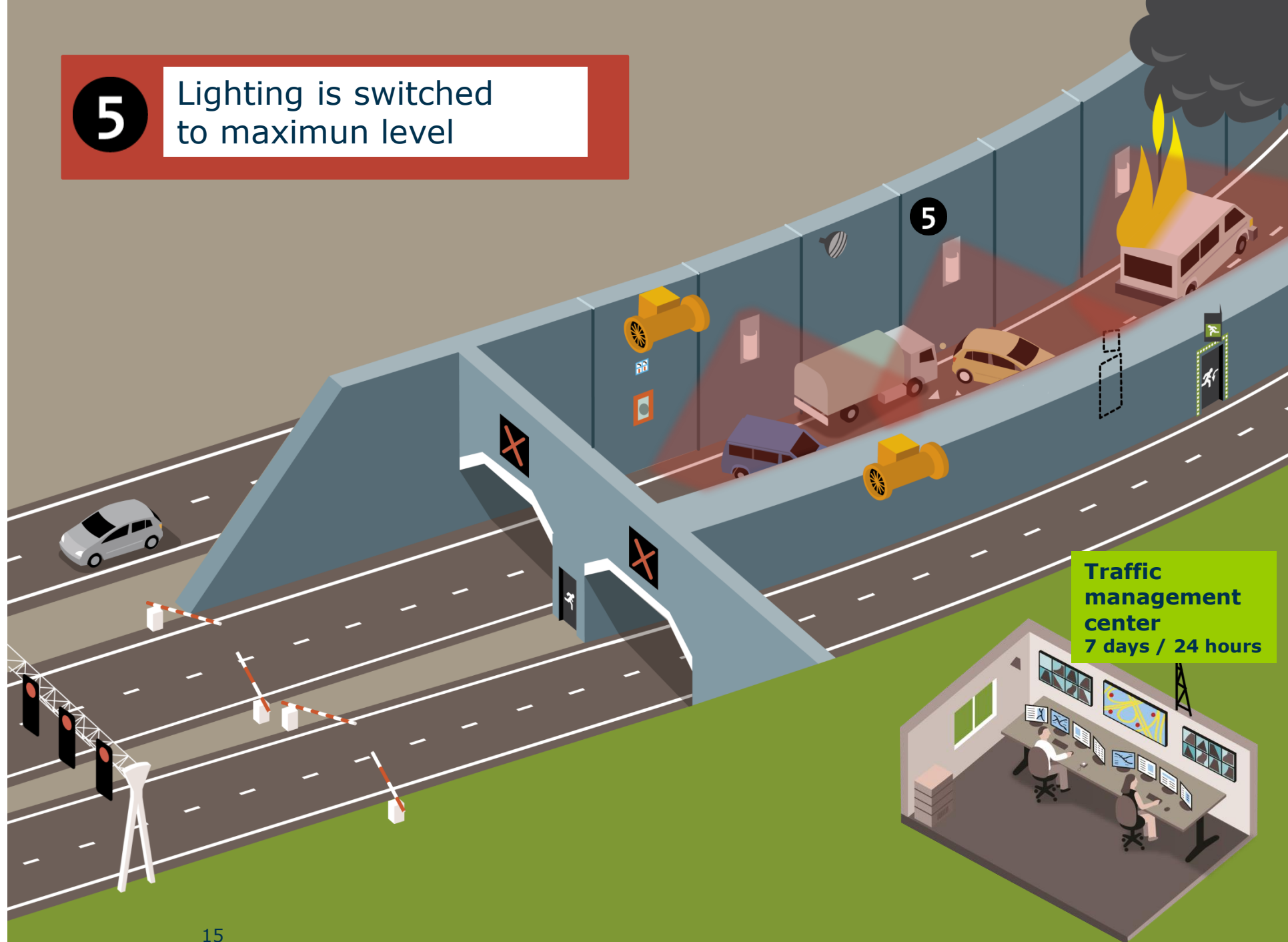
4

Preparing the escape route:  
Overpressure ventilation and  
lighting are switched on.



**Traffic  
management  
center**  
7 days / 24 hours

**5** Lighting is switched to maximum level



6

Traffic lights  
turn red



7

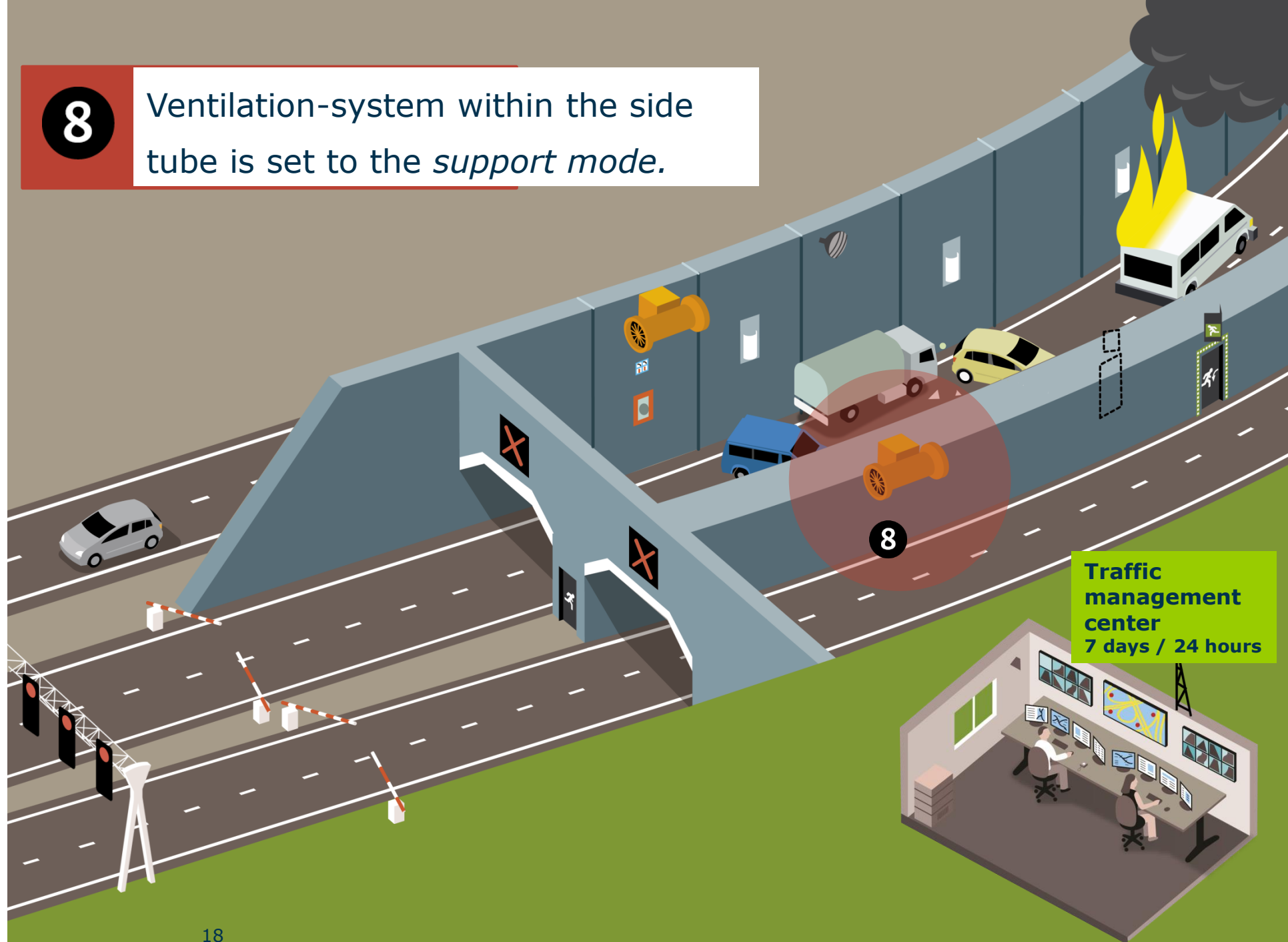
Barriers go down



**Traffic management center**  
7 days / 24 hours

8

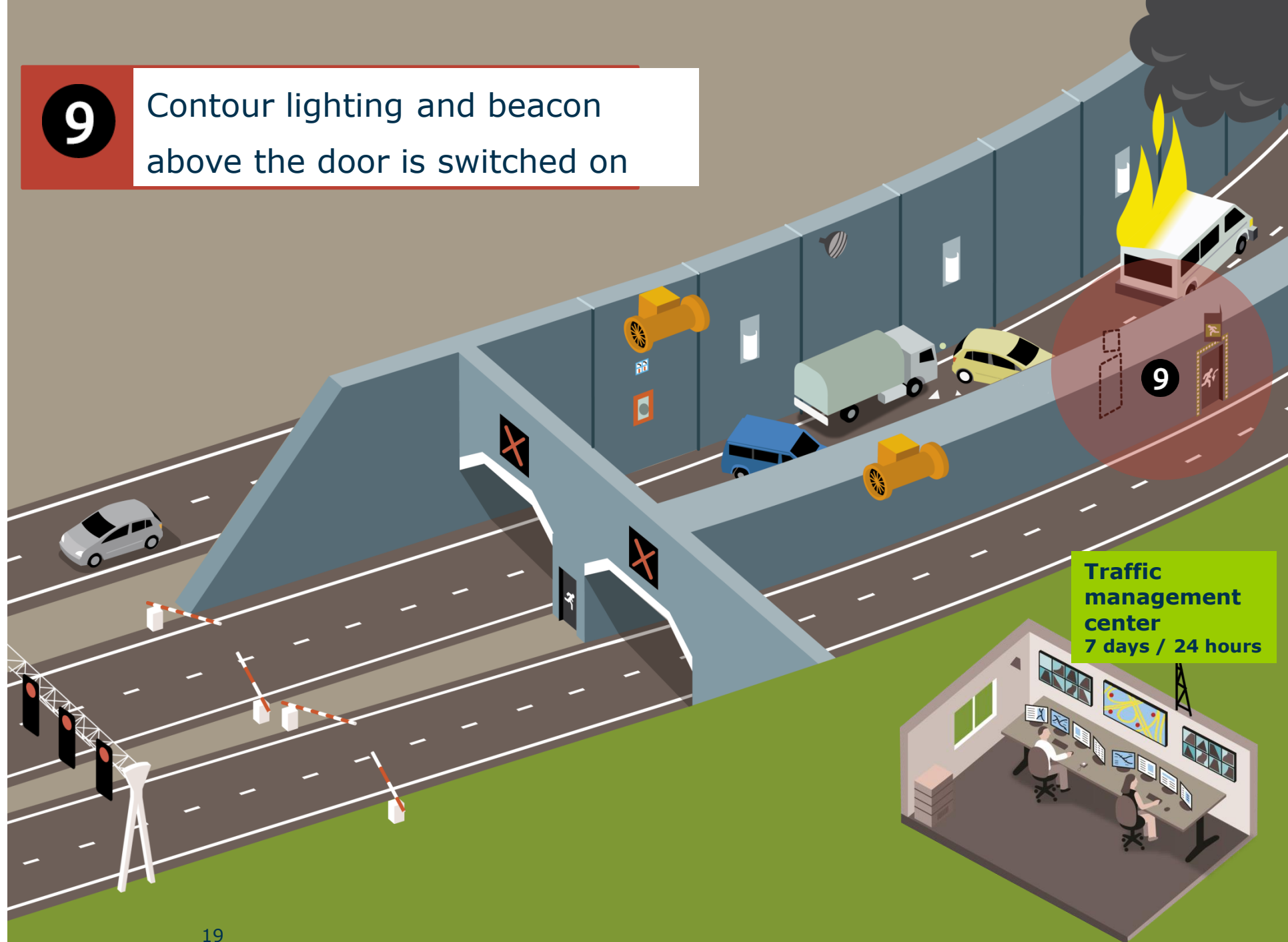
Ventilation-system within the side tube is set to the *support mode*.





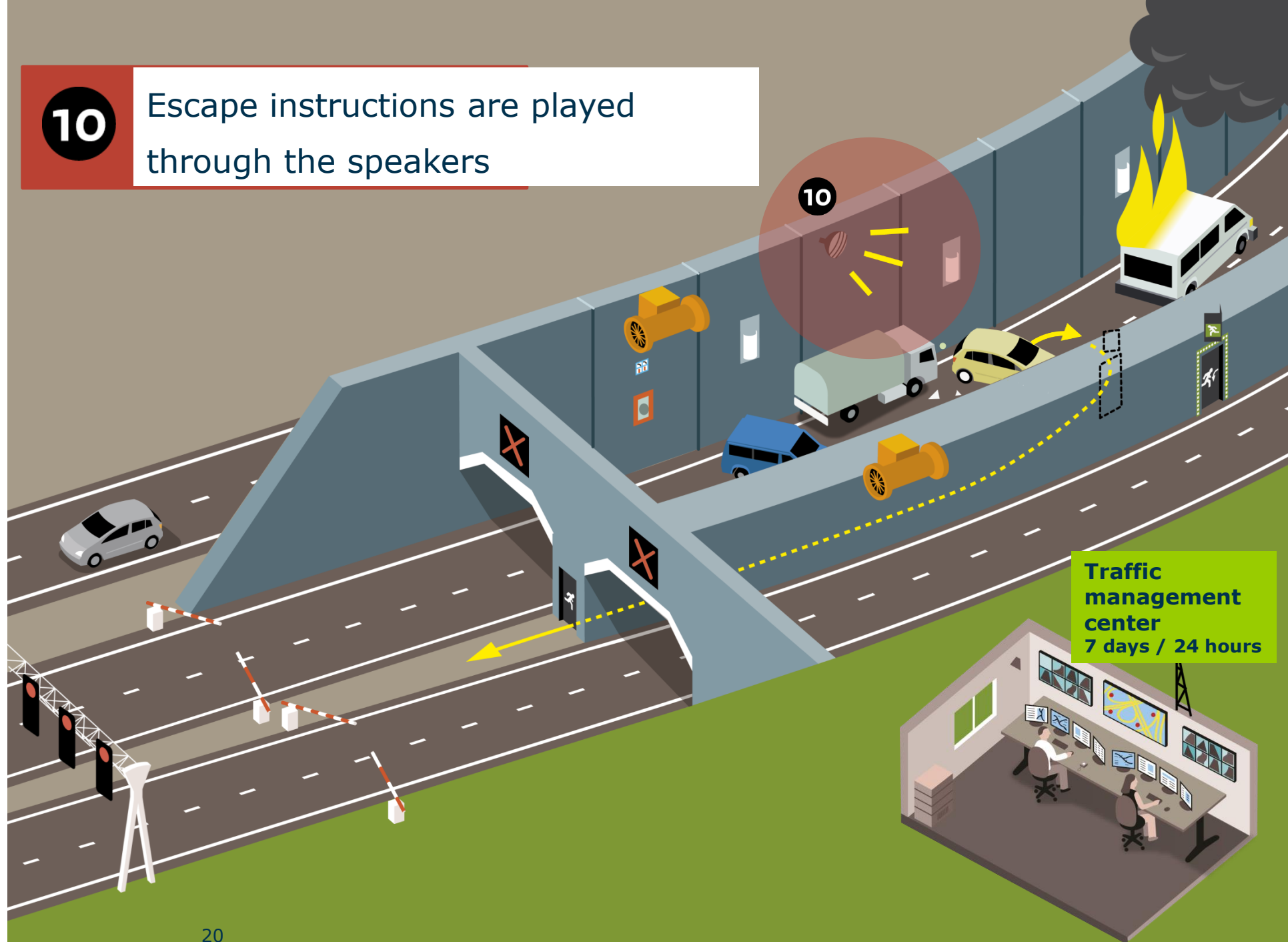
9

Contour lighting and beacon  
above the door is switched on



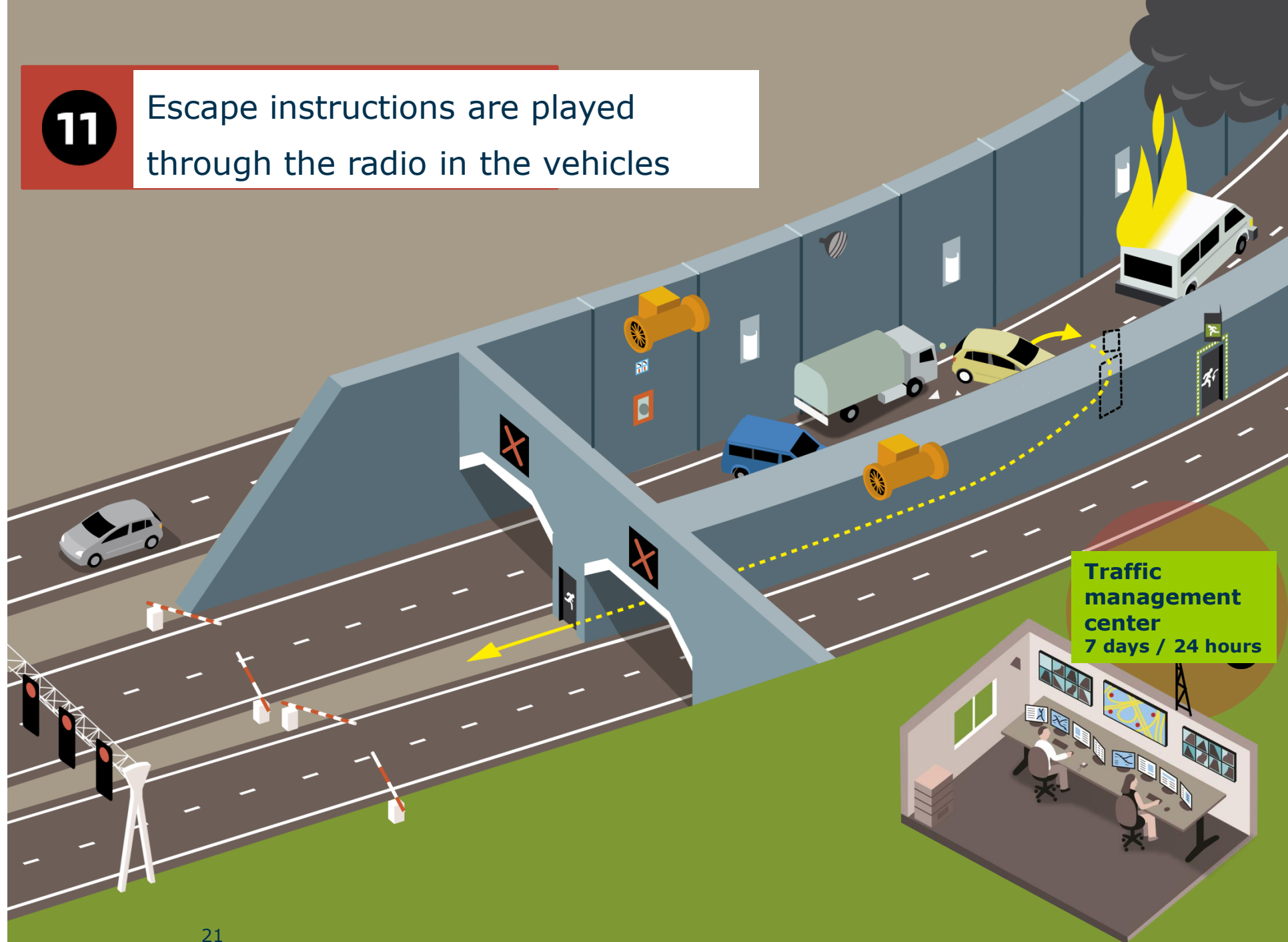
10

Escape instructions are played through the speakers



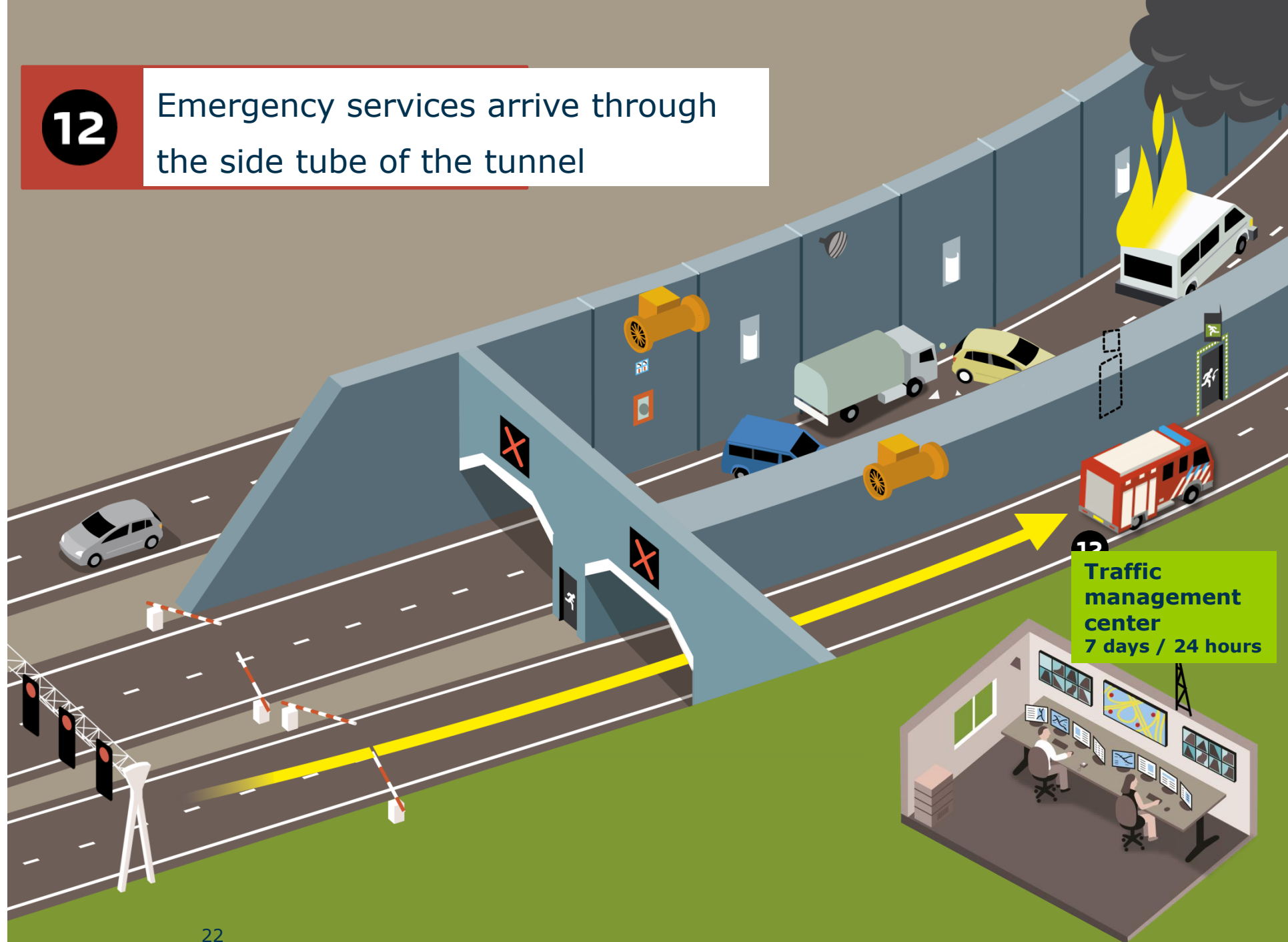
11

Escape instructions are played through the radio in the vehicles



12

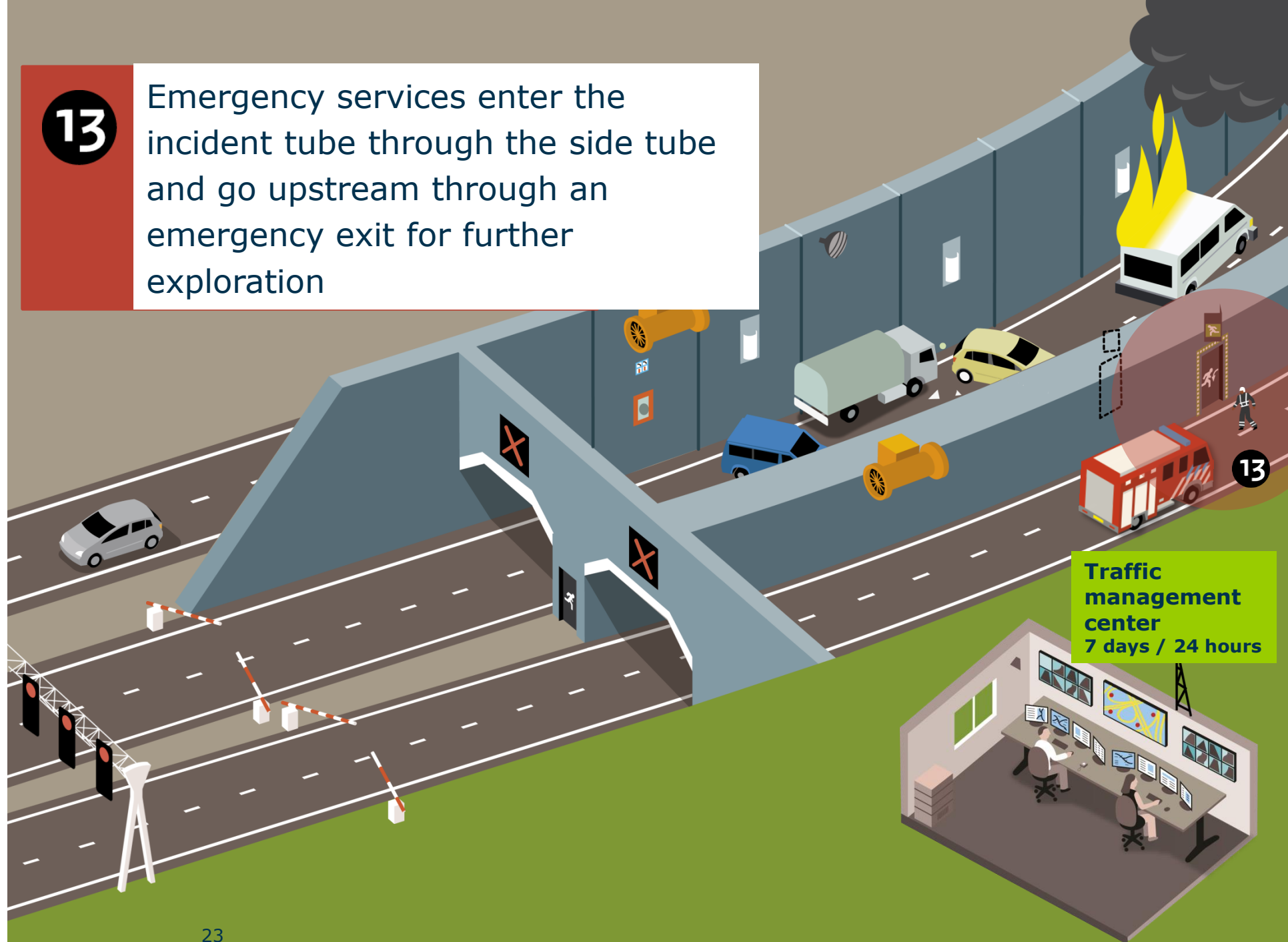
Emergency services arrive through the side tube of the tunnel



12  
Traffic management center  
7 days / 24 hours

13

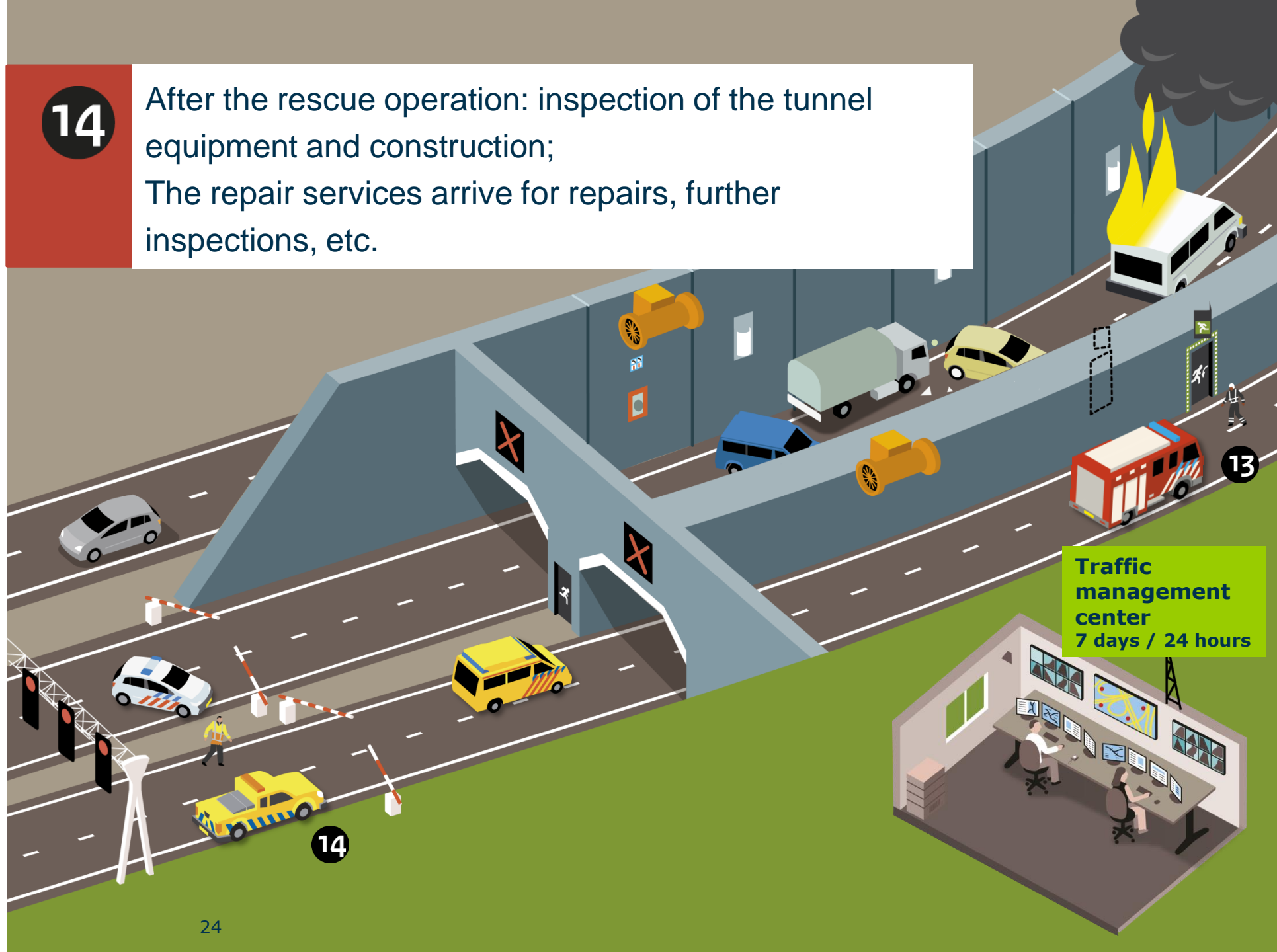
Emergency services enter the incident tube through the side tube and go upstream through an emergency exit for further exploration





14

After the rescue operation: inspection of the tunnel equipment and construction;  
The repair services arrive for repairs, further inspections, etc.



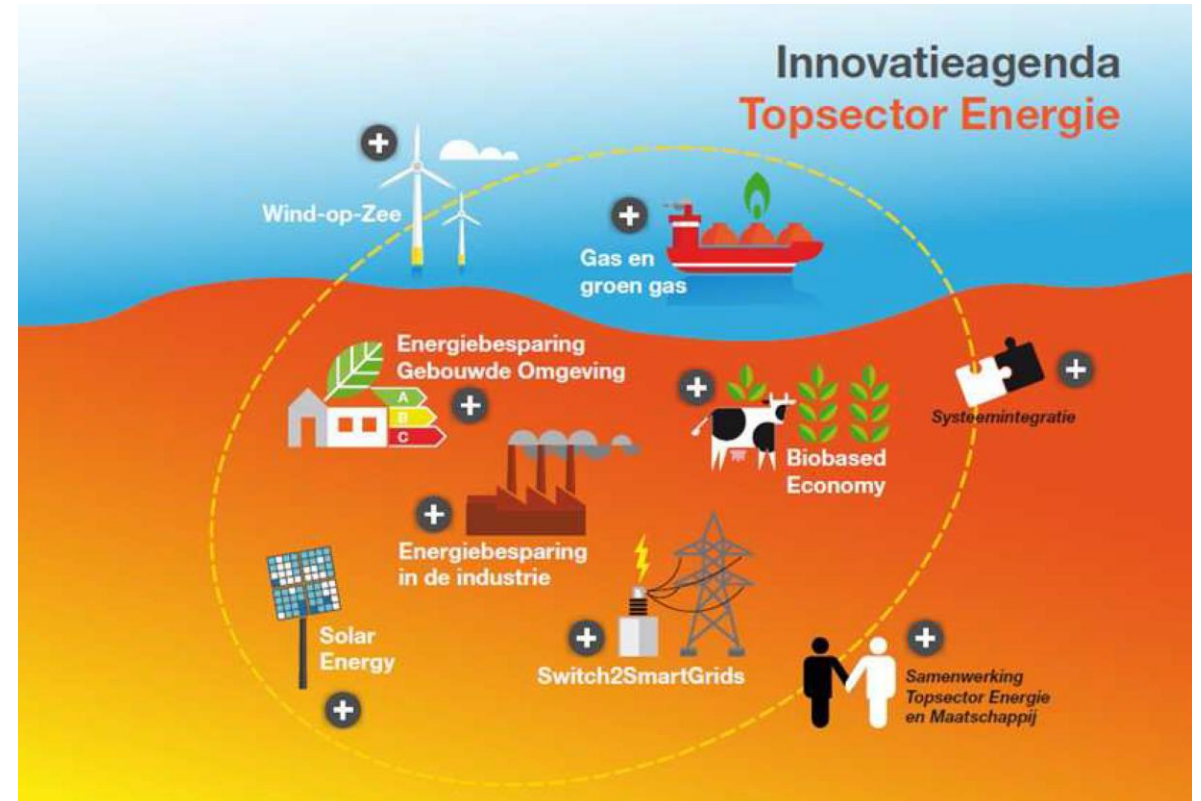
# 3. Sustainable fuels and energy carriers



# The dutch energy transition

- ▶ Climate agreement : CO<sub>2</sub> emission reduction
- ▶ Fossile fuels (gasoline, diesel. natural gas) removal

- ▶ Sustainable electricity
- ▶ Increase electric mobility
- ▶ Cleaner fuels

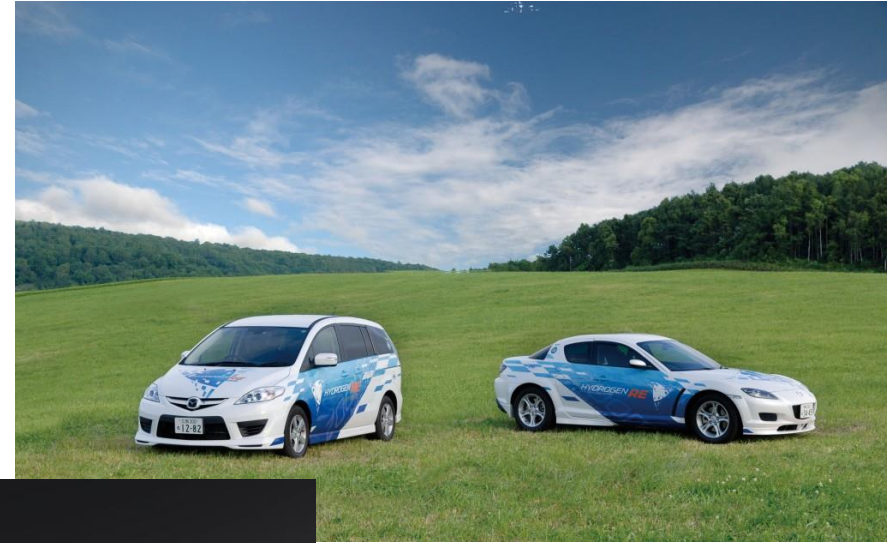




# New fuels – new risks

- ▶ Hydrogen vehicles
- ▶ Electric vehicles
- ▶ LNG – CNG vehicles

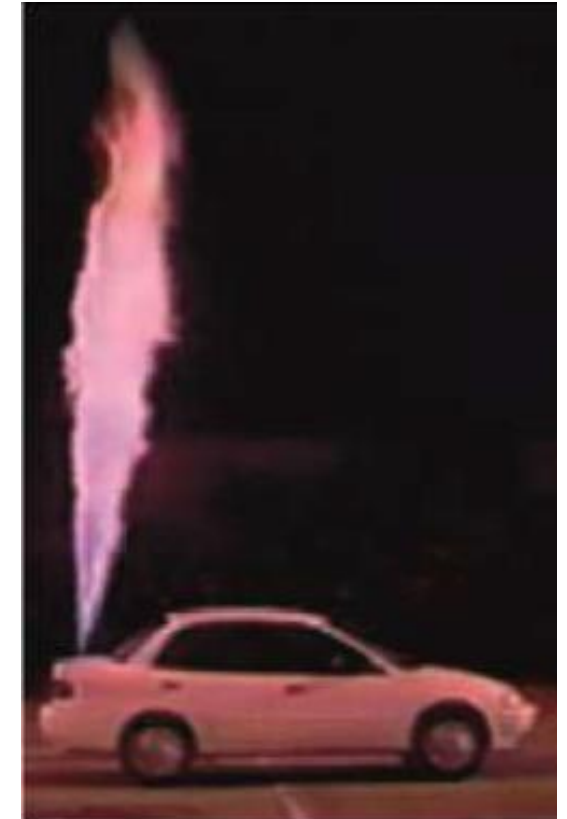
*Unknown if risks are bigger, but they are different*



# Characteristics of hydrogen

## ➤ Gas

- *Pressure for trucks: 350 bar*
- *Pressure for passengers cars: 700 bar*
- *Odorless*
- *Flammable*
- *Highly explosive*
- *Much lighter than air*
- *Use in transport: trucks, busses, trains, passenger cars*





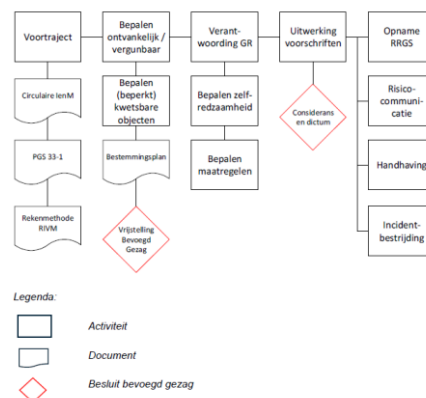
# Characteristics of electric vehicles

- ▶ Mostly lithium-ion battery
- ▶ Risks:
  - Thermal runaway
  - Explosions (by fire)
  - Difficult to control
  - Electrocution hazard
  - Release of hazardous gasses



# Products IFV – Fire Brigades Netherlands

## Flow charts



Figuur 4: Stroomschema vergunningverlening LNG-tankstation

## Films for practice



## Lesson material

Brandweeroptreden bij incidenten met LNG



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Brandweeracademie  
Postbus 7010  
6801 HA Arnhem  
www.ifv.nl  
info@ifv.nl  
026 355 24 00

## Protocols

Brandweer Nederland	Vloeibaar methaan: LNG (-162°C) Kenmerken en risico's	Richtlijn
<b>Fysische eigenschappen LNG (Liquefied Natural Gas)</b> <ul style="list-style-type: none"> <li>Om 1912-1913 v.v.</li> <li>Methaan (CH<sub>4</sub>) aardgas</li> <li>-162 °C</li> <li>1 liter LNG = 0,5 kg (1 liter LNG = 600 liter aardgas)</li> <li>Explosiegrens 5 – 16 vol %</li> <li>Zie Chemische veiligheidsboek</li> </ul>		
<b>RISICO'S LNG</b> <ul style="list-style-type: none"> <li>Zeer brandbaar gas.</li> <li>Zeer lage temperaturen (-162 °C) (bevroren gas) en effecten constructieonderdelen (broos worden). Gebruik speciale beschermende kleding bij mogelijk contact.</li> <li>LNG is bij vrijkomen zeer snel (het op ondergrondse kuilen) vloeit naar LNG in kan (ophopen).</li> <li>Kans op explosiegevaar bij besloten omgeving (LET OP: parkeergarages, werkplaatsen en tankstations etc.).</li> <li>Verspreidend in hoge concentraties (schaduw naar frisse lucht en naar buiten).</li> <li>Opgewarmd gas is niet meer zichtbaar (ook is niet meer zichtbaar als witte damp).</li> </ul>		
<b>KENMERKEN LNG-INCIDENTEN</b> <ul style="list-style-type: none"> <li>Huid rookt met koud op laag hangend gas op grote afstand LNG warmt op en vormt zich met licht.</li> <li>De (zichtbare) wolk is afhankelijk van temperatuur LNG en omgevingsfactoren zoals temperatuur buitenlucht en luchtdruk. Een zichtbare wolk hoeft niet altijd LNG te zijn, dit kan condens zijn.</li> <li>LNG is spilloos en kleurloos (zichtbaar door witte mist door condenseren van de omringende lucht (waterdamp)).</li> </ul>		
<b>VEILIG OPTREDEN</b> <ul style="list-style-type: none"> <li>Start OGS procedure i.v.m. stabilisatie van en ontbreken (groot effect) op veiligheid en bij bovengenoemde.</li> <li>Dringende veiligheid, inclusief afsluiting van de omgeving.</li> <li>Mak AL TUD gebruik van een draadloze (zacht) of explosievrije (hard) en gasmetingsapparatuur (zichtbaar maken kou en gas).</li> <li>Bij bovengenoemde (het op afstand terrein) en kom NIET in contact met de vloeistof.</li> <li>Mobile telefoons, portables, papers etc. alleen in veilig gebied gebruiken.</li> </ul>		
<b>WERKWIJZE BIJ LNG-INCIDENTEN</b> <ul style="list-style-type: none"> <li>Alleen een expert of ervaren overlegdeskundigen.</li> <li>Informeer bij het LIGOS (Landelijk Informatiepunt Ongelukken Gevaarlijke stoffen) voor deskundige ondersteuning 010-2469442.</li> <li>Alleen met de omgeving (bij name afstand 100 meter).</li> <li>Let op ontstekingsbronnen in de omgeving (bij name).</li> <li>LNG brand bij voorkeur niet blussen. Waar nodig (aangetrokken) objecten koelen (voorkom contact water met LNG). LNG brand alleen blussen indien noodzakelijk (insulatie).</li> <li>Huidcontact met stof behandelen als brandwond.</li> <li>Voorlopig contact van water met afsluiting i.v.m. dichtvriesen. Gebruik water alleen in overleg met een deskundige.</li> <li>Controleer bij alle soorten tanks de vullingsgraad. i.v.m. risico inschutting (opsparen eigenaar/bezitter).</li> </ul>		

## Materials for practice



## Guidelines

### Handreiking EV advisering LNG

Voor het geven van een Veiligheidsregio-advies



# 4. Conclusions and questions for research

# Conclusions

- ▶ We try to be prepared for emergency response in tunnels (construction, equipment and organisation)
- ▶ We have developed scenarios / protocols / procedures for new fuels:  
(f.e. blow off, vehicle fire, vehicle leakage, transport)
- ▶ BUT: regarding new fuels, we have not prepared anything yet for tunnels
  - No mature legislation on new fuels in tunnels
  - No data on exact physical properties of new fuels in confined space and therefore
  - No scenario's, procedures or protocols



# Questions for further research for tunnels

- ▶ **Hydrogen leakage** will lead to a flammable hydrogen-air cloud. Will this result in a vapour cloud explosion, a blast wave deflagration or detonation, heat radiation, a jet flame or a combination of these? What about the pressure build-up and propagation speed?
- ▶ How to control a **battery fire**, which toxic fumes are produced at what amount and at what speed?
- ▶ How do these effects influence the safety concept of the tunnel (construction, installation, selfresue, emergency response)?
- ▶ Do we need:
  - new calculations of the QRA for road tunnels?
  - new CFD models for modelling the combined explosion / fire risks?
  - new scenarios: gas fire instead of gasoline / diesel fire?
  - new training models to get the fire brigades fit for the job?

**Is safety taken seriously in the innovation and development of new fuels?**

