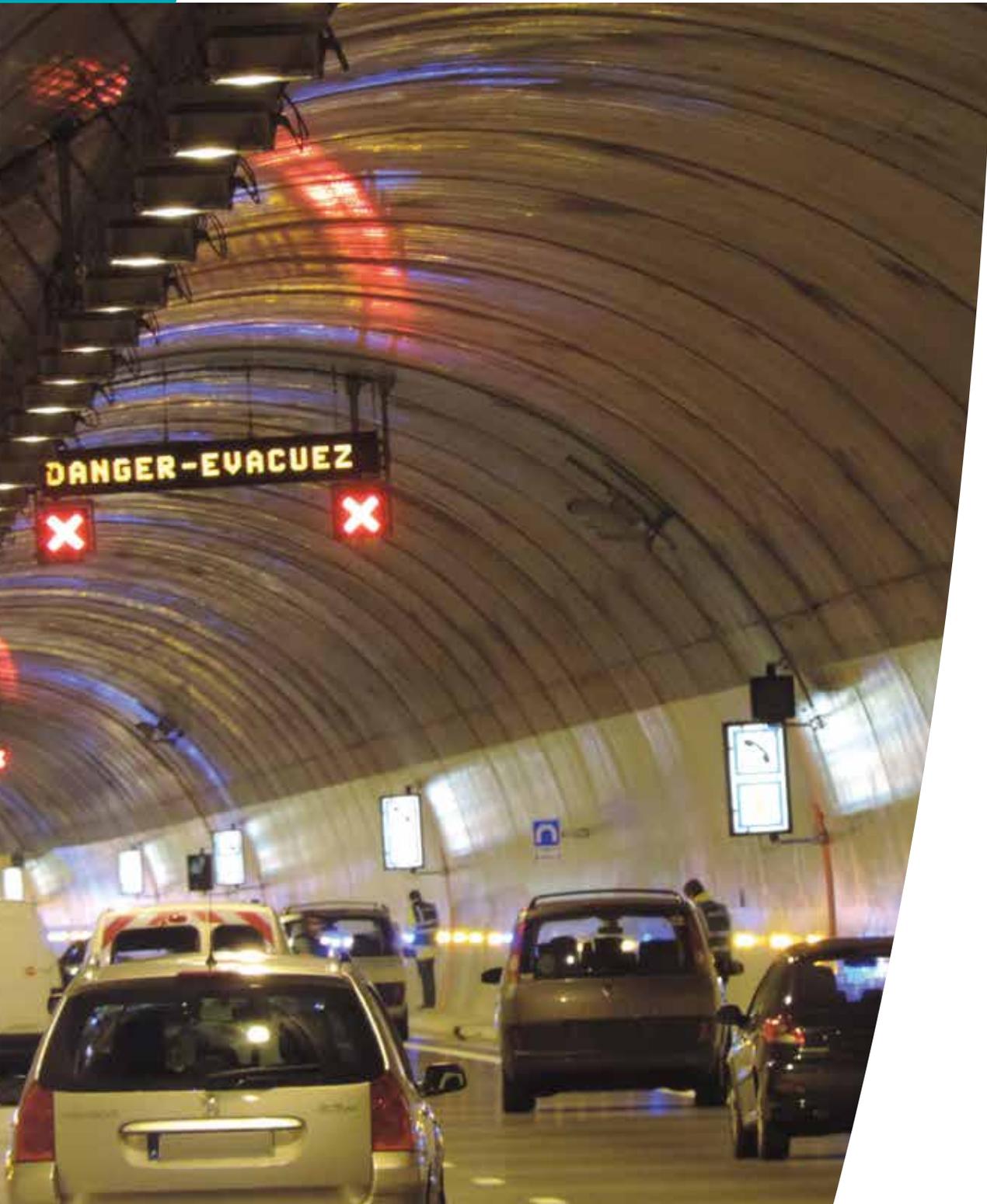


METHODOLOGICAL GUIDE ON SAFETY EXERCISES IN ROAD TUNNELS



DISCLAIMER

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*Methodological guide
on safety exercises
in road tunnels*

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INTRODUCTION

For road tunnels measuring more than 300 m in length, the law requires tunnel owners and the emergency services to run joint exercises for tunnel staff and emergency services personnel.¹ Where applicable, the safety officer² must also be involved in these exercises.

Beyond this legal requirement, safety exercises are a vital component of any safety management system, supplementing other actions designed to improve operational risk control in road tunnels.

This guide is intended to assist tunnel owners and operating personnel with the running of safety exercises, helping them:

- understand how these exercises fit into broader safety provisions and identify what lessons they can learn in terms of both tunnel design and operation;
- prepare, organise and run exercises, and conduct thorough post-exercise reviews to identify areas where practices can be improved.

It supplements existing documents that cover safety exercises in general (see Bibliography).

This guide is divided into two sections:

- section one summarises the general principles around safety exercises, looking at what the law says, how to schedule and classify exercises, the various objectives that safety exercises pursue, and the parties involved;
- section two is more operational in content, and is designed for those responsible for planning, arranging, conducting and analysing exercises and implementing improvements – looking at feedback from past exercises and explaining how to run a safety exercise in practice.



Photo 1: live exercise with warm smoke

1. Article R.118-3-8 of the French Roadway Code.
2. Article R.118-4-3 of the French Roadway Code.

GENERAL PRINCIPLES

2.1 REGULATORY CONTEXT

2.1.1 Applicable laws and regulations

Tunnels in France

All road tunnels in France that are 300 m or more in length, irrespective of the owner, are subject to the provisions of Chapter VIII, Section I of the French Roadway Code (legislative part, articles L.118.1 to L.118.5, and regulatory part, articles R.118.1.1 to R.118.3.8). Moreover, tunnels located on the State-managed road network are governed by circular no. 2006-20, implementing decree no. 2005-701.

Tunnels on the Trans-European Road Network (TERN) and measuring 500 m or more in length are also subject to Directive 2004/54/EC of 29 April 2004, transposed into French law by Act no. 2006-10 of 5 January 2006, and by Chapter VIII, Section 4 of the French Roadway Code.

Cross-border tunnels

In most cases, tunnels of this type are governed by an international agreement outlining how they are constructed and operated. Where this is not the case, French law applies to the French section of the tunnel.³

Moreover, cross-border tunnels on the TERN measuring 500 m or more in length are subject to Directive 2004/54/EC of 29 April 2004 (Annex II, paragraph 5).

2.1.2 Safety exercise obligations

For road tunnels measuring more than 300 m in length, tunnel owners and the emergency services must run joint exercises for tunnel staff and emergency services personnel. Where applicable, the safety officer must also be involved in these exercises. The exercises are performed annually.⁴

A debriefing must take place after each exercise to draw on lessons learnt, with the aim of improving tunnel safety. The list of completed exercises and lessons learned from them must be recorded in the ad-hoc document in the safety documentation.⁵

The safety officer (for tunnels measuring 500 m or more in length on the TERN) is involved in organising and reviewing safety exercises.⁶

Appendix 1 recalls those sections of the French Roadway Code and circular no. 2006-20 of 20 May 2006 dealing with safety exercises.



Photo 2: traffic management

3. Paragraph 3 of inter-ministerial circular no. 2006-20 of 29 March 2006 on the safety of road tunnels measuring more than 300 metres in length.

4. Article R.118-3-8 of the French Roadway Code.

5. Article R.118-3-3 of the French Roadway Code and inter-ministerial circular no. 2006-20 of 29 March 2006.

6. Article R.118-4-3 of the French Roadway Code.

2.2 WHERE EXERCISES FIT INTO THE SAFETY MANAGEMENT SYSTEM

Safety exercises are more than just a legal requirement. They are a vital component of the broader safety management system.

From a risk management perspective, a safety exercise may be defined as both:

- a mechanism to test protection systems against the impacts of a feared event (ensuring that, in addition to equipment maintenance and staff training provisions, these systems – which are only used extremely rarely – work as they should when needed, from a technical, human and organisational perspective);
- training and continuous improvement opportunities, allowing all parties to acquire, come to grips with and maintain the required know-how in a planned context, across different areas:
 - how to act (procedures and actions outlined in the Emergency Response Plan);
 - how to deal effectively with the other parties involved;
 - how to understand the tunnel system as a whole.

Running the safety exercises required by law therefore supplements other actions designed to improve operational risk control in road tunnels. To achieve this end, the exercises must focus on the priorities of managing a real-life event in a road tunnel:

- keeping the human toll to a minimum;
- limiting equipment and structural damage;
- re-opening the tunnel as soon as possible.

Looking beyond the practical, often technical recommendations in this guide, it is vital that the people involved in safety exercises play a leading role and harness the opportunity that a legally required exercise offers to embed a risk and safety culture across their practices. Because a safety exercise only involves some members of tunnel and emergency services staff, it is also important to organise on-site visits for all incident response teams or staff in charge of monitoring the tunnel.



Photo 3: testing arrival times

2.3 SCHEDULING OF EXERCISES

As mentioned previously, the tunnel owner and emergency services are legally required to run regular, joint safety exercises involving tunnel staff and emergency services personnel for road tunnels measuring 300 m or more in length.

Running an exercise of this type each year is important for system viability and effectiveness in the face of multiple potential changes (new people directly involved in crisis management, new operating procedures introduced by one or more parties, or a major change of tunnel infrastructure and equipment, etc.).

Where there are several tunnels under the same manager, covered by the same emergency services and located in close proximity⁷ to one another, the exercise may be run in just one of the tunnels. In configurations of this type, the requirement to run annual safety exercises in each tunnel will be assessed on a case-by-case basis in conjunction with the local prefecture. Ideally, there should be a multi-year programme of exercises for consistent planning purposes.

Although not required by law, it is advisable to run a safety exercise before commissioning a new tunnel, or after major modification works. Experience shows that exercises of this type provide a wealth of insights and give everyone involved a chance to come together, examine the tunnel and get a clearer picture of how the tunnel system works.

The *Commission Nationale d'Évaluation de la Sécurité des Ouvrages Routiers* (French assessment commission for the safety of road structures, CNESOR) often recommends running an exercise while works are ongoing, especially where the works are scheduled to take a long time to complete. The purpose of these exercises is to ensure that all parties working on the tunnel (including contractors) coordinate their efforts, and to approve intervention procedures while tunnel operating conditions are restricted as a result of the work.

– When the tunnel is closed during the works, the exercise is an opportunity to test the impact of the work on normal operating practices.

– When the tunnel remains open during the works, the exercise can be used to test the impact of the work on normal operating practices, and to approve the specific safety measures in place in this high-risk context.

The scenario may involve an unscheduled works-related event, or an event occurring in those parts that remain open, or a combination of the two.

Finally, in addition to legally required joint annual exercises, there is no reason why other internal, partial exercises could not be run to improve or test a particular aspect.

2.4 MAIN PARTIES INVOLVED

For the purpose of this guide, the term “emergency services” means all local services responding when an event occurs – both public and privately run services, regardless of whether the emergency personnel are part of the tunnel staff (internal emergency services) or external (external emergency services).⁸

2.4.1 Tunnel owner and operating personnel

The tunnel owner is the individual or public or private entity on whose behalf the tunnel is built. The operator is responsible for operating the tunnel. In most cases, tunnels are owned and operated by the same entity, although there are also other arrangements where these roles are fulfilled by separate entities.

The tunnel owner organises the exercise jointly with the emergency services. Responsibility for organising the exercise may be delegated to the operator, but the owner remains responsible for ensuring that the exercises actually take place. Regardless of the organisational arrangements at a given tunnel, the operator plays a key role in the safety exercise and is heavily involved in all phases of the process – from preparation through to implementing the resulting actions.

The following tunnel personnel may be involved, where they exist:

- the Control Station staff;
- the patrol officers;
- the maintenance staff;
- the operator’s incident response team;
- dedicated fire-fighters;
- etc.

7. A concept that refers to both straight-line distance and route distance.

8. Article R.118-1-1 of the French Roadway Code.

2.4.2 External emergency services

A distinction is made between:

Public rescue services:

- Fire and rescue services – depending on the tunnel's location, these may include Departmental Fire and Rescue Services (SDIS), the Departmental-Metropolitan Fire and Rescue Service (SDMIS), the Paris Fire Brigade (BSPP) or the Marseille Naval Fire Brigade (BMPPM). The fire and rescue services oversee rescue operations as prescribed by the operational rules dictated by the prefect. The Head of Rescue Operations is tasked with using all mobilised public and private resources to carry out the rescue operations, under the authority of the Director of Rescue Operations.⁹
- The emergency ambulance service (SAMU, typically one per department), which provides front-line medical care in emergency situations, and the mobile emergency and intensive care services (SMUR, three or four per department) under the SAMU's coordination. The SAMUs liaise constantly with the fire and rescue services via telephone link (between numbers 15 and 18).



Photo 4: rescue services

Law enforcement, as applicable:

- the national gendarmerie;
- the national police;
- the municipal police;
- the *Compagnies Républicaines de Sécurité* (CRS, national police general reserve forces).

2.4.3 Other parties

Prefecture

In most cases, the relevant prefectural departments are the Prefect's Office and the Inter-ministerial Defence and Civil Protection Department (SIDPC), whose prevention duties include developing, reviewing and monitoring the *Organisation de la Réponse de Sécurité Civile* (Civil Security Response Organisation, ORSEC) system, as well as organising and overseeing departmental civil security exercises.

Where the prefecture organises a civil security exercise (ORSEC, multiple victims (NOVI), etc.) in a tunnel, it may be treated as the annual safety exercise.

The mayor of the commune where the tunnel is located

The mayor of the commune is invested with municipal policing powers and is notified of, and invited to attend live exercises performed in tunnels in the commune. The mayors of the neighbouring communes through which traffic is diverted when a tunnel is closed or during safety exercises are also informed of live exercises, and in some cases invited to attend. Mayors can therefore play an important role in passing on information about in-tunnel conduct to their citizens.

In principle, the mayor is responsible for directing rescue operations within the commune.¹⁰ However, the impacts of an accident, incident or disaster that occurs may spread beyond the boundaries of a commune or exceed its response capabilities. In such cases, the department's central government representative (departmental prefect or police prefect) takes charge of rescue operations.¹¹

Where a tunnel measuring 300 m or more in length runs through more than one department, responsibility for directing rescue operations after an accident, incident or disaster rests with the central representative with the power to intervene as an administrative authority.

For tunnels measuring less than 300 m in length, responsibility for directing rescue operations after an accident, incident or disaster rests with the central government representative in the department in which the largest part of the tunnel is situated.¹²

Safety officer

In tunnels on the TERN measuring 500 m or more in length, the owner must appoint a safety officer. The appointment must be approved by the prefect, pursuant to article R.118.4.2 of the French Roadway Code.

The French Roadway Code also states that one of the safety officer's duties (as listed in article R.118.4.3) is to "participate

9. Article 25 of Act no. 2004-811 of 13 August 2004 on the modernisation of civil security.

10. Articles L.131-1 and L.742-1 of the French Internal Security Code.

11. Articles L.742-2 and L.742-7 of the French Internal Security Code.

12. Article L.2215-9 of the French Local Authority Code.

in organising and assessing safety exercises". In practice, this might mean that:

- before the exercise: the safety officer is involved in setting the objectives, and determining the scenario and resources;
- during the exercise: the safety officer attends the exercise as a special observer, gathering information about how the exercise progresses and any improvements that need to be made;
- after the exercise: the safety officer attends the debrief to share his or her observations, and checks that feedback has been implemented and has had the desired effect, particularly in terms of procedures (Emergency Response Plan and instructions).

The safety officer liaises between the operator and the SIDPC and helps coordinate the safety procedures.

In tunnels that do not legally require a safety officer, the owner may nevertheless have appointed someone with an equivalent role. It is therefore advisable for this person to participate in organising and monitoring safety exercises in the same way.

Traffic management services

These include the traffic management services responsible for the route on which the tunnel is located, as well as those in charge of diversion routes (if the exercise involves total or partial closure of the tunnel). Implementing a traffic management plan to address these disruptions requires coordinated action between all parties road operation parties and the traffic management services.

Other services and departments

Other local services and departments may be informed about a safety exercise, or even involved in organising it. In particular, these might include:

- approved roadside assistance and vehicle recovery companies;
- representative(s) of the technical departments of the communes where the tunnel is located;
- neighbouring or ancillary infrastructure managers (car parks, establishments receiving public (ERPs), etc.).

Consulting firms

One or more consulting firms may be brought in, as service providers, to help run safety exercises (for example, devising the programme, monitoring proceedings and drafting the final report).

However, consulting firms must not take the place of the tunnel owner, the emergency services or the safety officer, with whom all final decisions must rest.

Observers (also known as assessors)

Observers are tasked with issuing observations about the proceedings, and reporting verbally or in writing to the tunnel owner or the operator. They must be sufficiently skilled at performing this type of activity.

It is useful to clarify in advance what each observer's role entails, the required level of confidentiality, and what form the report is expected to take (specifying the precise topic, distinguishing between facts and interpretations, etc.).

In most cases, the observer will be required to take notes (possibly using a pre-defined template), and take photographs or videos. Observers may also be asked to take measurements¹³ (temperature, wind speed, etc.).

Observers may be told precisely where to stand during the exercise, or given the freedom to decide. They may be in a fixed location or be mobile. Under no circumstances may observers intervene in the simulation exercise. They should remain as discreet as possible.

Actors

The actors are involved in staging the exercise as users (involved or not in the incident/accident, injured/uninjured).

In some cases, the actors may be real users recruited specifically for the exercise so that their behaviour can be studied. An exercise of this type therefore involves cognitive psychology research, requiring specific preparation in accordance with the Act on the protection of persons consenting to biomedical research.¹⁴

13. These measurements are not an objective in their own right, but rather a way to help observers assess how the exercise is proceeding. The prime contractor or consulting firm is responsible for taking precise operational measurements according to a pre-defined protocol.

14. French Public Health Code, Book 1 – Public health protection, Section 2 – Human subject research, Chapter I – General principles on human subject research, articles L.1121-1 et seq.; Huret Law of 20 December 1988, consolidated in 2017.

The actors may also be recruited from among the owner's staff. Ideally, they should have no direct professional link to tunnel operations, to ensure that they behave as similarly as possible to real users. Students on risk management and medical courses (from non-profits such as the Red Cross, Order of Malta, nursing schools, etc.) could also be recruited as actors as part of their studies.



Photo 5: actors receiving treatment during an annual safety exercise

Guests

Other operators or owners could be invited to attend the exercise as guests, to learn lessons that they can apply to their own tunnels.

Press

The decision whether or not to inform the press depends on the level of importance attributed to the exercise. Whatever the decision, a designated contact person must be appointed to liaise with the press and manage direct interaction between the press and those involved in the exercise.

Contractors present during the exercise

Contractors present in the tunnel or the Control Station during the exercise must be informed that it is happening, at the very least. This requirement applies to all contractors, whether they are performing ongoing maintenance or major works.

The extent to which contractors are involved in exercise preparations, proceedings and review will depend on the stated objectives.

2.5 CLASSIFICATION OF SAFETY EXERCISES

Safety exercises can be divided into two broad categories: table-top exercises (sometimes known as classroom exercises) and live exercises (sometimes known as real-life exercises).

Exercises in both of these categories may be general or partial in nature.

A general exercise involves deploying the entire event management system and all human and material resources.

A partial exercise, meanwhile, implies a limited number of objectives and/or participants. For example, a partial table-top exercise could be limited to testing the Departmental Operations Centre (COD), while a partial live exercise might focus solely on user self-evacuation procedures.

2.5.1 Table-top exercises

Table-top exercises require no resources to be mobilised on the ground and do not require the tunnel to be closed. The participants receive information by radio, telephone, letter, fax, TV and email, and have to analyse and summarise the information then react, report, make suggestions, set priorities and make decisions. Exercises of this type involve developing a credible scenario beforehand.

The participants meet in one or more operations rooms. To help participants acquire the right reflexes and to cut response times

in crisis situations, the operations room should be identical, or as similar as possible to real-life conditions at the site.

These exercises can be run without affecting tunnel operations, allowing participants to familiarise themselves with the procedures, their roles and the layout and features of the tunnel, alongside the individuals who are likely to respond when a real emergency occurs. The visual representation of the tunnel may be provided using drawings, flow charts, or even a model.

These exercises allow the various participants to practise together, helping to boost crisis situation response effectiveness (rather than having people working together for the very first time).

Table-top exercises can be temporarily suspended to adjust the scenario, giving participants a chance to come up with multiple strategies based on the chosen storylines. To make the exercise more productive, it is advisable to involve both novices and experts. Because these are reflective exercises, the kinetics may differ from what actually occurs in real-time events.

NB: if the specific objective is to test activation of a crisis management unit, the participants should arrive gradually wherever possible, to check how new arrivals are able to grasp the work that has already been carried out, and to test how the operations centre manager issues situation updates and instructions.

An alternative option is to run table-top exercises using a simulator – an interactive virtual training system that provides a visual simulation of a given scenario in a structure. The degree of realism varies from one simulator to the next. The simulator user is involved in the exercise, analysing and managing the incident. Simulated exercises can provide important operational insights and help people develop the right reflexes. Moreover, they can be used for analysis purposes during the debrief.



Photo 6: table-top exercise

2.5.2 Live exercises

Live exercises are full-scale exercises that involve mobilising participants and equipment on the ground, in conditions that mimic real life as closely as possible.

Live exercises allow participants to work directly in a crisis situation inside the tunnel environment, liaising with other services and gaining a better understanding of their respective duties (for example, developing a central data repository). The tripartite live command structure (Head of Internal Operations, Head of Rescue Operations and law enforcement representative) must be established as early as possible, in a location clearly defined in the Emergency Response Plan and the Listed Establishments (ETARE) plan. The three commanders must make themselves known and should ideally remain together throughout the entire proceedings, so they can make collegial decisions on what action to take and ensure that all interventions are properly coordinated (who does what, how and where?).

Moreover, these exercises are an opportunity to test, in real-life conditions, how long it takes for respondents to arrive and to check that all operational and safety/security equipment is functioning correctly (Emergency Call Station (ECS), ventilation, variable message signs (VMS), barriers, etc.). Where appropriate for the scenario, the exercise should also test the user self-evacuation procedure.

It may not be necessary to deploy all human and material resources on the ground, or to inform all participants of the entire scenario (see Section B – 1.5 Choosing and developing the scenario). Full-scale exercises arranged by prefectures (such as NOVI exercises) come under this category.

For obvious safety and operator liability reasons, live exercises should not be run while the tunnel is under normal operation.



Photo 7: live exercise

The live exercise may be announced or unannounced.

An announced exercise is when all participants are made aware of the date and time beforehand. Depending on the objectives of the exercise, the degree of prior information may vary (theme, scenarios), notably to allow a certain leeway and spontaneity.

An unannounced exercise is when at least one participant is unaware of the date, time and scenario. Unannounced exercises are difficult because this model can introduce uncontrollable factors that could pose a safety threat as the exercise progresses. It is therefore not advisable to run exercises of this type, especially given that it is possible to introduce unforeseen circumstances into an announced exercise as explained above.

2.6 OBJECTIVES OF SAFETY EXERCISES

In mimicking real-life events, safety exercises are a useful training opportunity for respondents, allowing them to practise responding quickly and appropriately should a real incident occur.

The aim is to check that all respondents understand and can apply the relevant instructions, know how to use the technical and communication resources at their disposal, and are able to carry out their duties in coordination with other services. While safety exercises provide an opportunity to check that equipment is functioning correctly, their main purpose is to test organisational arrangements (procedures and human factors), to make sure that all participants are properly equipped to manage different types of feared event, and to improve resilience.

More specifically, the main objectives of safety exercises may include:

Assessing organisational and operational management:

1. testing coordination across different participants' response plans and strategies;
2. checking that the Emergency Response Plan procedures and associated instructions are suitable and properly implemented on the ground, across the entire alert chain:
 - detection of the event (receipt of the alarm);
 - participants' reactions (responders, mobilisation of senior officers);
 - deployment of equipment (especially signs and closure systems);
 - transmission of the alert to the emergency services and other relevant parties.
3. measuring how long it takes for responders to arrive and testing the deployment of resources on the ground (e.g. duty staff reaction time, how long it takes to close the tunnel, how long it takes for the various services to arrive on location, deployment of a diversion route, appropriate use of equipment, return to normal, etc.);
4. assessing how the system and organisation copes with a given scenario covered in the specific hazard investigation (where applicable);
5. testing the user self-evacuation and evacuation procedures (dealing with users who remain in their vehicles);
6. testing infrequent scenarios (fire in a plant room combined with an event in the tunnel, incident in the Control Station building combined with an event in the tunnel, etc.).

Assessing skills:

7. training new recruits (operator, rescue services and law enforcement staff);
8. providing joint practical training to different participants who would otherwise be unlikely to meet outside a crisis situation (operator, prefecture, law enforcement, rescue services);
9. maintaining and enhancing the skills of all parties involved in safety matters, so that they are better equipped to react quickly and appropriately when an event occurs, and giving them a better understanding (right reflexes and anticipation of side-effects) of the tunnel system (familiarisation with equipment and other responders, assessment of information escalation and reporting standards, fire-fighting, safety, monitoring and traffic management, etc.);
10. improving stress management.

Assessing infrastructure (civil engineering works and equipment):

11. checking that the equipment and resources used during the exercise are appropriate and working correctly (ventilation and smoke extraction system, signs, tunnel closure VMS, etc.);
12. testing available communication equipment (ECS, Emergency Call Network (ECN), fax, email, telephone, radio, video) and communication capabilities (situation update, information-sharing, understanding of garbled messages);
13. simulating the loss of equipment (loss of power and switching between sources, loss of the centralised technical management system, loss of lighting), and testing legally required redundant supplies (power, water, equipment);
14. testing and using safety apparatus (markers, signage, emergency recess, emergency exits, shelters, fire hydrants or dry riser supply).

Driving continuous improvement:

15. learning lessons and implementing measures where required (updating the Emergency Response Plan and instructions, centralised information management, training, etc.);
16. checking that the resources mobilised to deal with an event are adequate.

The 16 key objectives listed above are contained in the table below, showing how each type of exercise is able to address these objectives.

Objective	Table-top exercise	Live exercise
1	X	X
2	Partially	X
3		X
4	X	X
5		X
6	Partially	X
7	X	X
8	Partially	X
9	X	X
10		X
11		X
12		X
13		X
14		X
15	X	X
16		X

Table 1: objectives of table-top and live exercises

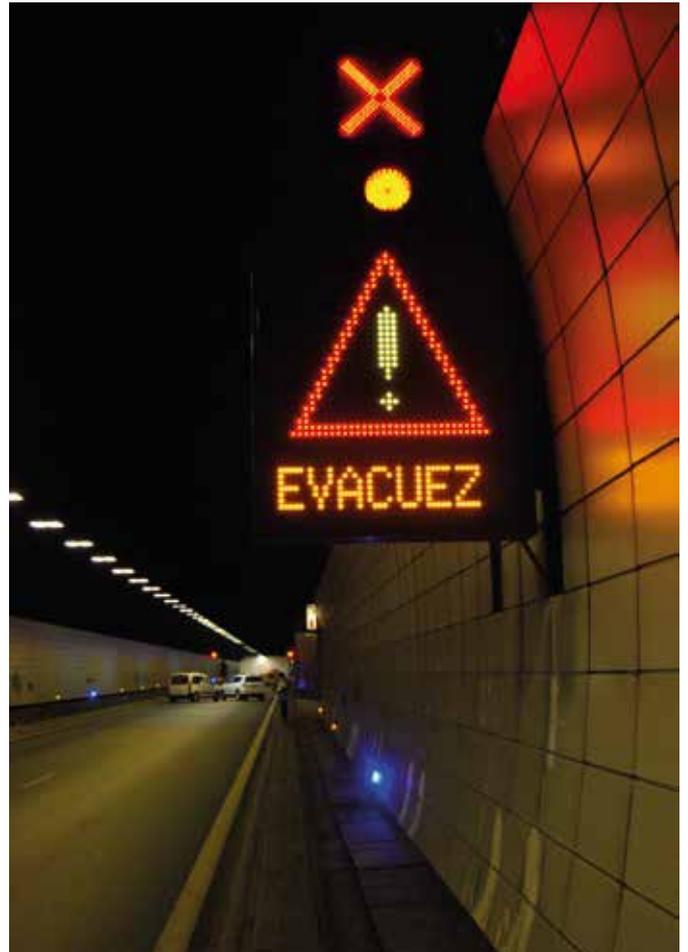


Photo 8: user self-evacuation

2.7 TECHNICAL VISITS AND TESTS

In addition to legally required safety exercises, the tunnel owner or operator may organise visits to enable both emergency services personnel and the operator's staff to regularly take a look at the tunnel's safety facilities. These visits could be arranged when the tunnel is closed for scheduled maintenance.

Visits of this type should not, however, be a substitute for safety exercises, for which the operator must keep documented records.

Similarly, it is important to maintain a clear distinction between the legally required joint exercises and technical tests. The various types of technical test are listed in Appendix 2.



Photo 9: technical visit

RUNNING AN EXERCISE

A safety exercise can be run using the Deming cycle¹⁵ (also known as the continuous improvement cycle), a virtuous cycle with four components: plan, do, check, act. Safety exercises designed with continuous improvement in mind have the following four phases: preparation of the exercise, implementation of the exercise, analysis of the exercise, and implementation of improvement actions.

In some cases, the analysis and improvement phases are combined into a single phase, sometimes called the feedback phase.

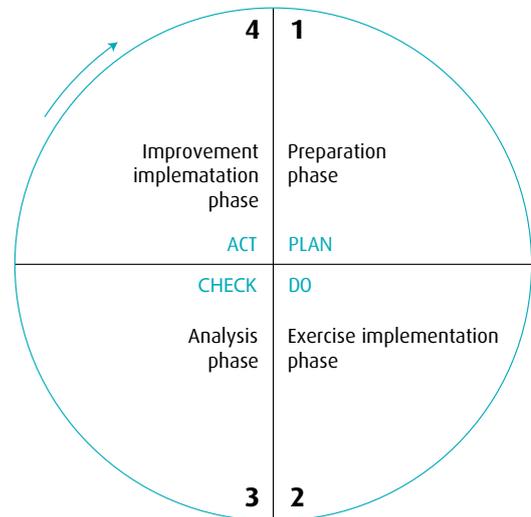


Figure 1: using the Deming cycle to implement a safety exercise



Photo 10: live exercise

15. Cycle with four components: plan, do, check and act.

3.1 PREPARATION PHASE

3.1.1 Exercise coordination unit

Once they have decided to organise a safety exercise, the tunnel owner and/or emergency services give advance notice to the prefect, the mayor and the relevant traffic police authority (if separate from the prefect and the mayor).

It is highly advisable to establish a safety exercise coordination unit as early as possible during preparations. This formal or informal unit is responsible for overall coordination of the exercise. As a minimum, the unit comprises a representative of the operator and/or owner and a representative of each of the emergency services. For tunnels on the TERN measuring 500 m or more in length, the safety officer will also be included in the coordination unit.

The exercise coordination unit may appoint an Exercise Director (EXDIR), with responsibility for organising, running and analysing the exercise. The unit may be led by the prefecture.

The exercise coordination unit should involve multiple parties, in line with the principles of the Act on the modernisation of civil security (see Appendix 3), which requires coordination efforts to extend beyond conventional departmental boundaries, remits and prerogatives in the interest of better collaboration.

The exercise coordination unit is responsible for driving the process across all participants, setting and coordinating the communication policy and approving the various phases. Whether present throughout the exercise or only for part of it, the unit may step in if required to ensure that the objectives are met. For example, the exercise coordination unit may amend the initial schedule or suspend the exercise (in the event of hazardous weather conditions, if the rescue services need to attend a real-life incident, etc.).

The various services involved in the exercise may be invited to one or more consulting meetings to discuss their respective concerns, depending on the scale of the chosen scenario.

Decisions on the objectives, exercise type, scenario and participants' roles are made at these meetings.

3.1.2 Setting objectives

For exercises run when a tunnel is in operation, the objectives should draw heavily on feedback from previous exercises and experience over the course of the tunnel's lifespan, to ensure that risks specific to that tunnel are considered. The analysis will need to focus on:

- reports from previous exercises and any prior fire tests;
- what action was taken subsequently;
- any problems identified during real-life interventions.

The examination should also look at the scenarios covered in the specific hazard investigation, or in the comparative risk assessment for transport of dangerous goods (TDG) (if this type of transport is permitted in the tunnel).

If they exist, instructions on the objectives of safety exercises issued by the *Commission Consultative Départementale de Sécurité et d'Accessibilité* (Departmental advisory commission on safety and accessibility, CCDSA) or CNESOR should be taken into account.

The stated objectives must be clear, realistic and measurable and shared with all relevant parties. To that end, it is not advisable to set too many objectives at once. The list of 16 key objectives in the previous chapter may provide a helpful reference. If there is a case for pursuing multiple objectives, it may be useful to spread these objectives across several years.

For a new tunnel, it is advisable to begin with live exercises to give responders a chance to familiarise themselves with the structure, then to approve the service alert chain and, finally, the various response procedures.

If conducting an exercise in a tunnel for the first time, it is highly advisable to start with an exercise involving the emergency closure of the whole tunnel or a tube, to check that the alert chain and the equipment are functioning as they should (basic scenario in the Emergency Response Plan).

3.1.3 Choosing the right type of exercise

Live exercises should be the preferred choice during the first few years of a tunnel's lifespan, since they cover all objectives.

However, because live exercises are expensive and generally cause traffic disruption, it is possible to introduce table-top exercises later down the line. This is not a question of abandoning live exercises altogether, but rather running occasional table-top exercises in their place.

Generally speaking, table-top exercises are cheaper because fewer people and less equipment have to be mobilised. Yet they are often more complex to set up, especially during the scenario development and detailed script-writing phases (see Appendix 4). Table-top exercises are not an effective way to test how long it takes for responders to arrive and to deploy human and material resources on the ground.

In summary, the following criteria will typically determine which type of exercise is appropriate:

1 – Objectives:

Table 1 (in section 2.6) shows the objectives to which each type of exercise is suited. As we have seen, the stated objectives will depend on the tunnel context and the analysis of the existing human resources and processes. A carefully designed plan will ensure that all 16 objectives are met over the course of multiple exercises.

2 – Timing and budget constraints:

Time and financial costs differ from one type of exercise to the next. Exercises involve multiple different parties, and their respective needs and constraints will naturally affect its content. For example, a live exercise involving a simulated fire and requiring a large number of people to be evacuated will place a heavy burden on the rescue services. It is therefore essential to consider this fact, without systematically postponing large-scale exercises.

3 – Inconvenience:

Exercises tend to cause the greatest inconvenience for tunnel users (temporary decline in service level, such as alternating traffic, or closure of one tube or the entire tunnel), local residents and, in some cases, other traffic managers (deployment of diversion routes). The degree of inconvenience stems directly from how long the exercise lasts when it is performed.

4 – Timescales:

It is also important to consider how long it takes to prepare for and carry out the exercise. For a live exercise, for example, it will be necessary to submit the relevant authorisation requests well in advance. For a table-top exercise, the time it takes to develop the scenario will depend on the experience of the coordinating team.

3.1.4 Choosing the scenario

The next step is to develop a realistic, workable scenario, based on the chosen objectives.

If they exist, instructions on safety exercise scenarios issued by the CCDSA or CNESOR should be taken into account.

Ideally, initial exercises should be based on simple scenarios. The scenarios may become more complex as the years progress. For example, if the emergency exits are a critical component of the safety system, one of the early exercises should involve testing how different participants use these exits, and organisers should avoid developing a “disaster” scenario that makes exit(s) unusable.

Scenarios should not be designed with the intention of testing configurations under which the minimum operating requirements are exceeded, since these situations involve closure of the tunnel. In some cases, however, the exercise may involve measuring how long it takes to close the tunnel once the minimum operating requirements are exceeded (e.g. loss of the centralised technical management system).

By way of indication, some typical scenarios are outlined below:

- breakdown of a light vehicle (LV) or heavy goods vehicle (HGV);
- collision between two LVs, with or without injuries;
- collision between one LV and one HGV, with injuries;
- collision between one LV and one coach, with many people involved;
- collision involving a fire;
- spontaneous HGV fire;
- fire in two separate locations;
- accident during roadworks;
- degraded operating conditions, with or without a simultaneous event;
- etc.

Using different scenarios from one year to the next can be helpful both to test a variety of different configurations and to avoid falling into a routine. It may be useful to use a tracking table to monitor the planning and the themes covered during the exercises.

Appendices 4 and 5 provide samples of scenarios actually used by operators.



Photo 11: live exercise with simulated fire

3.1.5 Developing the scenario

The scenario should be developed with both the exercise timeline and the participants' roles in mind. It is vital to have a detailed scenario, listing the actions assigned to each participant type (triggering the start of the exercise, mobilising the various services, indicating the actors' roles and positions in both space and time, etc.). Crucially, all parties mobilised for the exercise must have a role to play.

It may be useful to draw up a table (see Appendix 6) detailing these two elements (timeline and participants) and explaining how the exercise should proceed, in theory. This document should then be shared with the observers, so they can check it against how the exercise actually proceeds. It may also be beneficial to have a summary of the Emergency Response Plan, along with the corresponding instructions. These documents could then be used during the debrief session to review the exercise.

The confidentiality of the exercise should also be determined, focusing on the following aspects:

- date and time;
- scenario content;
- degree of information provided to the various services;
- degree of information within each service.

In some cases, it may be advisable to draw up an exercise agreement, especially where the scenario demands specific provisions. This agreement, between all or some of the exercise participants, should provide a clear framework setting out the exercise rules and boundaries. For example, the agreement may stipulate that the smoke extraction system should not be triggered, and the lights not switched off, immediately when simulating a fire with cold smoke, so as to match as closely as possible the actual visibility conditions that occurred during a real fire. The exercise coordination unit must discuss and approve the content of the agreement.

It is important to note, however, that many exercise agreements involve pre-positioning of the rescue services. Yet it is essential to carry out some exercises without pre-positioning, so as to measure how long it takes for the rescue services to arrive on site, and to allow the operator to check the instructions that should be given to users before the rescue services arrive.

Scenario credibility is particularly important for table-top exercises, to make sure the role-playing process works properly. The exercise coordinator (who is appointed at this stage) should have a thorough knowledge of the roles that the participants involved in the exercise play. Where this is not the case, it may be necessary to appoint more than one coordinator.

The scenario should be developed as a timeline, to ensure that the right information and instructions are issued to the participants as the exercise progresses, so that they can react appropriately. Moreover, there should be sufficient information and instructions to keep all participants occupied, and they

should be issued at a sustained pace to maintain momentum throughout the exercise. It is important to remember that a table-top exercise may be suspended temporarily, with each sequence of events interspersed with dedicated time for reflection.

Appendices 4 and 5 provide samples of scenarios actually used by operators.

3.1.6 Assessing the likely cost

Once the scenario has been developed, the exercise coordination unit representatives should then set about estimating what budget to assign to the exercise. This phase will only be performed if the exercise coordination unit considers it necessary.

Because the circumstances vary so much, it is difficult – or even impossible – to give an “average cost”. Depending on the scale of the exercise, it may involve significant direct expenditure and a large number of participants. Conversely, it may be possible to run the exercise relatively inexpensively.

It is possible, however, to list the main expenditure items (non-exhaustive and in no particular order):

- human resources, including time spent, depending on the parties involved (thinking time, preparation, consultation, action, restoration of the tunnel, debrief);
- material resources (including setting fires and installing protections, where applicable);
- cleaning (and damage repair, where applicable);
- external subcontractors;
- excess usage of water, electricity, etc.
- loss of revenue (tolls);
- participant comfort and safety (e.g. providing covers in the interconnection tubes, refreshments, personal protective equipment (PPE), sanitary facilities, etc.).

3.1.7 Practical preparations

A live exercise is a major event involving full or partial closure of the tunnel. It is therefore essential that local residents and other stakeholders are notified in advance. Moreover, closure of the tunnel should be governed by an official order, unless the exercise forms part of a traffic management plan which has, in itself, been the subject of an official order.

Prior to a live exercise, it is necessary to:

- specify the practical arrangements around the exercise, including an analysis of the associated human and material resources;
- ensure that all tunnel systems are working and that the sensors are correctly calibrated;
- make sure that the various services receive the right information (law enforcement, traffic management centres, etc.);

- draw up a list of people who are not directly involved in the exercise (local authority staff, elected representatives, local residents) but who still need to be informed;
- identify any factors that are likely to influence or undermine the exercise, so that remedial action can be taken if required:
 - atmospheric conditions (e.g. strong winds or fog);
 - traffic conditions (anticipate peak traffic periods during the exercise);
- assess exercise-related risks and determine how to ensure that participants and local neighbours are kept safe;
- have people on standby to deal with any technical problems that may arise during the exercise and affect its smooth running.

Material resources

It is important to consider, well in advance, what resources will be required to:

- run the exercise in general (securing a meeting room, producing and distributing the exercise schedule, arranging return transport for observers, guests and actors);
- deploy the scenario (vehicles, smoke grenades, fire-setting equipment, protective equipment to safeguard the tunnel and equipment against heat (where applicable), model, plan, summary, etc.), including emergency services equipment;
- observe and/or record the exercise (cameras, control station video recording, timeline templates for the observers to complete, hand-held anemometers, temperature sensors, etc.) – producing audio/video recordings in the monitoring room and video recordings in the tunnel can often provide a wealth of information;
- coordinate the exercise as it progresses (radios, walkie-talkies), to keep observers and participants informed and to coordinate their actions (starting and ending signals);
- keep the participants comfortable (sanitary facilities, covers, refreshments, etc.).

In addition to tunnel-specific safety equipment, live exercises require additional resources:

- to make sure the exercise runs safely (barriers, tabards, additional fire-fighting equipment, etc.);
- to clean and restore the tunnel.

Appendix 7 details the types of smoke that should be used for live exercises involving a fire, along with the practical arrangements for running an exercise of this type.



Photo 12: smoke generators

Human resources

Human resources should be divided into people involved in:

- preparing for the exercise – preparation and coordination meetings;
- for live exercises, setting up the tunnel as per the scenario, preparing the equipment and deploying the diversion route, if necessary;
- for table-top exercises, setting up the room as per the scenario and preparing the equipment;
- running the exercise – people involved in supervising and coordinating the exercise (including emergency services personnel for exercises involving a real fire), people participating in the exercise by virtue of their role (operator and emergency services personnel); each person's position should be established in advance, with two people posted in key locations;
- observing the exercise – observers should be well placed to monitor proceedings in a tunnel; this may be in the control station or in the crisis room adjoining the control station, but it is also important to have at least one observer on the ground to monitor how the participants behave (Appendix 8 includes a sample observers' questionnaire for live exercises);



Photo 13: observer wearing a specially marked tabard during a live

- playing out the scenario (actors) – the tunnel owner must ensure that actors are covered by its insurance policy or, where applicable, take out a specific policy for the exercise. The organisers may decide to develop a relatively strict scenario, with precise instructions for the actors about their position and actions, to make it easier to manage the safety aspects. Alternatively, a decision may be made to give some actors leeway over their behaviour, to make the scenario a little more “realistic” in terms of when and how the alert is issued, whether or not they decide to make their way to an exit, etc. In this case, particular measures will need to be taken to ensure that the exercise progresses safely, with special attention given to locating and gathering all of the actors at the end of the exercise. For example, an exercise of this type is a useful way to test emergency services coordination when evacuating a large number of users.

Generally speaking, actors should not be involved in an exercise in which hot smoke is used to simulate a fire. Where an exercise involves simulated injuries, their tabards should expressly indicate the type and severity of the injuries;

- informing the public – this should be done in conjunction with the prefecture. Ideally, a press conference should be arranged and a press kit distributed prior to the exercise. Members of the press will need to be supervised by one or more designated persons throughout the duration of the exercise, and kept at a sufficient distance away from the actors and observers such that they do not interfere with the progress of the exercise;
- restoring normal operations (cleaning and restoration) and re-opening the tunnel (after a live exercise).



Photo 14: self-evacuation of a person with reduced mobility

3.2 EXERCISE IMPLEMENTATION PHASE

3.2.1 Setting the scene

An exercise is much more than a “game”, whereby the organisers justify what went wrong by insisting that things do not work like that in real life. Where exercises are unrealistic, the participants find it hard to play along. So it is important to set the scene in a way that makes the scenario more realistic. This, in turn, helps to ensure that:

- the people involved in the exercise are motivated;
- the scenario is clear for all to see and the exercise runs smoothly.

Below are some concrete examples of how this can be achieved:

- placing stopped vehicles on either side of the vehicles involved in the incident (broken down, in a collision or on fire) to simulate congestion and observe how the emergency services would progress in real life;
- blocking traffic over 500 m behind an event, using a vehicle spanning the lanes to block the progress of the fire and rescue services;

- making the vehicles involved in the scenario easy to identify, so they can be distinguished from other vehicles (such as patrol vehicles), for example by:
 - using make-up to identify the “injured” actors;
 - making the actors wear tabards detailing their injuries;
 - reminding the actors to behave as if they were injured throughout the exercise (for example, someone with a broken leg cannot walk and therefore cannot be evacuated on foot by the rescue services);
- setting a time limit beyond which those with severe injuries are considered to have died, for the purpose of the exercise;
- for a simulated fire without a real fire, producing cold smoke close to the “on fire” vehicles and clearly identifying these vehicles to make the scenario more realistic for the rescue services (e.g. cordoning off an area marked “high temperature – no entry without specific equipment”, etc.).



Photo 15: evacuation of an injured casualty

For example, the tasks may include:

- installing vehicles in the tunnel;
- applying make-up to the actors (which can take time, but does not necessarily have to be done in the tunnel);
- creating smoke. It is extremely difficult to create a dense plume of smoke in the right place because of natural air flow and ventilation capacity. So the solution, where possible, is to create a large volume of high-quality smoke in a position compatible with the objectives of the exercise;
- for a simulated fire with a real fire, installing protections and dismantling sensitive equipment, setting the fire, etc.;
- marking out the diversion route, stacking cars at the tunnel portals, etc.

3.2.2 Pre-exercise brief

Live exercises are preceded by a pre-exercise brief, led by the exercise coordination unit, at least one hour before the exercise begins. The meeting should be attended by at least one representative of all participant groups. The number of participants attending the meeting may vary for partially unannounced exercises. The brief should take place in a location that is easy to access, with participants informed and reminded of the location beforehand (e.g. crisis room, ventilation station, communal room, etc., ideally close to the tunnel).

The purpose of the brief is to go over the exercise schedule (to be distributed), the safety rules and the press rules one final time, and to give the observers further clarifications about their roles (to be distributed). Appendix 8 includes a sample observers' questionnaire.

The Exercise Director may ask all participants to synchronise the time on their watches and mobile phones at the start of the exercise.

Where applicable, it may also be worthwhile arranging a separate press information meeting.

For table-top exercises, a simple "introductory" message for all participants should suffice.

3.2.3 Running the exercise and managing safety

It is essential to draw up a precise chronology of events as the exercise progresses, so that the various interventions can be compared on a timeline and presented during the feedback phase. Faxes or emails should be sent to different recipients, containing the words "emergency response exercise", to check this aspect.

As a general rule, it is important to keep a close eye on the points mentioned above in the preparation section, while being mindful that safety is of the utmost importance. For a live exercise involving deployment of resources on the ground, it may be useful to appoint a designated person with responsibility for safety. A risk assessment must be conducted so that precautionary measures can be put in place and all potential hazards eliminated. If someone is appointed to take charge of safety, he or she must be present throughout the exercise, to ensure that all participants follow the safety instructions and do not place themselves or others in danger.

All people present during the exercise, other than the actors, must wear a high-visibility vest. Some people, such as press representatives, observers and guests, need to be easily identifiable. This could be achieved, for example, by getting them to wear vests or tabards with specific wording or in different colours.

People not directly involved in the exercise must be held a safe distance away, behind a clearly marked cordon (ribbon, barriers, etc.). For exercises involving a fire scenario, these people will need to be evacuated if smoke passes the safety cordon, for whatever reason. Refer to Appendix 7 for more information about managing safety during this type of exercise.

3.2.4 Ending the exercise and returning to normal

The decision to end the exercise rests with the Exercise Director, once he or she has consulted the participant group leaders or coordinators.

For a live exercise, the tunnel must be re-opened to traffic with all systems intact. It is vital to re-open the tunnel quickly, following the defined procedure for re-opening after closure. Technicians should be brought in to make sure that all equipment is in full working order.

The tunnel should be checked to make sure there are no people or vehicles remaining inside, that all scenario-related equipment (for information purposes or specific actions) has been deactivated, and that the minimum operating requirements are met.

3.3 ANALYSIS PHASE

3.3.1 Post-exercise debrief

Where possible, all exercise participants should attend an immediate debrief, when the exercise is still fresh in their minds. For example, each participant could be asked to comment on how the exercise went, listing what worked well and what could be improved, and recording their comments in writing for record-keeping purposes.

3.3.2 Examining records and observations

Everyone taking photos or recording videos must have signed an agreement not to distribute them without the Exercise Director's express authorisation.

The records (videos, photos, sensor measurements and audio files) and observation sheets are examined once the exercise is complete, to supplement the initial observations given at the general debrief and for inclusion in the final report.

Depending on the circumstances, this work may be performed by the Exercise Director, by a consulting firm, or by a specialist service (such as a cognitive science service).

3.3.3 General debrief

If necessary, each service may hold an initial, internal debrief, forwarding the observations to the Exercise Director for the purpose of preparations for the general debrief.

The general debrief should take place a few days after the exercise, involving all services that took part in the exercise, to analyse the proceedings and to draw on initial lessons learnt. The meeting's conclusions will then be included in the final report.

There are several different ways to structure the general debrief:

- by objective;
- by the timeline of events;
- by service involved in the exercise;
- by equipment type.

It may be useful to re-use the initial table drawn up during the preparatory phase, and to note down any gaps between what was planned and what actually happened.

The following list sets out themes that could be used to structure the debrief (the list will need to be adapted depending on the exercise type):

- alert sequence;
- resources mobilised;

- emergency services access to the tunnel;
- communication;
- evacuation of casualties and victims;
- rescue services search/identification;
- individual behaviour (vehicle position, distance between vehicles);
- casualty count;
- clearance of vehicles, injured people and evacuees;
- how the equipment functioned (especially the ventilation system, if the exercise involved a fire);
- how the control stations functioned (if any);
- fire-fighting (where applicable);
- inspections (if any);
- re-opening of the tunnel;
- return to normal;
- compliance with procedures.

Once the debrief is complete, areas for improvement are identified, an action plan is drafted, and a press release may be distributed.

3.3.4 Final report

The final report is drawn up after the general debrief.

The report details the circumstances of the exercise, outlines how it proceeded, and explains what lessons have been learned and what action will be taken, if any. The report may be drafted by the Exercise Director. The plan below, provided by way of an example, is based on the continuous improvement cycle:

1 – Initial planning and development:

- services involved, people, titles, and information about the equipment used;
- list of preparatory documents (previous exercise reports, meeting minutes, exercise plan, distributed documents, etc.);
- exercise theme;
- exercise scenario;
- preparatory actions.

2 – Exercise:

- timeline, showing when different services' actions occurred;
- information about equipment functioning; signage, radio communication, lighting, ventilation/smoke extraction, fire system, etc.;
- quantified elements (event detection time, tunnel closure time, tunnel portal arrival time, incident site arrival time, evacuation time, return to normal time, etc.).

3 – Analysis:

- examination of recordings and observations;
- comparison of quantified elements against values contained in the specific hazard investigation;
- comparison with procedures in the Emergency Response Plan and the ETARE plan;
- functioning of the tripartite command structure (Head of Internal Operations, Head of Rescue Operations and law enforcement representative);
- qualitative elements around human and organisational behaviour;
- conclusions of the general debrief;
- organisation and management of on-site response teams;
- overall assessment of the exercise.

4 – Improvement implementation:

- areas where organisation could be improved for future exercises;
- list of decisions on next steps and recommendations (who, what, when, etc.);
 - list of actions;
 - allocated resources;
 - methodologies;
- milestones and time scales;
- action plan tracking table (to be completed at a later date).

5 – Other points

The final report is drawn up on the basis of observers' notes, comments made during the debrief meetings, and the content of the centralised technical management system log (if any).

The report could also include elements from partial reports produced by the various services involved in the exercise.

The draft final report is then shared with participants for comment, before being forwarded to the joint organising services for approval.

The final, approved report is shared with all services involved in preparing, conducting and analysing the exercise, so that as many people as possible can learn from its contents. The final report could also be shared (in whole or in part) with the consulting firms, observers, guests and site contractors (depending on the degree of confidentiality and as necessary).



Photo 16: annual safety exercise with warm smoke

3.4 IMPROVEMENT IMPLEMENTATION PHASE

The following guidelines should not be taken as hard-and-fast-rules, but rather as a thematic framework for analysing an emergency response exercise, learning lessons from the findings, identifying where things could be improved and, in some cases, reviewing rescue services or operator arrangements.

It may be beneficial to track implementation of the recommendations and lessons learned for future assessment.

3.4.1 Organisation and procedures

The final report lists the decisions made and the next steps for both the operator and the emergency services, identifying those operational or response procedures that need to be revised or updated.

From an organisational perspective, for example, the analysis often finds that safety decision-making and information circulation procedures could be reworked or improved, at least in part.

In some cases, the problems uncovered may require more sweeping reforms (rather than a simple update of procedures), leading to changes in the way the emergency services are organised or in how services coordinate their work with one another. These actions may have implications for the Emergency Response Plan and operational instructions.



Photo 17: table-top exercise

3.4.2 Technical and human resources

The technical and human resources used should be analysed to identify any shortcomings. Special attention should be paid to those resources mobilised during the exercise, and whether they match the resources available in real life (including overnight and at weekends).

Any technical shortcomings will need to be addressed, for example by:

- changing the scenarios in which certain items of equipment are deployed;
- revising the maintenance policy and arrangements;
- replacing certain items of equipment;
- etc.

If necessary, new systems may be deployed. Examples might include:

- signage and other provisions to support self-evacuation of users;
- a system to facilitate rescue service response;
- etc.

3.4.3 Information and training

If the analysis reveals that existing competencies fall short of requirements, additional training could be arranged to improve the situation, on topics such as:

- crisis management and safety apparatus usage in tunnels (for operators and/or managers);

- knowledge of tunnel-specific safety apparatus (for rescue services);
- how to deliver information to users (language and format);
- foreign languages (for all responders working in cross-border tunnels).

Some of this additional training could be delivered through technical visits to the tunnel, giving operators, tunnel and traffic management staff, and emergency services personnel a chance to familiarise themselves with the installations. These visits, which require less organisation than a safety exercise, could be carried out during a planned closure of the tunnel.

Users could also be provided with information based on exercise feedback. The tunnel owner must first ensure that the information is consistent with, and relevant to the recommended practices as prescribed by law.

3.4.4 Updating the safety documentation

The safety documentation containing a list of completed exercises and lessons learned must be updated annually. It might be beneficial to attach the next steps tracking table to this document.

By way of a reminder, whenever an existing tunnel undergoes a substantial modification, a list of all safety exercises completed in the five years prior to the change, along with the lessons learned from these exercises, must be added to the initial safety documentation.¹⁷

17. Article R.118-3-1 of the French Roadway Code.

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GLOSSARY OF TERMS

- BMPM:** *Bataillon de Marins-Pompiers de Marseille* (Marseille Naval Fire Brigade)
- BSPP:** *Brigade de Sapeurs-Pompiers de Paris* (Paris Fire Brigade)
- CCDSA:** *Commission Consultative Départementale de Sécurité et d'Accessibilité* (Departmental advisory commission on safety and accessibility)
- MOR:** Minimum Operating Requirements
- CNESOR:** *Commission Nationale d'Évaluation de la Sécurité des Ouvrages Routiers* (French assessment commission for the safety of road structures)
- COD:** *Centre Opérationnel Départemental* (Departmental Operations Centre)
- CODIS:** *Centre Opérationnel Départemental d'Incendie et de Secours* (Departmental Fire and Rescue Operations Centre)
- COI:** *Commandant des Opérations Internes* (Head of Internal Operations)
- COS:** *Commandant des Opérations de Secours* (Head of Rescue Operations)
- CRS:** *Compagnie Républicaine de Sécurité* (national police general reserve forces)
- AID:** Automatic Incident Detection
- DOS:** *Directeur des Opérations de Secours* (Director of Rescue Operations)
- EXDIR:** EXercise DIrector
- PPE:** Personal Protective Equipment
- ERP:** Establishment Receiving Public
- ESD:** *Étude Spécifique des Dangers* (Specific Hazard Investigation)
- ETARE:** *ÉTABlissements RÉpertoriés* (Listed Establishments)
- CTM:** Centralised Technical Management
- IDI:** Initial Detailed Inspection
- NOVI:** *NOMbreuses Victimes* (Multiple Victims)
- ORSEC:** *Organisation de la Réponse de Sécurité Civile* (Civil Security Response Organisation)
- ECS:** Emergency Call Station
- CS:** Control Station
- PCO:** *Poste de Commandement Opérationnel* (Operational Control Station)
- ERP:** Emergency Response Plan
- HGV:** Heavy Goods Vehicle
- AMP:** Advanced Medical Post
- VMS:** Variable Message Sign
- CAP:** Casualty Assembly Point
- ECN:** Emergency Call Network
- FB:** Feedback
- TERN:** Trans-European Road Network
- SAMU:** *Service d'Aide Médicale Urgente* (emergency ambulance service)
- SIDPC:** *Service Interministériel de Défense et de Protection Civile* (Inter-ministerial Defence and Civil Protection Department)
- SMUR:** *Service Mobile d'Urgence et de Réanimation* (mobile emergency and intensive care services)
- SDIS:** *Service Départemental d'Incendie et de Secours* (Departmental Fire and Rescue Service)
- SDMIS:** *Service Départemental-Métropolitain d'Incendie et de Secours* (Departmental-Metropolitan Fire and Rescue Service)
- TDG:** Transport of Dangerous Goods
- RE:** Relative Emergency
- LV:** Light Vehicle

APPENDIX 1 – REFERENCE DOCUMENTS

Applicable laws at the time of writing (excerpts relating to exercises)

French Roadway Code

“Article R.118-3-1 – Whenever an existing tunnel undergoes a substantial modification, a list of all safety exercises completed in the five years prior to the change, along with the lessons learned from these exercises, must be added to the initial safety documentation.”

“Article R.118-3-3 – No later than five years before the expiry of the permit, the owner shall submit to the prefect four copies of a dossier containing:

a) The safety documentation described in article R.118-3-2, updated and supplemented by a report on all significant incidents and accidents occurring during the reporting period, along with an analysis of these incidents and accidents, and a list of safety exercises performed pursuant to article R.118-3-8 and the lessons learned from these exercises.”

“Article R.118-3-8 – The owner mentioned in article R.118-1-1 and the emergency services shall organise joint exercises for tunnel staff and the emergency services. The exercises shall be performed annually. Where there are several tunnels under the same manager, covered by the same emergency services and located in close proximity to one another, the exercise may be run in just one of the tunnels.

These exercises shall be based on incident scenarios in accordance with the specific risks occurring in the tunnel. The exercises shall be used in particular to measure the time taken for the emergency services to arrive on scene and shall undergo a joint assessment.”

“Article R.118-4-3 – [...] The safety officer [...] shall participate in organising and assessing the exercises mentioned in article R.118-3-8 [...].”

Circular no. 2006-20 of 29 March 2006 on the safety of road tunnels measuring more than 300 metres in length / State-managed road network

2. In-service tunnel operation

“The organisation of periodic exercises: at least once a year, the manager shall organise a safety exercise to test all operational instructions, the response and safety plan, and implementation thereof by tunnel staff; this exercise shall be assessed in order to learn lessons for tunnel safety improvement;

[...] In addition, the safety documentation mentioned in article R.118-3-2 of the Code shall be a reference framework providing all concerned parties with the approved documents necessary to maintain safety in the tunnel under all circumstances. You must ask the tunnel manager to keep this documentation up to date, paying special attention to the following documents:

- the tunnel operational instructions;*
- the emergency response plan;*
- the list of completed exercises and lessons learned;*
- the list of significant incidents and accidents.”*

Directive 2004/54/EC of the European Parliament and of the Council of 29 April 2004 on minimum safety requirements for tunnels in the Trans-European Road Network

Annex II – 5. Periodic exercises

“The Tunnel Manager and the emergency services shall, in cooperation with the Safety Officer, organise joint periodic exercises for tunnel staff and the emergency services.

Exercises:

- *should be as realistic as possible and should correspond to the defined incident scenarios,*
- *should yield clear evaluation results,*
- *should prevent any damage to the tunnel,*
- *may also, in part, be conducted as table top or computer simulation exercises for complementary results.*

a) Full scale exercises under conditions that are as realistic as possible shall be conducted in each tunnel at least every four years. Tunnel closure will only be required if acceptable arrangements can be made for diverting traffic. Partial and/or simulation exercises shall be conducted every year in between. In areas where several tunnels are located in close proximity to each other, a full scale exercise must be conducted in at least one of those tunnels.

b) The Safety Officer and the emergency services shall evaluate jointly these exercises draw up a report and make appropriate proposals.”

French Internal Security Code

Article L.742-1:

“Responsibility for directing rescue operations rests with the competent police authority, pursuant to the provisions of article L.132-1 of this Code and articles L.2211-1, L.2212-2 and L.2215-1 of the French Local Authority Code, except where the provisions of articles L.742-2 to L.742-7 apply.”

Article L.132-1:

“The mayor, by virtue of his policing powers, shall participate in public safety and crime prevention missions, except where the provisions of articles L.742-2 to L.742-7 apply.”

APPENDIX 2 – TECHNICAL TESTS

Safety equipment acceptance tests

The purpose of safety equipment acceptance tests is to ensure that the work performed complies with the provisions of the contracts signed by the tunnel owner. These tests cover the following equipment in particular: power supply; ventilation; lighting; ECS; fire-fighting equipment; fire detection; signage; tunnel closure system and signs; radio communications; lifting rings; alarms triggered on the opening of safety recess doors, emergency exit doors, emergency shelter doors and when a fire extinguisher is taken off its hook; closed-circuit television camera network; automatic incident detection system, etc. The tests are normally held before a new tunnel opens or when substantial changes are made to safety installations.

The tests check that each type of equipment is working properly, and in particular that the tunnel's overall safety chain is functioning correctly. An acceptance report is produced at the end of the tests. The prime contractor signs the acceptance reports.

Fire and smoke extraction test

Fire and smoke extraction tests are an entirely separate matter. Performed once the ventilation and smoke extraction equipment acceptance tests are complete, these tests ensure that the tunnel ventilation system has sufficient capacity to extract the smoke produced by a fire. The findings are used to update the ventilation system management instructions in the event of a fire.

These tests involve producing smoke (ideally hot smoke) with calibrated fires. They are not intended to check that the

mechanical ventilation system complies with the requirements of the Technical Directive. As such, it is not necessary to generate smoke in the same volume as the design fires appearing in the circular.

These tests are typically performed before a new tunnel is commissioned or after substantial modifications to the smoke extraction system or procedures, by the contractor that performed the work and/or the prime contractor. A written or verbal test report is produced.

The rescue services are involved in these tests for training purposes.

Equipment controls

Booklet 40 (guidelines on implementing the technical directive for monitoring and maintenance of engineering structures) includes special arrangements for the monitoring and maintenance of bored tunnels, cut-and-cover tunnels and similar road structures. Whilst intended for tunnel owners in charge of operating, maintaining and managing the non-concession State-managed road network, it can also be used as a reference by any owner in charge of privately managed structures.

There are four different types of equipment control:

- “continuous” control;
- statutory controls;
- detailed inspections – initial detailed inspection (IDI) prior to commissioning, and periodic detailed inspections (refer to booklet 40 for more information);
- special safety sequences (where the tests involve scenarios or partial scenarios involving several items of equipment).

APPENDIX 3 – ORSEC SYSTEM

Act no. 2004-811 of 13 August 2004 on the modernisation of civil security outlines the third-generation ORSEC system, which is designed to mobilise and coordinate civil security bodies and entities under the sole authority of the prefect. The aim is to ensure that all public and private parties that could potentially play a role in public protection are fully prepared. The system goes beyond planning, aiming instead to put in place a single, permanent operational structure for managing events with a major public impact.

The exercises are the culmination of the planning process.

Below is an excerpt from the preamble to the Act on the modernisation of civil security:

“3. From exercise to training

Tests should be run to check that the plans are workable and realistic, involving not just the public authorities and rescue services, but also members of the public. The aim is to build a set of varied, realistic exercises as a matter of policy. In the coming years, safety and civil defence exercises will not be limited to testing transmission systems and training general staff. Instead, exercises will need to be carried out as often as is necessary, at full scale, with involvement from the public. In the short term, each department will be required to perform one full-scale exercise every year.

The new exercises will be carried out at three levels: senior officials and general staff, crisis respondents and participants, and members of the public. Locally, crisis management training will be extended beyond the rescue services. Multi-year exercise planning, based on priorities emerging from risk assessment, will ensure that crisis preparations are carried out consistently. Training will also focus on rapid response to expectations among the public and press, who are already well-versed in some types of civil security exercise, since effective communication by the authorities is vital to crisis management. The exercises will be independently assessed and objective tools will be produced to make sure that the lessons learned are reliable.

Examining society's reactions and expectations, as revealed in the aftermath of recent natural disasters and technology crises, has encouraged the emergence of a new culture of feedback – a process that supports continuous improvement of risk management systems.

This practice, which is now more widespread, must be improved by sharing work and by appointing an authority with responsibility for fostering a multi-disciplinary approach, and for disseminating the conclusions to both services (so they can fine-tune their procedures) and the public at large (in the interest of transparency and information).”

APPENDIX 4 – SAMPLE TABLE-TOP EXERCISES RUN BY OPERATORS (OBJECTIVES, SCENARIO AND TIMELINE)

This appendix contains two sample table-top exercises run by tunnel operators.

The samples are provided for information purposes only and should not be treated as typical examples. However, they are intended to provide insights for operators and other parties involved in table-top exercise preparations, to help them set objectives and develop a scenario and timeline suited to the tunnel in question.

Sample 1

Objectives

- Test triggering of the Departmental Operations Centre (COD) in the prefecture.
- Test the link with the Head of Rescue Operations (COS).
- Test the flow of information.
- Test deployment of the COS and the link with the Head of Internal Operations (COI).
- Check that all parties involved are familiar with the procedures.
- Apply the Emergency Response Plan (ERP).

Scenario

At 10:00 am, a heavy goods vehicle (HGV) catches fire at point of reference (PR) 15 (southbound). A traffic jam forms. The fire appears to spread to several light vehicles (LVs). Users evacuate via the various emergency exits.

Timeline

9:30 am

- The coordination unit is installed.
- Tabards are put on.
- The observers and actors are briefed.
- The exercise agreements are recapped.

10:00 am

- The HGV catches fire.
- Traffic flow stops: a 50 metre traffic jam forms behind the HGV (10 LVs).
- The tunnel undergoes emergency closure for “fire”.
- The alert file is used.

10:05 am

- The smoke extraction system is activated (extraction outside the tunnel) and the toll booth is closed.

10:10 am

- Confirmation that the equipment is working is given. Confirmation that vehicles are queueing at the tunnel portals (105 vehicles at the toll booth).

10:15 am

- Users evacuate via doors 501, 601 and 603. A message is received from door 603: “There are three of us. Two of us are coughing and one of us has stopped moving.” The call is acknowledged.
- The CRS is informed so the message can be passed to the Departmental Public Security Division (quality of discussions, instructions given, transmission of information).

10:15 am

- Traffic builds up as the tunnel is closed.
- Vehicles are present between the toll booth and the barriers (300 metre tailback).
- Vehicles are present in the cut-and-cover section (150 metre tailback).
- Vehicles are present at the entrance to the cut-and-cover section (southbound, 1,000 metre tailback, growing quickly).
- Vehicles are present in the slip road “wedged” between the entry ramp barrier and the cut-and-cover section (600 metres).

10:20 am

- The first SDIS team arrives, confirming that the fire is spreading.

10:20 am

- Traffic stops flowing from a southerly direction (not affected by the fire).
- People between the cut-and-cover section and the tunnel have exited their vehicles.
- A responder is on the scene at the cut-and-cover section portal (southbound).
- People are being evacuated.

10:25 am

- The crisis hotline is used.

10:30 am

- A southbound SDIS vehicle is stuck.

10:40 am

- Congestion is forming on the secondary network.
- There is a 2 km traffic jam.
- Users are moving back the wrong way along the entry ramp (call to the CRS to deploy patrols).
- A U-turn is set up at the toll booth and a request is placed for northbound closure, with a delay of 15 minutes after the arrival of staff on the scene.

10:55 am

- The Head of Rescue Operations and the Head of Internal Operations discuss setting up the Advanced Medical Post (AMP).

11:00 am

- The Departmental Operations Centre (COD) is activated.

11:00 am

- Traffic update: road closed with a 3 km tailback before the cut-and-cover section.
- U-turn functioning properly.
- Users blocked in the tailback are being evacuated via the intervention vehicle exit.
- People are becoming aggravated at the eastern portal and are starting to head back the wrong way to the toll booth.

11:05 am

- The casualty count is performed.

11:10 am

- A call comes in from a user who is lost.

11:30 am

- The deputy-prefect arrives
- and the COD is effective.

11:30 am

- The COS carries out a provisional assessment.

12:00 noon

- The re-opening procedure begins.
- The electrical systems are checked.
- The civil engineering structures are checked.
- The southbound is inspected: nothing to report/emergency exits checked.
- The SDIS vehicles withdraw.
- The vehicles stuck in the tailback between the tunnel and the cut-and-cover section are evacuated.

12:15 pm

- The COS carries out the final assessment.
- The COS should be able to provide the following information: number of vehicles (one burnt-out HGV and 10 LVs stacked behind it) and the number of people involved (20, including 2 requiring medical attention and 18 other casualties).

12:30 pm

- The exercise ends.

Sample 2

Objectives

- Test coordination between the parties involved, with a special emphasis on the circulation of information and familiarity with the terminology used.
- Test the management of a serious accident.
- Manage an evolving situation.
- Test information collection, analysis and dissemination.
- Manage an event with disruptions (user call from an ECS).
- Test the deployment of the ETARE plans.
- Test the deployment of bus diversions.
- Manage traffic and evacuate people from the tailbacks at the tunnel portals.
- Count the victims and gather information for the inquiry.
- Manage re-opening of the tunnel and vehicle evacuation.

Scenario

A removal van collides with a bus, causing a serious accident without TDG affecting both traffic lanes and formation of a tailback behind the accident.

Timeline

9:00 am

- All participants arrive on site, are informed of their roles, and issued instructions that they must follow throughout the exercise.

TO = 9:30 am

- The Automatic Incident Detection (AID) system detects a stationary bus that has broken down in the tunnel.
- The operator shuts off the lane and informs law enforcement.

TO + 5 min.

- A removal van collides with the bus, causing a serious accident without TDG affecting both traffic lanes and creating a tailback behind the accident.
- The operator closes the tunnel in both directions.
- The bus driver uses his radio to call the bus/safety control station (CS).
- The van driver calls the CS from the ECS at emergency recess 7.
- The CS operator calls the rescue services, law enforcement, etc.

TO + 10 min.

- The patrol officer arrives on the scene (the officer was on patrol in another tunnel when the incident occurred) and reports back to the CS.
- Bus: 12 passengers in total, 3 with minor injuries (relative emergencies), driver unharmed.
- Van: driver and central passenger injured, third person with minor injuries (relative emergency).

TO + 15 min.

- An impatient user calls the CS from the ECS at emergency recess 4, stating that he witnessed the accident and asking when he will be able to continue his journey.

TO + 20 min.

- The rescue services arrive at the western portal (intervention level 1) and place a call via the ECS to:
 - confirm that the tunnel is closed to traffic in both directions;
 - locate the incident in relation to the emergency exits;
 - discuss the possibility of accessing the scene;
 - determine the vehicle type in question (LV, HGV, etc.);
 - gain permission to enter the tunnel by driving in the wrong direction;
 - send a flash message to the Departmental Fire and Rescue Operations Centre (CODIS).
- The first law enforcement officers arrive on scene.

TO + 25 min.

- The rescue services arrive at the eastern portal (intervention level 2) and place a call via the ECS to:
 - confirm that the tunnel is closed to traffic in both directions;
 - locate the incident in relation to the emergency exits;
 - discuss the possibility of accessing the scene;
 - gain permission to enter the tunnel;
 - send a flash message to the CODIS (request for reinforcements, etc.).
- The rescue services arrive at the CS: instructions from the COS and the COI, change of COS.
- The CS room is activated, partnership with the COI, deployment of tools, SITAC begins.
- Objectives:
 - assemble the casualties;
 - head count: 3 REs (relative emergencies) out of the 12 people present in the tunnel, assessment for the van.
- Rescue services team on the scene:
 - check inside the emergency exits;
 - set up a casualty assembly point (CAP);
 - estimate response time;
 - second group of law enforcement officers arrives on scene.

TO + 30 min.

- Via the AID system, the operator detects smoke from an LV in the tailback close to an emergency exit.
- The smoke extraction system is activated (ventilation, sirens, mobile separators).
- The information is passed to the COS/COI for action, with the following objectives:
 - request additional local back-up to strengthen response means for urgent response;
 - request reinforcements;
 - request installation of traffic cones and signage from the operator for responder safety;
 - determine smoke extraction phases (evacuation and response);
 - evacuate the injured casualties.
- Law enforcement officers instruct users to evacuate the tube.

TO + 45 min.

- The fire is under control (extinguished).
- The rescue services begin checking inside the emergency exits.
- Users are at the assembly point.
- The law enforcement officers are at the assembly point, providing information to users.

TO + 1 h 20 min.

- Emergency exit verification complete: confirmation that the danger has passed.
- Vehicles unaffected by the fire and the accident are cleared, under the command of law enforcement officers.
- A journalist arrives at the CS asking to interview the COS and the COI.
- Interviews with the COS then the COI.
- Description of the accident.
- Update on victims and severity.
- Expected response time frame and tunnel closure period.
- Instructions issued to users stuck in the tunnel.

TO + 1 h 30 min.

- The vehicles involved in the accident are evacuated.
- The tunnel re-opening procedure begins.
- The COS and COI are informed that the rescue operations have ended.
- The rescue services withdraw.
- The COI is given permission to begin re-opening the tunnel.
- Law enforcement officers agree to evacuate, after checking with the technical services that there are no residual risks.

TO + 1 h 45 min.

The exercise ends.

APPENDIX 5 – SAMPLE LIVE EXERCISES RUN BY OPERATORS (OBJECTIVES, SCENARIOS)

This appendix contains two sample live exercises run by tunnel operators.

The samples are provided for information purposes only and should not be treated as typical examples. However, they are intended to provide insights for operators and other parties involved in live exercise preparations, to help them set objectives and develop a scenario suited to the tunnel in question.

Sample 1

Objectives

- Test automatic barrier closure and user self-evacuation.
- Test the emergency services alert chain and smoke extraction from the affected section.
- Check “guided” evacuation to the emergency exits.

Scenario

A van hits the side wall of the carriageway and catches fire.

The minibus directly behind the van collides with it from the rear.

Three cars stop behind the minibus.

The exercise zone is situated between two smoke extraction sections, near emergency exits 133 and 134. Thick smoke slowly envelops the tunnel.

There are 20 people inside the tunnel, the “fire scenario” is applied, and an “alert” is issued to the various internal and external responders.

The thick smoke makes it hard for the rescue services to progress.

There are 2 people injured in the van accident. The driver is still in his seat, in a state of shock, and the passenger has a bloody face. The passenger exits the vehicle to call the rescue services using his mobile phone (dialling 18).

After placing the call, he begins feeling unwell and does not return to the driver.

There are 6 people in the minibus behind, who are taking what they believe is the best course of action under the circumstances.

The other 12 users, in the 3 cars, do the same.

Sample 2

Objectives

- Test the proper functioning of the alert and command chain.
- Test the management of interfaces and procedures between the parties involved.
- Test the tunnel audio system.
- Check the door opening detection equipment in the fresh air ducts.

Scenario

The tunnel is open to traffic. Two people are working in the fresh air duct, after receiving approval from the CS.

An HGV (carrying dangerous materials) collides with an LV. The incident causes a multi-vehicle collision with another LV.

There is one person, severely injured, trapped in each of the two LVs.

Liquid and gas are leaking from the HGV.

One of the two people working in the fresh air duct is injured while trying to evacuate and is immobilised.

Sample 3

Objectives

- Assess emergency service response procedures in simulated operational conditions.
- Assess the effectiveness of the diversion routes.
- Assess cooperation between services.
- Assess the red plan (fire rescue services).
- Assess the white plan (medical rescue services).
- Assess the prefecture’s public information unit.

Scenario

A coach collides with a vehicle. There are 30 victims.

The red plan (for the emergency services) and the white plan (for the hospital) are activated.

The exercise is set to run for eight hours (8:00 am to 4:00 pm). The 30 victims are divided as follows: 2 deceased, 5 with extremely severe injuries, 8 with severe injuries and 15 with minor injuries or unhurt.

The Advanced Medical Post (AMP) will be positioned close to the tunnel.

Sample 4

Objectives

- For the operator:
 - Test the proper functioning of the alert chain.
 - Test the functioning of the smoke extraction system.
 - Test the functioning of the dynamic signage.
 - Test the functioning of the crisis room.
 - Test the assisted opening system and the position of the handle for people with reduced mobility.
- For the public rescue services:
 - Test the “tunnel” operating procedures.
 - Test radio communications.
 - Test the ETARE plan.
- For law enforcement:
 - Test the alert procedures for deployment of the Traffic Management Plan (TMP).
 - Handle tailbacks in a simulated situation.
 - Test the re-opening and commissioning procedure.
- For the various services involved:
 - Test deployment of the COD.
 - Test inter-service procedures.
 - Test coordination between the parties involved.

Scenario

At 9:30 pm, two LVs stop in the tunnel (southbound). A large amount of smoke is coming from one of the vehicles. One of the LV drivers calls the CS operator from the ECS at the nearby emergency recess.

There are 22 LVs queueing behind the incident.

There are 2 people with injuries (1 in the vehicles involved in the incident and another in a separate vehicle by emergency exit 9).

There is a person with reduced mobility near to emergency exit 9. The emergency services are alerted using the applicable procedures.

Sample 5

Objectives

- Test the ERP procedures.
- Test the degraded mode procedures (loss of lighting, loss of radio communication from the emergency services, loss of fire-fighting network pumps).
- Test coordination between the rescue services and the operator.
- Set up links between the Operational Control Station (PCO) and the COD.
- Test the draft ORSEC plan for highways.

Scenario

The exercise involves fires in two separate locations – in the road tunnel and in the tunnel's main plant room. The incident is triggered by a collision between two cars, causing a fire to break out in the tunnel. At the same time, equipment in the plant room at the western portal of the tunnel overheats following work.

There are around a dozen casualties in the tunnel.

APPENDIX 6 – SAMPLE LIVE EXERCISE TRACKING TABLE

A table could be drawn up to help monitor the exercise as it progresses, with:

- the parties involved in the columns;
- the timeline in the rows.

The actions shown in bold are those that need to be triggered artificially. The other actions should occur normally as a result of the ERP and the rescue plans.

The timeline is provided for information purposes only, since the actual timings will naturally depend on circumstances, including the reactions of the parties involved.

In the following example, the scenario involves an accident between an HGV and an LV, followed by a fire. More specifically, an HGV and an LV collide during free-flowing traffic (on the surface and in the tunnel, off-peak daytime conditions). The vehicles involved in the accident are blocking traffic in both directions. Other vehicles are stopped behind the accident.

Time (min.)	Vehicles involved	Actors	Regulator Operator	Fire-fighters	Law enforcement	Operations team
0	the vehicles come to a stop, blocking both lanes	remain in their vehicle behind the accident				
1			detects and analyses an alarm on the AID system			
2			implements the appropriate instruction: closure of the tunnel			
3			calls from various services	handle the call	handle the call	prepares to respond
6	smoke comes from the LV (simulated fire)	leave their vehicles and head to the emergency exits	detects and analyses an alarm on the AID system	make their way to the tunnel	make their way to the tunnel	
7		a user calls from an ECS	launches the smoke extraction scenario handles the user call			
20				reach the scene of the fire, begin investigating the smoke-filled area and start fighting the fire		

25					set up the safety cordon and meet users at the assembly point	
30				begin the evacuation via the emergency exits	inform users	
45	the smoke generator shuts off			complete the evacuation via the emergency exits, and inspection of the exits the fire is extinguished		
50					take users from the assembly point back to their vehicles	
60		return to their vehicles and exit the tunnel	detects and analyses an alarm on the AID system		monitor the vehicles as they leave	
75	the vehicles involved in the accident are evacuated					cleans the carriageway inspects the equipment
End of exercise						

Table 1: admissible levels inside tunnels

APPENDIX 7 – PRACTICAL ARRANGEMENTS FOR RUNNING AN EXERCISE WITH SMOKE, AND CHOOSING THE TYPE OF SMOKE TO USE

Before running an exercise with smoke, it is important to determine what the objective is then, depending on this objective, to decide what type of smoke to use.

The objective could be:

- to check that the smoke extraction system works and to observe what happens when it is activated;
- to observe how people evacuate under degraded environmental conditions;
- to assess the capability of the rescue services to operate in a smoke-filled environment;
- etc.

There are various types of smoke that can be produced during an exercise. The key decision is around the temperature of the smoke – cold, warm or hot.

The smoke temperature has a major impact on preparation time and restoration of the tunnel to normal conditions. It is also essential to consider what protections may be needed, if any, to safeguard the tunnel, and what cleaning will be required (if the smoke has produced soot). Operating constraints (especially how long the tunnel can be closed for) also need to be taken into account when devising the scenario.

The section below contains some pointers to help make this decision.

Irrespective of the type of smoke used, special attention must be paid to the length of time for which the smoke is produced (which should be consistent with the scenario and will determine what quantity of smoke grenades or fuel will be needed).

Cold smoke

Cold smoke can be produced using a series of smoke grenades or one or more smoke generator(s). These systems produce white, non-toxic smoke that is similar to fog. Because the smoke does not contain any hot fumes, it cannot be used to reproduce the stratification that occurs in a real fire.

Smoke of this type is useful, however, for observing air flows in the tunnel – especially the current created by the longitudinal ventilation system. Cold smoke is therefore effective at demonstrating whether the system is capable of clearing smoke downstream of a fire.

Using cold smoke also helps to reduce visibility in the tunnel and make a scenario more realistic.

Warm smoke

Warm smoke more closely resembles how smoke behaves in the event of a real fire, especially in terms of stratification (if any), but does not require significant resources and high costs.

One particular way of producing warm smoke in tunnels has become widespread in recent years. The method involves burning a mixture of potassium nitrate and potato starch (known as the “Chardot mixture”) to produce a large quantity of smoke at a temperature of around 50°C a few metres above the seat of the fire.

It is important to get the composition of the mixture right and to keep a close eye on both the volume of smoke produced and the heat generated. The mixture is placed in a series of containers, lit successively to maintain a stable smoke production volume throughout the duration of the test. The containers generally produce around 300 kW for between 5 and 8 minutes. The containers may be lit one by one or several at a time, depending on the size of the fire that is being simulated.

The benefit of this method is that it produces sufficient heat to keep the smoke airborne, without the risk of damaging the tunnel and equipment through excessive heating. However, the carriageway will need to be protected against certain types of damage, especially melting tarmac. Moreover, because warm smoke does not leave noticeable dirty marks on the tunnel, there is no need for special protective measures.

Hot smoke

There are several different ways to produce hot smoke, for example by burning containers of flammable liquid, setting fire to a vehicle or using various other materials. These fires produce a similar amount of heat to the real-life fires that are likely to occur in tunnels, from one to several megawatts (depending on the type of fire used).

Setting fire to a written-off vehicle or a stack of highly combustible materials (such as wooden pallets or tyres) should generally be reserved for pre-commissioning ventilation system tests or for experimental research programmes. These tests are time-consuming, expensive and a potentially risky exercise, both for the tunnel itself and for the people involved. If a decision is made to set fire to a vehicle, an LV should be used.

Safety exercises rarely require relatively or extremely powerful fires. In most cases, cold or warm smoke should suffice. In those few cases where a decision is made to use hot smoke, flammable liquid containers (such as domestic heating oil, heptane or alcohol) are the most suitable choice.

APPENDIX 8 – SAMPLE QUESTIONNAIRE FOR OBSERVERS

The exercise questionnaire below was designed for a scenario involving the evacuation of users following an LV fire.

General observations

- Was the scenario credible and easy to understand?
- Did the actors play their part?
- What was visibility like inside the tunnel?
- Were the vehicles located in the right positions, as indicated?

Immediate reactions

- Did people stay inside the vehicles? For how long?
- Did everyone recognise the danger?
- Did people use their mobile phones to make calls?
- Did they flee by car? If so, how (in the direction of traffic or after making a U-turn)?
- Other comments:

Evacuation

- How was the evacuation triggered?
- What was the evacuation strategy (alone, in one or multiple groups, etc.)?
- Where were the people evacuated to (emergency exits, emergency recesses, towards the incident, ends of the tube)?
- Were they wearing high-visibility vests (yellow vests)? Did they leave their keys in the ignition?
- Other comments:

Emergency Call Stations

- Were they used (if so, emergency recesses and/or emergency exits)?
- What was the conversation like (easy to understand, confused, questions, answers given)?
- Were the instructions followed?
- Did users stay in the emergency recesses after the call or did they head to the emergency exits?

Emergency exits

- Were users hesitant to use the emergency exits?
- How many exits were used?
- Did users find it difficult to open the doors in general? What about people with reduced mobility? And the observer?
- Did they feel safe in the emergency exit?
- How long did they stay there before heading to the assembly point?
- Did users go back into the affected tube? Why?

Signage

- Were the exits properly signalled (visibility, lighting, pictogram, etc.)?
- Were the emergency recess signs clear to the observer? Did users notice and understand them?
- Other comments:

Overall assessment

- What are your observations about user behaviour (assembly, mutual support, misunderstandings, etc.)?
- What went well in this exercise?
- What could be improved?
- What went well in terms of tunnel safety?
- What could be improved?

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