CETU

Guides

ROAD TUNNEL SAFETY MANAGEMENT SYSTEMS

Stakeholders, components, construction and life cycle of an SMS

December 2025

Centre for Tunnel Studies

www.cetu.developpement-durable.gouv.fr

MINISTÈRE DES TRANSPORTS

Liberté
Égalité
Fraternité

GUIDES

CETU guides are the result of methodological work conducted by CETU. They are intended to serve as a reference for the design, construction, or operation of underground structures. Although relevant at the time of writing, any guide may become obsolete, particularly due to regulatory or technical developments. Each user is responsible for its correct application.
These documents can be downloaded from the CETU website.

ROAD TUNNEL SAFETY MANAGEMENT SYSTEMS

Stakeholders, components, construction and life cycle of an SMS

December 2025

Centre for Tunnel Studies
25, avenue François Mitterrand
69500 BRON – France
Tel. 33 (0)1 40 81 30 30

cetu@developpement-durable.gouv.fr
www.cetu.developpement-durable.gouv.fr

TABLE OF CONTENTS

APPENDICES

1 INTRODUCTION

Following the major fires that occurred in Alpine road tunnels between 1999 and 2005, changes to the French regulatory framework [1] laid the foundations for the current safety approach, which is based on:

- the involvement of all stakeholders, for whom responsibilities are clearly defined;
- a technical reference framework (Appendix 2 to Inter-ministerial Circular No. 2000-63 of 25th August 2000 on safety in tunnels on the State-managed road network, known as IT 2000 [2][1]), along with risk analysis methods;
- procedures designed to verify the appropriate level of safety from the design stage and throughout the life of the tunnel;
- feedback from operational experience (events, technical incidents and safety exercises).

Since the implementation of this approach, many operators have carried out major modernisation and safety work in their tunnels longer than 300 m, the threshold defined by the regulations.

At the same time, work has been carried out on their internal organisation to ensure the safety of users travelling through these tunnels, as well as that of the staff who operate them and any other persons who may be called to conduct activities within them.

The importance of operational organisation has been highlighted through a systemic approach to safety, based on continuous improvement.

It should also be noted that for tunnels longer than 500 m located on the trans-European road network (TEN), specific organisational procedures have implemented in accordance with the transposition of European regulations (Directive No. 2004/54/EC of the European Parliament and of the Council of 29th April 2004 on minimum safety requirements for tunnels in the TEN). These specific procedures rely on a safety officer who provides an external perspective on key operational safety issues throughout the life of the tunnel.

In 2015, in France, an audit concerning the implementation of the policy to improve the safety of tunnels on the State-managed road network was conducted by the General Council for the Environment and Sustainable Development (CGEDD). This audit highlighted the significant technical and organisational improvements brought about by the safety approach that had been implemented, while emphasising the importance of improving and maintaining safety levels over time. Following one of the audit's recommendations, the Transport Infrastructure Directorate (DIT) requested the implementation of safety management systems (SMS) for the 44 tunnels longer than 300 m operated by the Inter-departmental Road Directorates (DIR), within a five-year time scale, as of 2016.

The CETU, which assisted the DIRs in developing their tunnel safety management systems, is publishing this document to help all operators wishing to adopt a similar approach to structure the safe operation of their road tunnels and ensure the long-term viability of the organisation put in place. This guide can also be used to explain the approach to the various parties involved in an SMS under construction, or to raise awareness among stakeholders in an existing SMS, in order to strengthen their involvement. Infrastructure managers, when they are different from the operator, may also be affected by certain provisions of the SMS.

Furthermore, operators who do not wish to implement a full SMS approach can use certain sections of the document detailing SMS components, in order to work on a specific topic. This document is designed to be as practical as possible so that operators can use it in either way, with all the information they need to address the component or method element in question.

After providing the main definitions and introducing the stakeholders involved in an SMS, this guide details each component. It then proposes a methodology for building an SMS and outlines the essential changes that need to be made to an SMS during its lifetime. At the end of the document, a glossary explains all the acronyms used.

These boxes provide details on a particular subject.

These boxes contain information that allows the reader to explore the subject in greater depth.

The reader will find examples here.

1. For ease of reading, the bibliographical reference for this document will only be given here.

2

THE SMS: A RISK MANAGEMENT TOOL

This section of the guide aims to provide an initial overview of what an SMS is.

A presentation of the areas in which SMS are commonly deployed first outlines the main principles of this risk management tool, before drawing lessons for its application to road tunnels.

A definition of SMS for road tunnels is then proposed and the scope of application is discussed.

Finally, the links between SMS and Quality Management Systems (QMS) are presented, because although they do not have the same purpose, their operation is comparable.

2.1 SMS IN SECTORS OTHER THAN ROADS: LESSONS FOR TUNNEL SMS

2.1.1 SMS in sectors other than roads

Unknown in the road sector until 2017, SMS have been widely developed in other sectors for many years.

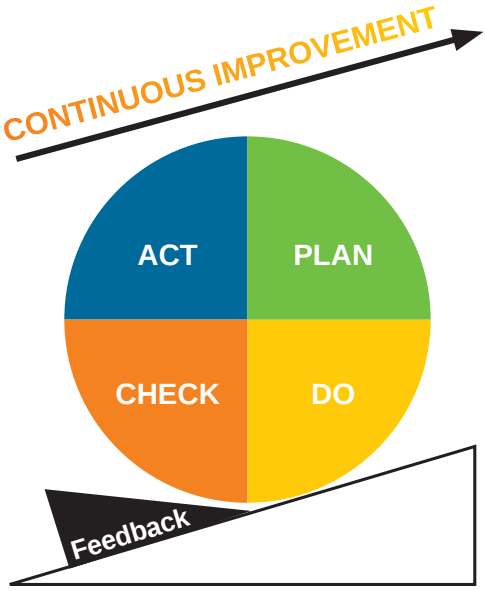
In partnership with the STRMTG (the French technical body in charge of the safety of ropeways and guided transport), the CETU carried out a review of existing SMS in six transport and industrial sectors: civil aviation, railways, urban guided transport, ski lifts, facilities classified for environmental protection (ICPE) and basic nuclear facilities.

After analysing the regulations applicable to each sector studied, interviews were conducted with a supervisory authority and, where possible, with an operator. Several key points emerged from this analysis.

Firstly, an SMS is a comprehensive and systematic process for managing the risks associated with the safety of an activity. Its objective is to help control these risks and maintain them at an acceptable level for the operator by drawing on the organisational, human and material resources of the structure.

Furthermore, an SMS is based on the principle of continuous improvement, according to the virtuous "plan, do, check and act" circle or “Deming wheel”. It includes performance objectives and reporting tools.

In addition, based on a risk analysis, an SMS makes it possible to distinguish between issues that are important and those that are less important in terms of safety, and thus to better define priorities for continuous safety improvement actions.



Deming wheel

Finally, in practice, an SMS is based on **four pillars**, which are:

- **a safety policy**;
- **an organisation** (responsibilities, procedures, indicators, management and monitoring tools);
- **an assessment system** (feedback, risk analysis, audits, etc.);
- **an instilled safety culture**.

2.1.2 Lessons learnt for Tunnel SMS

The benchmarking work carried out has provided a solid basis for defining and building road tunnel SMS. Discussions with various departments with experience of SMS, at different levels of maturity, have provided feedback on their practices, both successes and difficulties, and advice on implementing an SMS.

The interviews highlighted several conditions for the success of a Tunnel SMS:

- **Simplicity:** to facilitate the operation of the SMS and updates to procedures, references to existing procedures and documents should be prioritised;
- **Improvability** of the SMS: due to its very nature (continuous improvement), the initial SMS will be enhanced over time;
- **Flexibility** of the SMS manual: a standard manual can be provided as a working basis, but it is essential to adapt it to the context of each operator;
- **Usefulness** of the SMS for the operator: the system must not replace the activity; energy must be devoted to the content (substance), not the container (form); the SMS must make it possible to structure the existing safety approach, bring it to life and improve it.

They also highlighted the importance of:

- **the commitment of the person responsible** for defining the safety policy;
- **adapting the organisational structure** to be put in place, **to the size of the organisation and the challenges involved**;
- **the role of the SMS coordinator**, who coordinates the activities of the various stakeholders and implements the SMS, without being responsible for all its activities;
- **the commitment of all personnel** involved in the operation and monitoring of tunnels;
- **coordination with quality procedures**.

An SMS is therefore a method for managing safety and providing the means to control the risks of a given activity.

2.2 APPLICATION TO ROAD TUNNELS

2.2.1 General information

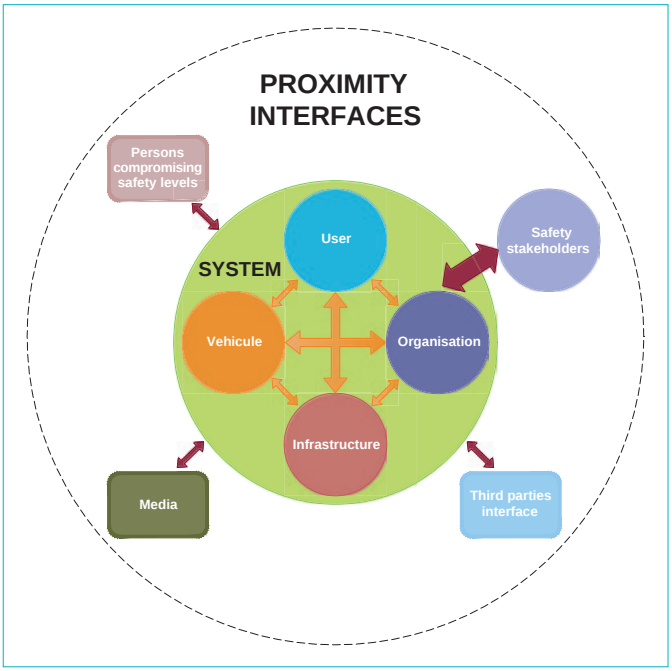
The systemic approach to road tunnel safety, which takes into account technical, human and organisational factors, is based on four interacting elements: infrastructure, users, vehicles and organisation [3]. The tunnel system interacts to a greater or lesser extent with its immediate environment. All of the elements and interfaces are illustrated in the figure opposite.

The system cannot be understood from the perspective of just one of these four elements, as they all communicate and interact with each other. It is also open to its external environment.

Although the SMS approach is new to road tunnel operation, several components of an SMS are already in place due to the regulatory requirements of the French Road Infrastructure Code (Code de la Voirie Routière) and associated texts, or existing best practices within organisations.

The implementation of an SMS can therefore be seen as the assembly of pre-existing elements – at varying degrees of maturity – and new elements that will need to be identified and gradually implemented.

Building an SMS therefore involves strengthening and sustaining the consistency of existing initiatives and coordinating their interactions more effectively, rather than creating a new system from scratch.



Systemic approach to road tunnel safety

This extension of the existing safety approach, on a daily basis and throughout the entire operations organisation, aims to develop a safety culture within the operating body (see section 4.5).

The objective of the SMS is to:

- structure the management of risks associated with the operation of road tunnels through **a systemic** approach;
- ensure the proper functioning, over time, of the technical and organisational safety measures defined, particularly at the time of commissioning, by making the approach **systematic**;
- strengthen and organise traceability in order to guarantee **legal certainty**.

2.2.2 Definition of an SMS

Collaborative work began in 2016 within the framework of a national working group (WG) involving eight interdepartmental road directorates (DIR) and the CETU, with the aim of enabling each DIR to develop and implement an SMS for its tunnels. Input stemmed from methodological work conducted by the CETU.

Based on the definitions of SMS in other sectors and adapting them to the context of tunnel operation, the SMS WG collectively defined SMS for Tunnels as **"the organisation and provisions established to optimise the safe operation of road tunnels by managing risks in an efficient manner and adapted to operational challenges"**.

2.2.3 The example of tunnels on the State-managed road network

Method

The implementation of SMS by the DIRs on the State-managed road network took place in three stages:

- in 2017 and 2018, adoption of the approach and development of the first elements of the SMS, with the support of the SMS working group;
- in 2019 and 2020, implementation of experimental SMS, based on a self-assessment, supplemented by a document review, then field review carried out by the CETU ;
- from 2021 onwards, consolidation of the SMS, which have since been subject to regular audits by the CETU.

Lessons learnt

The development of the SMS in the DIRs may initially have seemed difficult and required a significant investment of time and resources. However, since they have been in place, the SMS have brought benefits recognised by all staff. Their development has raised safety awareness among all parties and given meaning to safety measures. It has enabled weaknesses in organisation to be identified and corrected, mainly by defining responsibilities (*who does what?*), leading to improvements perceived by all staff, notably thanks to improved communication between departments. The SMS manual is also a useful document for new staff, as it describes all activities related to tunnel operation.

On a day-to-day basis, the SMS re-energises staff and enables better sharing of tunnel-related issues within the operator's departments, which is largely maintained through regular meetings. It also promotes continuous vigilance regarding the safety level of the tunnel. Internal or external assessments, such as audits, fuel this dynamic by highlighting strengths and areas for improvement.

For the safety officer[2], where one exists, the SMS streamlines and facilitates exchanges with the various stakeholders in the DIRs, whose missions are clearly defined.

Finally, the SMS enables the operator to optimise the use of available resources, based on an approach aimed at controlling risks as effectively as possible, while maintaining traceability of reasoning and decisions taken. It is important to note that in the DIRs, the development and implementation of the SMS Tunnels was carried out with constant human resources.

Lioran tunnel (© CETU)

2. Mandatory for tunnels longer than 500 m located on the TEN.

2.3 SMS SCOPE

The operator must first define the scope of the SMS to be implemented. This scope is both geographical and functional.

2.3.1 Geographical scope

The geographical scope, i.e. the list of tunnels covered by the SMS and their main characteristics, must be specified.

Initially, the SMS may only cover tunnels longer than 300 m and the control centre (CC) from which they are monitored, including the emergency CC where applicable.

If the operator so wishes, generally when the SMS is more mature, the SMS may be extended to tunnels shorter than 300 m, or even to other tunnels. The provisions may be adapted to these tunnels, depending on the issues they cover.

An operating body with an SMS for tunnels subject to the provisions of the French road infrastructure code can thus decide to include tunnels less than 300 m long within the scope of this Tunnel SMS, so that they can benefit from the system. From then on, the detailed periodic inspections of structural elements and equipment, which are mandatory on the State-managed road network regardless of the length of the tunnel, will benefit from the same procedures: scheduling, implementation, definition of the action plan and monitoring of its implementation, etc.

This scope is described in the SMS manual (see paragraph 5.2) by means of a detailed list or cartographic elements. In addition, a reference to document 1 "Reference status" of the safety documentation for the various tunnels may be provided (with reference to [4]).

2.3.2 Functional scope

The functional scope is defined as:

- the stakeholders of the SMS, i.e. users of the tunnel, staff operating the tunnel (management, field agents, maintenance technicians, operators), partners and emergency services, external service providers and, more generally, all persons whose safety could be compromised in the event of a tunnel malfunction;
- the activities concerned, i.e. traffic monitoring and management, field interventions, structural element and equipment asset management, training, etc.

As with the geographical scope, the functional scope must be clearly stated in the SMS manual. Although the Tunnel SMS must ultimately cover all aspects related to the safety of tunnels and personnel, and all activities related to tunnel operation, the operator may choose to prioritise certain aspects. These choices must also be explained in the SMS manual or in the safety policy definition document (see paragraph 5.1.5).

2.4 LINK TO THE QUALITY MANAGEMENT SYSTEM

As mentioned above, the SMS is based on the principle of continuous improvement according to the virtuous cycle of "plan, do, check and act" or Deming Wheel. It includes performance objectives and reporting tools.

Its principle is therefore based on an approach that is quite similar to that of a Quality Management System (QMS).

However, the SMS focuses on the safety of the activity, while the QMS generally focuses on the quality of a product or service and customer satisfaction.

When the operator already has a Quality Management System (ISO 9001 certification), two approaches are possible:

- integrate the SMS into the QMS;
- make references to the QMS in the SMS.

There are numerous similarities between the SMS and the QMS, and the logic is similar: the aim is to implement a rigorous continuous improvement system, which also serves as an effective management and sharing tool.

There may also be interactions with a health and safety management system (ISO 45001 certification).

In all cases, the SMS will benefit from the operator's experience in building and operating these other systems. Its audits can consolidate any certification audits.

The absence of a quality management system in an organisation should in no way be considered an obstacle to the development of an SMS.

Entrance to the Noailles tunnel (© DIRCO)

2.4.1 SMS integrated into the QMS

Integrating the SMS into a QMS process provides benefits from existing synergies. Examples include:

- risk analysis and the definition of indicators, as well as the responsibilities and missions of the various stakeholders;
- the control and feedback mechanism, including internal or external audits, as well as an annual review of processes and management with the establishment of improvement action plans.

In this case, the components of the SMS must be matched to the sub-processes or activities. The self-assessment grid in Appendix A may be useful for this purpose.

2.4.2 SMS built independently of the QMS

The decision to build the SMS independently of the QMS allows the SMS to be structured by developing a self-contained SMS manual.

This requires particular attention to be paid to the common interfaces with existing QMS processes, with references to them in the SMS manual (see section 5.2). Although completely independent, safety reviews can be developed in the same way as process reviews or management reviews.

3

KEY STAKEHOLDERS IN THE SMS

This chapter presents the key stakeholders involved in implementing and managing a Tunnels SMS. These are:

- the accountable manager;
- the SMS coordinator;
- local SMS contacts.

Of course, all those involved in tunnel operation have a role to play in the Tunnels SMS. Information about them is provided in section 4.1.

3.1 ACCOUNTABLE MANAGER

Within the framework of the Tunnels SMS, the accountable manager is appointed and named by the head of the operating body.

The accountable manager confirms and communicates his or her commitment to safe tunnel operation in a letter setting out the safety policy. This letter is a fundamental part of the SMS documentation.

Within the organisation, the accountable manager is the guarantor of the proper implementation of the safety policy that he or she has defined.

In addition to this commitment and the definition of the organisation's safety policy, the accountable manager:

- nominates the SMS coordinator and sends this person a letter of assignment;
- appoints any local SMS contacts;
- defines the responsibilities of the key stakeholders in the SMS;
- sets safety objectives and ensures they are met;
- ensures the performance and sustainability of the system;
- chairs the safety review;
- ensures that the necessary resources are maintained.

This person acts as a driving force to encourage staff to get involved and adhere to the SMS.

La Défense Tunnel (© CETU)

3.2 SMS COORDINATOR

The SMS coordinator is responsible for implementing the SMS.

He or she is appointed by the accountable manager on the basis of his or her skills, ability to lead the process and, in most cases, the possibility of developing synergy between his or her role as SMS coordinator and other duties for which he or she is responsible.

A letter of appointment designates the person by name, specifies the content of their mission and reinforces their legitimacy with regard to all the staff concerned within the organisation. This letter of appointment is part of the SMS documentation accessible to all staff.

Based on the guidelines defined by the accountable manager, this person oversees the development of the SMS and ensures its implementation.

To this end, the SMS coordinator:

- develops and updates procedures relating to the operation of the SMS, in collaboration with the staff involved;
- leads, coordinates and monitors activities related to the SMS, including documentation, in collaboration with the various designated managers;
- ensures that the SMS is aligned with the continuous improvement system and the quality management system in place, where applicable;
- ensures the implementation, dissemination and promotion of the SMS within the organisation;
- ensures the coordination of the SMS and the tunnel operator's actions with third parties;
- ensures that the objectives set are met, that the permanent control and evaluation system of the safety level is implemented and that the monitoring of performance indicators is conducted;
- monitors regulations and safety-related information in the field of road tunnel operation.

The SMS coordinator is not responsible for all activities related to safe tunnel operation, but coordinates them within the framework of the SMS.

Their position within the organisation may be hierarchical, reporting to senior management, or cross-functional, acting as a project manager. Depending on their skills, the SMS manager may be supported by other people within the organisation.

FURTHER INFORMATION

Given that the person carrying out this mission must be able to adopt a wide perspective, it is preferable to nominate someone for this role who is not an operational staff member, although this may sometimes seem difficult, particularly in small organisations or those operating a single tunnel. The designated person must be able to free up time for SMS coordination duties, but operational tasks may take precedence over the fundamental tasks of the SMS due to the contingencies of tunnel operation.

For tunnels who have a safety officer, the SMS coordinator works in coordination with this officer (see paragraphs 4.4.2 and 5.1.1).

3.3 LOCAL SMS CONTACTS

The appointment of local SMS contacts is a key strength of the SMS, particularly in the case of an organisation operating several tunnels at several different sites or from a remote control centre.

As active representatives of the SMS coordinator in the field, local contact points contribute to the development of the SMS and ensure its implementation and promotion within their entity.

Like the SMS coordinator, local SMS contacts receive a letter of assignment from the accountable manager, appointing them and specifying the content of their mission, in order to give them legitimacy in this role.

Co-developing important procedures for the SMS with local stakeholders is an asset and can lead to better understanding and acknowledgment among all players.

4

COMPONENTS OF THE SMS

The SMS must cover all aspects of tunnel operation. It must therefore address the following components:

- roles and responsibilities;
- skills management;
- management of the tunnels structural elements and equipment;
- coordination with third parties;
- safety culture;
- organisation of feedback;
- documentation;
- management of any modifications;
- performance assessment.

Some of these components are part of the safety approach already in place, in which case they are referred to as occupational components: asset management, feedback, etc.

These components of the SMS are elements which, if not handled properly, can jeopardise the safe operation of the tunnel. For example, the management of a tunnel's structural elements could be considered an factor that does not affect the safety of the tunnel, whereas in practice, a problem can lead to serious safety issues, such as falling rocks or water ingress causing large puddles in the tunnels, which are dangerous for traffic.

The components are not operational activities, but rather topics to be addressed. For example, the skills management component refers to operator activities such as recruitment, initial training, continuous training, etc.

There are nine components covering all activities that ensure the safe operation of tunnels. They are detailed in this chapter.

4.1 ROLES AND RESPONSIBILITIES

Safety management in road tunnel operation involves several activities carried out by different stakeholders in different departments.

To facilitate the achievement of safety objectives, these activities must be coordinated, specifying the roles and responsibilities of the various departments or stakeholders in tunnel operation and within the SMS, as well as how they interact.

4.1.1 Regulatory provisions

For all tunnels longer than 300 m, French regulations define the distribution of roles and responsibilities among tunnel safety stakeholders, particularly in the Road Infrastructure Code.

Thus, with regard to the organisation of tunnel operation, Article R. 118-3-1 states that the preliminary safety documentation shall include "*A description of the planned organisation of human and material resources and the measures planned by the project owner to ensure the safe operation and maintenance of the tunnel* […]".

The French technical Directive (IT2000) also refers to operating resources in paragraph 5.1: "*Operations must be organised and have the necessary resources to ensure accident prevention* […] *and the safety of persons in the event of an incident or accident*".

Finally, for the State-managed road network, the circular of 16th February 2011 on the publication of the new technical directive for the monitoring and maintenance of infrastructure (ITSEOA) and its booklet 0 [5] distinguish the tunnel owner in charge of construction from the tunnel owner in charge of management, and give each a specific role:

- **the tunnel owner in charge of construction** must:
  - integrate the constraints of the future tunnel manager as early as possible,
  - establish the tunnel documentation,
  - carry out the initial detailed inspection;
- **the tunnel owner in charge of tunnel management** must adopt an organisation that enables it to carry out its tasks in the best possible conditions, namely the monitoring, condition assessment, maintenance and repair of tunnels; to do this, it must identify three levels within its organisation:
  - the decision-making level, which is responsible for the asset management policy,
  - the organisational level, which implements the policy defined by the decision-making level and proposes any amendments it deems useful,
  - the operational level, which carries out or controls tunnel monitoring, maintenance and repair operations.

4.1.2 Main expected benefits of the SMS

The implementation of the SMS provides an opportunity to review the definition of roles and responsibilities at all hierarchical levels with a view to clarifying responsibilities.

Roles and responsibilities must therefore be defined within the framework of the SMS – for example, in a document entitled "*Who does what?*", known to all, well understood and regularly updated (see box below).

The various roles of "manager", "contributor", "proofreader" "validator", etc. are specified for each activity, giving preference to the roles of the staff members over their names or the name of a general department where it would not be clear who is actually responsible for the activity. The RACI method can be used[3].

Who does what?

*Administration department **Meetings of the National Commission for the Assessment of Road Infrastructure Safety (CNESOR) and the local Transport Infrastructure Safety Commission (SIST)

			Management		AD*	Department at headquarters responsible for operations and safety				Department at headquarters responsible for infrastructure	Operations department												
			Director	Deputy Director Accountable manager	Training unit	Head of Department	SMS coordinator	Head of Equipment Unit	Tunnel Project Manager	Tunnel Operations Manager	Infrastructure Unit	Head of Department	Tunnels division Tunnel project manager	Head of the Control Centre	Operations Manager	Control Room Operators	Maintenance Manager	Maintenance Technician	District Manager	Assistant District Manager	District Operations Manager	Head of Maintenance and Response Centre	Maintenance and Response Officers	Infrastructure Correspondent
SMS	Management	Construction and update	I	A	I	I	E	I	Co	Co	I	I		I	Co	I	I	I	I	Co		I	I	I
		Monitoring	I	A	I	I	E	I	C	Co	I	I		I	Co	I	I	I	I	Co		I	I	I
		Implementation of actions	I	A	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I
Tunnel domain management	Facilitation meetings	Profession-specific meetings		A			E		Co	Co		E	Co	Co	Co		Co		Co	Co				
		Maintenance technician meetings				I		A	C	C				I			Co	Co						
		Tunnel technician meetings							E	C		I	I	I			Co	Co						
	External meetings	Annual multi-entity meetings per geographic department					C		I			A	Co	Co	Co				Co	E				
	Document management	Definition of document policy		A			E					Co		Co	Co				Co	Co				
		Document upload on server					A		Co	Co		A		Co	Co		I	I	A	E		I		
		Intranet update					A		Co	Co		A		Co	Co		I	I	A	E		I		
Administrative management	Management of regulatory aspects of road tunnels	Monitoring of regulatory obligations (DS, Operating authorisation, exercises, feedback, etc.)		A /G			E /G	I	I	I		I		I	I				A/L	E/L				
		Completion of tunnel regulations monitoring table (and follow-up monitoring)		I			C			Co		I		Co	Co		Co	Co	A	E		Co		
		Development of related tools: procedures, document templates, etc.		A			E	I	I	I		I		I	I				I	I				
	Safety documentation (SD) update (Pxx => Relevant item in the safety documentation)	Management of contract drafting and award procedure for consultancy firm in charge of implementation					C					A							Co	Co	E			
		Monitoring of the consultancy firm's proposals and their implementation					C					A		Co (P0-P1-P5-P6)	Co (P0-P1-P5-P6)		I	Co (P1-P6)	E	E		Co (P5-P6)		
		Drafting of tunnel owner's report before its dispatch to the Prefecture					C					A		Co	Co				E	E				
		Management of contract drafing and award procedure for expert appraisal					C					A							Co	Co	E			
		SIST/CNESOR meetings**					C					A		Co					Co	Co				
	Annual update of the SD	Annual update of SD files					C					A		Co (P5-P6)	Co (P5-P6)				E	E		Co (P5-P6)		
Regulatory obligations	Update of instructions	Updates to control room operator instructions					C					I		A	E				Co	Co		I		
		Update of instructions to the maintenance and response centre					C					I		I	I				A	E		Co	I	I
		Decisional-aid tool for on-call personnel					C					A		E	Co				E	Co				
	Safety exercise	Preparation of the exercise		I			C		I	I		Co		Co	Co				A	E		Co		
		Exercise implementation coordination		I			C		I	I		I		Co	Co	Co	I	I	A	E		Co	Co	
		Feedback		I			C		I	I		Co		Co	Co	Co	I	I	A	E		Co	I	
	Significant incidents and accidents	Tunnel incident report form					C	I				I		I	Co	A+E			I	Co		I		
		CETU database entry					C							Co	Co	Co			Co	Co	A + E	Co	Co	Co
		Simplified feedback		I			C	Co	Co	Co		I		Co	Co	Co	Co	Co	A	Co	E	Co	Co	Co
		In-depth feedback		A			E	Co	Co	Co		A		Co	Co	Co	Co	Co	Co	Co		Co	Co	Co
		Annual report		A		I	E	I	I	I		I		I	Co	I	I		I	Co		I		
	Tunnel safety officer	Recruitment procedure and handling of correspondence with Prefectures for recruitment approval		A			E					Co		I	I	I			I	I		I		
		Accounting aspects of the contract					I												I	I				
		Contract implementation		A			E					Co		I	I				A	E				
Monitoring, maintenance and repair of structural elements of tunnels	Continuous monitoring	Recording and reporting of tunnel defects									A/G								A/L	I		Co		E
	Experts and approved qualified organisations = Initial detailed inspections/ Periodic detailed inspections	Intervention scheduling									A+E											Co		Co
		Implementation									A+E											Co		Co
		Follow-up									A+E											Co		Co
	Initial detailed inspections / periodic detailed inspections	Inspection planning and preparation Inspection scheduling									A+E											Co		Co
		Implementation									A+E											Co		Co
		Follow-up									A+E											Co		Co
	Maintenance/repair works	Scheduling and monitoring of works									A+E								E	I		Co		E
		Minor maintenance									I								A	I		Co		E
		Specialised maintenance or major repair works									A+E								E	I		Co		E
	Specific operations	Convergence measurements									A+E								I	I				I
		Ground movement measures									A+E								I	I				I
	Sweeping, washing, hydrocleaning, etc.	Scheduling and preparation																	A	E		E		
		Management of contract drafting, contract award and orders																	A + E	Co	E	Co		
		Intervention tracking																	A	I		E		
Tunnel training	Training for control room operators and operations managers (programme, monitoring)	Development of the training programme		A	E		Co							Co	Co									
		Development of training content					C							A + E	E									
		Monitoring of operator training			A + E		Co							Co	Co									
	Training of other tunnel operating staff	Development of the training programme		A	E		Co												Co	Co				
		Development of training content					Co												A	E				
		Monitoring of staff training			A + E		Co												Co	Co		Co		
	Training of technicians and maintenance managers	Development of the training programme		A	E		I	Co	Co	Co				Co			Co							
		Development of training content			I			Co	Co	Co				A			E							
		Monitoring of technician training			A + E									Co			Co							
	Training of on-call managers	Development of the training programme		A	E							Co												
		Development of training content					A +E					E		Co					Co					
		Monitoring of on-call manager training			A + E		Co					Co												

E – Editor	Individuals who carry out the task for which they are appointed. They report to an A. Each action has at least one E.
A - Approver	People who approve and validate actions. They are accountable for the scope entrusted to them. They are the ones who are truly responsible. They have authority over the editors. Each action must have a single A.
C - Consulted	These are generally experts who have specific skills for the task in question. They have an advisory role.
I - Informed	These individuals must be informed because they may be impacted in some way by the action in question. They are copied in on important points and decisions.
Co – Contributor	These individuals contribute to the editor's task.

3. Method for clarifying the roles and responsibilities of each actor, ensuring the precise identification of the person responsible for each task: implementation, approval, consultation, information.

4.1.3 Methodological elements

While the missions of the key stakeholders in the SMS, as defined in Chapter 3, must be made explicit, it is the roles and responsibilities of all personnel involved in the tunnel sector that deserve to be clearly defined here.

Firstly, these are the heads of operational and maintenance departments (operations managers, district managers, maintenance centre managers, control room managers) who are responsible for implementing the SMS within their entities. Some may be local representatives or on-call managers.

The roles and responsibilities of on-call managers must also be clearly defined in terms of their coordination, information and decision-making duties.

In addition, the roles and responsibilities of other personnel involved in tunnel operations must also be defined, in particular:

- control room operators, who monitor the situation, raise the alarm and activate operational and safety measures;
- field agents, who provide continuous monitoring, secure access points, protect broken-down vehicles and remove obstacles, and are available to assist the emergency services;
- maintenance personnel, who contribute to safety by carrying out diagnostics and in-house maintenance or supervise subcontractors for equipment operating under minimum operating conditions (MOC);
- the "infrastructure" department, which participates in the management of maintenance and monitoring of infrastructure;
- the training unit, which contributes to skills management, the development of skills development plans, the monitoring of staff skills, etc.;
- the communications unit, which participates in user information campaigns and initiatives in normal situations, as well as media relations in normal situations or during degraded operating conditions.

In addition, all other parties potentially involved in the tunnel sector and contributing to the implementation of the SMS must be mentioned, with a description of their activities.

Examples of tasks and responsibilities directly related to the SMS, to be assigned and distributed among the various stakeholders:

- *ensure awareness of the applicable requirements and any changes to them; ensure compliance with the procedures and regulations in force;*
- *participate in updating the SMS manual and procedures that relate to one's own activities;*
- *ensure that sufficient, qualified and competent staff are available to carry out the planned tasks and activities in accordance with regulations and instructions;*
- *in the event of changes, ensure that a safety impact assessment is carried out, participate in risk assessment, define prevention and protection measures, and ensure that procedures are applied;*
- *report events that impact safety and participate in their analysis, through feedback;*
- *implement preventive and corrective actions within one's department;*
- *implement and promote the safety policy within one's department;*
- *encourage staff, third parties and subcontractors to report any hazards they observe in order to contribute to prevention;*
- *participate in management reviews and safety reviews.*

4.1.4 Documenting roles and responsibilities in the SMS manual

An introductory chapter of the SMS manual should be devoted to defining roles and responsibilities.

As specified in paragraph 5.2, it is possible to refer to existing documents. For example, it may be relevant to refer to section 5, "Description of operations: organisation and resources," of the safety documentation (with reference to [4]).

In addition, an organisational chart showing the accountable manager and the SMS coordinator, the staff with safety-related functions and all the bodies involved in the SMS may be usefully included in the SMS manual.

4.2 SKILLS MANAGEMENT

Skills management is an important component of the SMS. Whilst skills management concerns initial and continuous staff training, it also includes recruitment and management of skills that are in shortage, particularly when employees leave (due to retirement or transfers).

4.2.1 Regulatory provisions

Regulations

Safety exercises [6] are an integral part of the training of a tunnel operator's staff and emergency response personnel. It is therefore important to bear in mind the regulatory references below, which cover both the more general issues of training and skills, and the role of exercises.

Tunnels in operation longer than 300 m

Article R. 118-3-8 of the Road Infrastructure Code stipulates that: : "*The tunnel owner referred to in Article R. 118-1-1 and the emergency services shall organise joint exercises for operating staff and emergency services. These exercises shall be carried out annually. However, where several tunnels have the same operator, fall under the same emergency services and are located in close proximity to each other, the exercise may be carried out in only one of them.*"

Tunnels longer than 500 m on the trans-European network (TEN)

The safety officer "*verifies that training programmes are established and implemented for operating staff and emergency services*". He "*participates in the organisation and evaluation of the exercises provided for in Article R. 118-3-8.*"

European Directive No. 2004/54/EC also states (paragraph 3.1 of Annex I): "*The personnel involved in the operation as well as the emergency services shall receive appropriate initial and continuous training.*"

Tunnels longer than 300 m on the State-managed road network

The Technical Directive dated 2000 states:

5.1 – Operating resources

"*Personnel assigned to operations must receive the training necessary to achieve these objectives*[4]."

Level D2 - On-call duty with means of action: […] " *Additional equipment and the corresponding training must then be put in place in the department providing on-call duty.*"

5.3 – Maintaining safety levels

"*The skills of operating and emergency personnel shall be maintained and improved through ongoing training and the organisation of exercises.*"

5.3.1 – Safety exercises

"*At least once a year, the operator shall organise an internal exercise to test the operating instructions and their implementation by its staff, and to take any corrective measures that may be necessary (updating of instructions, staff training, etc.).*"

Note: The National Commission for the Evaluation of Road Safety Infrastructure (CNESOR) considers that the tunnel operator is responsible for ensuring that its staff receive the necessary training to perform their duties, including maintenance personnel ([7], in particular paragraph 6.6).

4.2.2 Main issues in relation to the SMS

The personnel involved in the operation of road tunnels (control room operators, on-call managers, maintenance staff, other operating staff) are essential to the safety of road users in tunnels. They must perform a number of daily tasks that require specific skills and abilities, in terms of knowledge, know-how and interpersonal skills. Among these, the SMS must focus on those relating to tasks and activities that impact safety.

The SMS must therefore ensure that all personnel involved in the operation of road tunnels have the necessary skills to carry out their duties and that these skills are monitored and updated as necessary.

In addition, the SMS helps to strengthen and consolidate the skills management strategy and to conduct an in-depth review to identify critical positions and the associated skills requirements, in order to develop a structured response tailored to the challenges of safe tunnel operation. This naturally involves training, but also anticipating departures and recruitment.

The SMS ensures that the operator has a skills management policy that specifies its objectives in this area. This policy is validated by the accountable manager, disseminated internally and reviewed regularly according to clearly defined procedures. The persons responsible for defining, implementing and monitoring training plans are clearly identified.

4. Ensure accident prevention and personal safety in the event of an incident or accident.

4.2.3 Methodological elements

In addition to the methodological elements provided below, definitions relating to skills management are included in Appendix D.1.1.

Identification of stakeholders involved in tunnel safety

In view of the expectations, the SMS must make it possible to identify all those involved in the safe operation of tunnels.

To this end, the operator shall compile a list of tasks and activities that have an impact on safety, including those related to the SMS. In particular, it shall identify "critical" positions, such as control room operators whose presence is subject to MOC (minimum operating conditions) in the emergency intervention and safety plan (ESP).

Examples of tasks and activities that impact safety:

	Examples of tasks	Examples of activities
Control room operator	Monitor tunnel traffic	Trigger the appropriate fire scenario
Maintenance technician	Ensure that safety equipment is in good working order	Carry out periodic operational tests
Field Agent	Conduct patrols	Install traffic cones in the event of a stationary vehicle in a tunnel
On-call manager	Coordinate with external responders in the event of an emergency	Notify the prefectural authority if the situation falls below minimum operating conditions (MOC), resulting in tunnel closure
External companies	Carry out the planned works safely	Comply with procedures related to work with heat devices

Skills mapping

The operator then maps the necessary skills, identifying skills by job type. This mapping is carried out for all relevant personnel at all hierarchical levels, i.e. at a minimum:

- control room operators;
- maintenance technicians, including those responsible for IT maintenance of control centres;
- field agents or patrol officers;
- on-call managers.

This mapping includes qualifications/authorisations and mentoring. It identifies skills that may be in shortage and critical to the system. This enables the operator to better anticipate staff renewal.

An example of a skills mapping for maintenance and intervention staff is provided in Appendix D.1.5.

Skills development plan

Once the mapping of expected skills has been finalised, it is necessary to identify, for each employee, the skills they need to acquire or strengthen, and thus to develop an individualised skills development plan. For each position, the content of initial and continuous training is then defined and sessions are scheduled. In this context, the assistance of the department in charge of skills management and training is essential.

The skills development plan is therefore the result of linking tasks and activities that impact safety with the associated skills requirements, in order to build a structured training response that is tailored to these requirements. The requirements assessment is based in particular on:

- the requirements identified through feedback on safety exercises and events;
- needs identified during annual reviews;
- individual skills assessments.

The skills development plan is drawn up on the basis of existing training opportunities (mentoring, general training), supplemented by specifically developed initiatives (development of a simulator, training focused on the organisation's procedures, etc.). It is then broken down into annual and multi-annual training programmes, balancing the requirements to be met with the resources available where necessary.

Experienced staff with recognised skills can act as internal mentors whom the operator can rely on to develop the skills of all their teams, for example through mentoring and initial and ongoing training. However, the operator must be vigilant about the sustainability of the system and where possible, consider consolidating the essential role of these mentors by creating pairs for skills that may be in shortage and critical to the system.

Thus, for each job (control room operators, on-call managers, maintenance technicians, other operations staff), the tunnel operator has a skills development plan that includes:

- **recruitment:** the operator has identified the prerequisites[5] and prior knowledge[6] essential for taking up a position;
- **initial training:** the operator has considered the skills that the employee must acquire at the start of their position. This can take several forms (face-to-face training, distance learning, mentoring, etc. – more details are provided in Appendix D.1.3);
- **continuous training:** the operator has considered the skills and knowledge for which refresher training is useful or even essential. In the context of road tunnel operation, participation in safety exercises and debriefings is part of the continuous training for all categories of staff (more details are given in Appendix D.1.4);
- **the accreditation process** (regulatory or otherwise), where applicable;
- **management of departures:** the operator anticipates the departure of its staff, particularly when they have very specific skills and knowledge or extensive experience.

The procedures for defining and implementing the skills development plan are set out in the SMS documentation.

Monitoring system

As part of the SMS, the skills monitoring system ensures that the described procedures are followed and verifies:

- on the one hand, the proper implementation of the skills development plan (monitoring of the skills management system);
- and, on the other hand, the effectiveness of training (monitoring of staff skills, which also includes monitoring of qualifications/authorisations and compulsory medical examinations, for example for staff with heavy goods vehicle licences).

As part of the continuous improvement process, initial and refresher training courses are evaluated after they have been implemented for several employees. They are also adapted in line with any new needs that may be identified:

- following feedback obtained from exercises and events;
- following changes such as the integration of a new tunnel, the commissioning of new equipment, technological developments, changes in procedures or instructions, etc.

Skills monitoring also includes consideration of how to ensure the continuity of these skills:

- by anticipating the departure of employees in positions critical to safety who have extensive experience (early recruitment and mentoring of new recruits);
- by facilitating the transfer of their knowledge and existing best practices, encouraging them to document and share them.

In order to monitor the management of employees' skills, the operator also has a tool that allows them to track the training courses taken and identify those that are still necessary for each employee.

SMS training

The training programme for staff whose activities may have an impact on safety includes a module explaining the principles of the SMS. It must therefore be tailored to the operation and procedures of the SMS and cannot be generic. In particular, it covers:

- the organisation of the SMS within the tunnel operation;
- safety objectives;
- the reporting of incidents;
- the role of each individual in the SMS;
- human factors;
- etc.

Training is also provided to staff involved in the SMS for the tasks assigned to them that are directly related to the SMS. Continuous training for these staff members helps to maintain their skills.

Information and training for third parties

Information and training activities for third parties, and their traceability, are documented and detailed in the SMS manual or in a procedure referred to in the SMS manual.

The main principles governing the training of subcontractors and external partners working in tunnels must be established and documented. The operator must be able to prove that it has ensured that these individuals have undergone specific training for tunnel operations and that it has provided them with all necessary safety instructions in advance, in accordance with the specific health and safety plan or the prevention plan.

External partners (emergency services, law enforcement, etc.) can familiarise themselves with the tunnel and its equipment during site visits organised by the operator during scheduled tunnel closures. They also take part in safety exercises.

5. Prerequisites: what the candidate should be able to do upon arrival at the job, required skills.
6. Pre-acquired skills: what the candidate is actually capable of doing when they start the job, what they have mastered.

Training courses or one-off initiatives may be provided by the operator for the general public (radio communication campaigns on what to do in a tunnel in the event of a fire) or for specific target groups such as young people and heavy goods vehicle drivers (e.g. drivers of regular public transport services using the tunnel, or drivers of local dangerous goods transport companies). The aim is to raise awareness of the risks associated with driving in tunnels, the correct response in the event of an incident, road safety and the risks faced by operating staff when working on the road. Patrol officers may take part in these initiatives to talk about their daily work and the risks and incidents they face.

It should be noted that, at national level, driver training takes into account the specific characteristics of road tunnels, both in theory lessons (highway code and highway code test) and in specific training courses for heavy goods vehicle licences (initial and renewal). In addition, several films illustrating the correct behaviour to adopt in tunnels have been produced and distributed to the general public in recent years (behaviour in the event of fire or a breakdown, how to respect a safe distance between vehicles thanks to blue markers on tunnel walls, etc.).

Tende Tunnel – Fire test (© CETU)

4.2.4 Documenting skills management in the SMS manual

A chapter of the SMS is devoted to this "skills management" component.

As part of a process to professionalise tunnel operations, the tunnel operator first creates a training programme for each position, which can be adapted to suit individual employees, based on a skills map that they draw up for each role. Once this programme is in place, the employees concerned enter an individual professional development process, which includes initial training and continuous training.

The SMS manual sets out the principles of the skills management process that has been put in place, or the existing elements of this process, and refers to specific documents and procedures. In particular, it specifies the persons responsible for the various stages, the procedures for review, modification, validation and dissemination. An annual skills review is presented at the safety review.

As specified in paragraph 5.2, it may be useful to refer to other existing documents. For this topic, in addition to specific operational documents addressing skills management, the manual may refer to the following documents, established and monitored by the human resources department:

- local training plan;
- skills development plan;
- training records;
- mentoring logs, etc.

4.3 ASSET MANAGEMENT FOR STRUCTURAL ELEMENTS AND TUNNEL EQUIPMENT

Asset management is another important component of the SMS. Often handled by two different departments, addressing this component via the SMS allows for better mutual understanding among the tunnel operator's staff.

4.3.1 Regulatory provisions

The regulations governing asset management are mainly derived from the Road Infrastructure Code. They are explained in detail in CETU information note no. 21 [1].

The provisions specifically applicable to tunnels on the State-managed road network are derived from the Technical Directive dated 2000 and the Technical Directive for the Monitoring and Maintenance of Civil Engineering Structures (ITSEOA), in particular its booklet 40 [8] (State-managed road network).

Tunnels in operation longer than 300 m

According to the Road Infrastructure Code, the preliminary safety documentation and subsequent safety documentation contain a description of the organisation of human and material resources and the measures planned by the tunnel owner to ensure the safe operation and maintenance of the tunnel.

In the event of a substantial modification to an existing tunnel, the preliminary safety documentation also contains this description for the period during which the work is carried out.

During the periodic safety inspection (R. 118-3-3 of the Road Infrastructure Code) and when a safety assessment is carried out at the request of the prefect (R. 118-3-5 of the Road Infrastructure Code), the Expert or Approved Qualified Organisation provides an assessment, in particular on the condition of the tunnel and its equipment, in its safety report accompanying the safety documentation when it is submitted to the prefecture.

Tunnels longer than 500 m on the trans-European network (TEN)

The safety officer "*verifies that procedures for the maintenance and repair of the tunnel structure and equipment are established and implemented*".

Tunnels longer than 300 m on the national road network (RRN)

The Techncial Directive dated 2000 addresses the maintenance of safety levels in paragraph 5.3: "*Civil engineering structures and equipment shall be maintained in such a way that they can fulfil their functions as often and whenever necessary*".

Technical directive for the monitoring and maintenance of civil engineering structures (ITSEOA) (State-managed road network)

The circular of 16th February 2011 relating to the publication of the new ITSEOA and booklet 40 [8] of this technical directive (application guide for tunnels and covered trenches) impose asset management obligations on operators of tunnels on the State-managed road network, for both structural elements and equipment, in order to maintain the tunnel in good condition.

Rond-Point Tunnel – Periodic detailed inspection of structural elements (© CETU)

These include:

- the monitoring and maintenance of structural elements, which can be broken down into several areas of activity:
  - continuous monitoring as part of general network monitoring, which involves reporting any anomalies encountered during patrols or other interventions on the tunnel,
  - periodic monitoring activities, whether annual checks of tunnels or periodic detailed inspections,
  - actions related to specific events in the life of the tunnel, such as validation of works, end of regular service verification or end of warranty,
  - assessment and rating of the condition of structural elements during detailed inspections,
  - routine maintenance and specialised maintenance,
  - any repairs to damage that may be related to a specific situation (e.g. ground movements), including an investigation and assessment phase leading to a diagnosis of the tunnel structure,
  - any renovations to tunnels that may be necessary to bring them into regulatory compliance or even change their intended use;
- maintenance, inspection, assessment and renewal of equipment, which can also be divided into several areas of activity:
  - maintenance, which refers to all actions taken to ensure that equipment can perform as expected when required,
  - inspections, whether continuous, regulatory, periodic or scheduled as part of test sequences,
  - assessment of conditions at the time of detailed inspections,
  - the replacement of equipment due to deterioration, wear and tear or obsolescence.

In order to comply with these steps, which ensure proper monitoring of the tunnel, the tunnel owner must establish multi-annual programmes and provide its teams with the means to implement them through training and sufficient staffing levels. If it is unable to do so in-house, the tunnel operator may outsource all or part of the tasks, while ensuring that it retains control.

To date, there is no certification requirement for applying the procedures described in booklet 40, but experience and references in tunnel maintenance are highly recommended.

Tunnel owners managing tunnels located on the concession network or on the road network managed by local authorities, which do not fall within the scope of this directive, must of course also maintain their tunnels in order to ensure the safety of persons. They are encouraged by the CNESOR [7] to implement procedures similar to those in ITSEOA booklet 40 with regard to inspection, control and maintenance.

Montets Tunnel – CCTV camera (© CETU)

4.3.2 Main expected benefits of the SMS

The SMS helps tunnel owners to ensure proper upkeep and maintenance of the tunnel and its equipment, in accordance with, or in the spirit of, the requirements of section 40 of the Technical Directive for the Supervision and Maintenance of Civil Engineering Structures (ITSEOA) [8], depending on the tunnel owner concerned.

The organisation for the management of structural and equipment assets is described in the SMS manual, which details, with reference to the ITSEOA:

- the three levels of internal organisation of the managing tunnel owner (decision-making, organisational and operational), setting out their roles in policies, plans and procedures;
- monitoring and maintenance for structural elements;
- maintenance, inspection and replacement of equipment.

Booklet 1 [9] – ITSEOA Construction File indicates that the tunnel history file (THF) must enable the collection of information on the design, construction and life of the tunnel.

For a new tunnel, the tunnel history file[7] is given to the tunnel manager when the tunnel is commissioned and includes the Subsequent Intervention File for the Tunnel (SIF).

As part of the SMS, the operator monitors periodic detailed inspections and regulatory requirements. In particular, this monitoring includes the implementation of follow-up actions (who, what, how, by when).

Asset management of structural elements

A tunnel is first and foremost a civil engineering structure, the good condition of which must be guaranteed over time. The SMS makes it possible to organise the means of achieving this objective, which are based on the following actions:

- defining, validating, disseminating and revising an asset management policy for structural elements;
- keeping the tunnel history file (THF) up to date;
- ensuring monitoring;
- carrying out periodic checks (annual visits and detailed periodic inspections every six years);
- taking action if necessary following a specific event;
- assessing the condition of the tunnel (condition rating);
- maintaining the tunnel (routine maintenance, specialised maintenance);
- repairing the tunnel in the event of defects (to the actual structure, waterproofing, etc.);
- bringing the tunnel into compliance in the event of regulatory changes.

The SMS contributes to the implementation of monitoring, routine and specialised maintenance, and repair or renovation measures, based on the provisions of ITSEOA booklet 40 [8], through its asset management policy for structural elements. The procedures for its validation, dissemination and revision – including frequency – are defined and documented.

The planning of monitoring operations is documented, including the procedures for intervention, the person responsible for them, the equipment required to carry them out, etc. The involvement of the various stakeholders, coordination with the department responsible for infrastructure, and the frequency of the actions to be carried out must be defined. The persons responsible for establishing, validating and disseminating the monitoring and maintenance programme must be identified.

The media used (manual or computerised logbooks, reports, minutes, etc.) and the procedures for transmitting, checking and monitoring information must also be defined.

A table for monitoring defects and the action to be taken is a fundamental part of the SMS for managing tunnels and planning budgets and works. It is updated at least annually with information from all monitoring and maintenance actions.

The appointment of a specialist "tunnel" correspondent within the department responsible for infrastructure allows information to be centralised and provides a complete update of the tunnel history file.

7. For existing tunnels, design data and even construction data are often missing. It is entirely possible to reconstruct a tunnel history file. In this case, it is often preferable not to aim for completeness immediately, but rather to take a pragmatic approach aimed at gathering data relating to the life of the tunnel (annual visit reports, reports following detailed periodic inspections of structural elements and equipment, etc.), according to procedures to be defined.

Equipment asset management

The proper functioning of equipment is essential for safety. It is vital to ensure the availability of the tunnel in accordance with minimum operating conditions and to guarantee the proper implementation of safety measures in the event of an incident. As with structural elements, the SMS helps to organise the means of achieving the objective of good equipment asset management on a long-term basis. The actions required to achieve this are partly identical to those defined for structural elements. For equipment, they are as follows:

- defining, validating, disseminating and reviewing the equipment asset management policy;
- keeping the tunnel history file up to date;
- maintaining the assets (preventive, corrective and remedial maintenance, etc.);
- remaining aware of the condition of the assets;
- carrying out periodic checks (continuous checks, detailed periodic inspections every six years, specific safety sequences, etc.);
- assessing the condition and performance of equipment;
- taking action when necessary following a specific event;
- renewing assets (planning, monitoring, stock management);
- bringing the tunnel's equipment into compliance in the event of regulatory changes.

The equipment asset management policy, like the structural element asset management policy, is based on ITSEOA booklet 40 [8]. The procedures for its validation, dissemination and revision – including frequency – are defined and documented.

In addition to the distribution of tasks among the various stakeholders, the SMS is used to define the organisation put in place for the management, scheduling, monitoring and control of operations to be carried out, either in-house or outsourced, and the human resources available.

The planning of controls is documented, in particular intervention methods, the person responsible for them, the equipment necessary for their implementation, etc. The persons in charge of monitoring and follow-up are identified and provisions are established to enable appropriate monitoring of malfunctions. Corrective actions are managed and tracked.

The media used (manual or computerised logbooks, reports, minutes, etc.) and the procedures for transmitting, checking and monitoring information must also be defined.

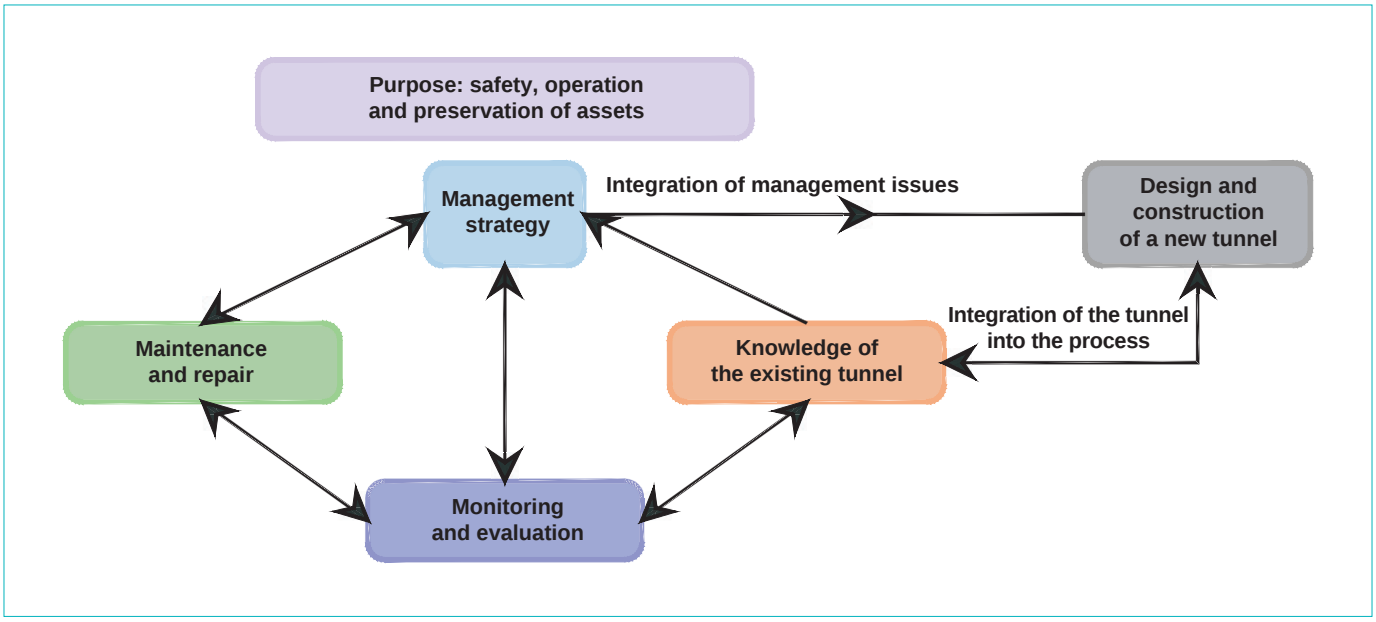
A maintenance plan must be drawn up, defining for each piece of equipment: whether maintenance is preventive (systematic or conditional) or corrective; whether maintenance actions are carried out in-house or subcontracted (specifying the associated contract), their frequency, etc. The person in charge of planning is identified. The parties responsible for monitoring and follow-up are also identified, and provisions are in place to ensure appropriate monitoring. The stock management procedure is documented.

Finally, a multi-annual equipment renewal programme is developed, and the person responsible for it is identified, as well as the person in charge of inventory management and spare parts orders.

4.3.3 Methodological elements

Asset management of structural elements

The asset management policy for structural elements includes at least the definition of the key issues and aims not only to preserve the condition of the tunnel, but also to associate it with a performance objective. It helps to define budgetary policy and prioritise maintenance and repair actions. The target and the method of disseminating and sharing this policy are defined. All those involved in the asset management must adopt consistent operating procedures and share expertise and best practices.



The continuous asset management approach for structural elements of a tunnel

Asset management of structural elements is based on two main activities:

- **Monitoring:** this allows the condition of structures to be tracked over time. There are several monitoring activities:
  - **Continuous monitoring** (patrols): this allows obvious signs of damage, clearly abnormal developments and the consequences of unforeseen events to be detected. To ensure follow-up, a permanent record of events is kept, containing any anomalies observed, alerts and follow-up actions taken, actions carried out and maintenance actions to be carried out, specifying the procedures (who, how, verification, management of follow-up actions if necessary),
  - **Inspections:** these enable a health check of the tunnel to be carried out and the presence of serious problems or a clear deterioration to be detected. They include:
    - **annual inspections**, carried out by the operational department,
    - **Periodic Detailed Inspections (PDI)**, every six years, carried out by qualified persons,
  - **Assessment of the condition of the tunnel**, based on a rating system: this enables the condition of the tunnel to be monitored and helps to define budgetary policy and prioritise maintenance and repair work;
- **Maintenance and repair actions:** these are implemented to meet the objectives set by the asset management policy. They must take into account the inevitable deterioration in the condition of tunnels over time. Various strategies may be adopted: addressing condition deteriorations (i.e. restoring initial condition), slowing condition deteriorations, or improving the initial condition. Maintenance and repair actions aim to ensure the sustainability of the tunnel and include:
  - **routine maintenance:** cleaning of drainage systems, roadways and pavements, maintenance of portals, maintenance of approaches to the tunnels and galleries, etc.,
  - **specialised maintenance:** hydrocleaning, washing side walls, repointing and sealing bricks and stone, treating non-structural cracks, purging, etc.,
  - **repairs and improvements:** structural reinforcement, water ingress treatment, modernisation work, etc.

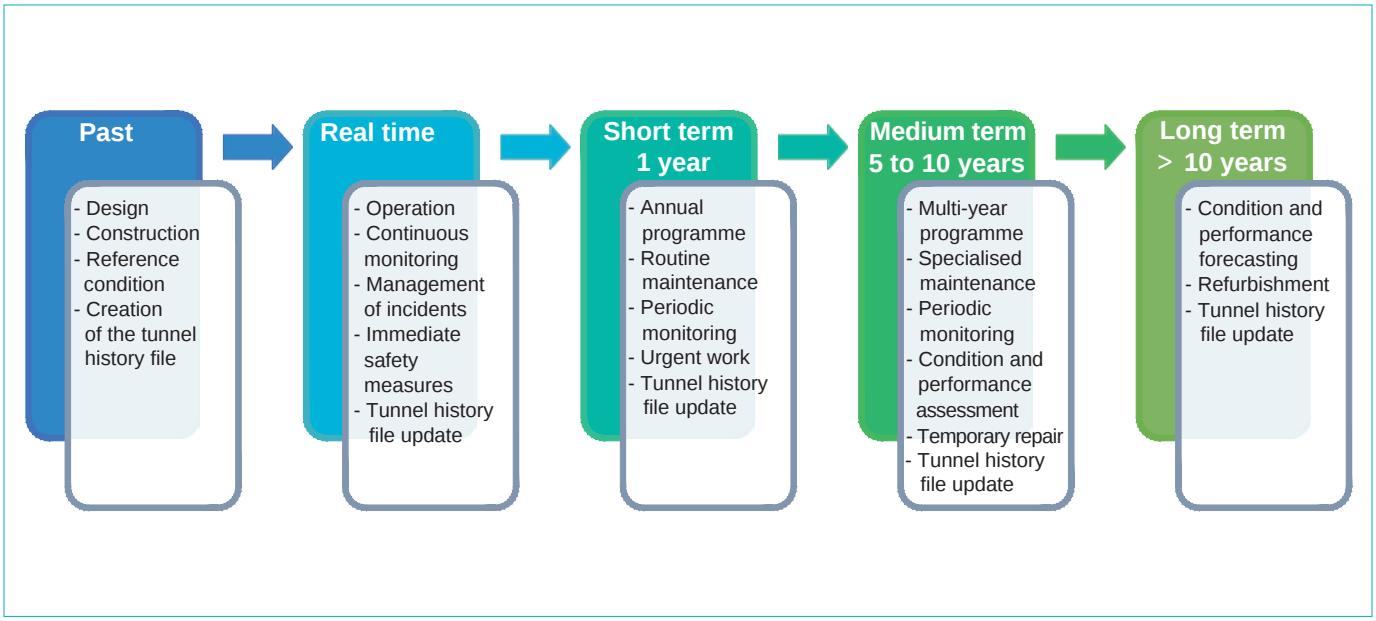
Following a specific incident, a list of which may be predefined by the operator based on their assessment of key issues, the following actions must be taken:

- checking the condition of parts of tunnels under warranty or under responsibility (carrying out special end-of-warranty inspections);
- establishing a baseline condition at the end of construction or after major works (carrying out Initial Detailed Inspections (IDI) and exceptional detailed inspections);
- checking the condition of the tunnel after an unforeseen event that may have damaged it (enhanced monitoring);
- intensifying monitoring of the tunnel, for example in the event of uncertainty about the origin of the damage or suspicion about the guarantee of structural integrity (implementing of high-level monitoring).

As part of the SMS, the operator assesses how the following are managed:

- the organisation, implementation and traceability of structural element monitoring and maintenance operations, in particular:
  - the management, planning and definition of the monitoring and maintenance policy,
  - the implementation and monitoring of resulting actions, including their traceability,
  - the implementation and monitoring of actions following IDI/PDI, including their traceability;
- the scheduling, organisation and traceability of repairs;
- description of the system used to ensure the described operation.

The assessment methods are described in the procedures (person responsible, frequency, formal requirements) and the results of asset management actions for structural elements are archived in the tunnel history file.



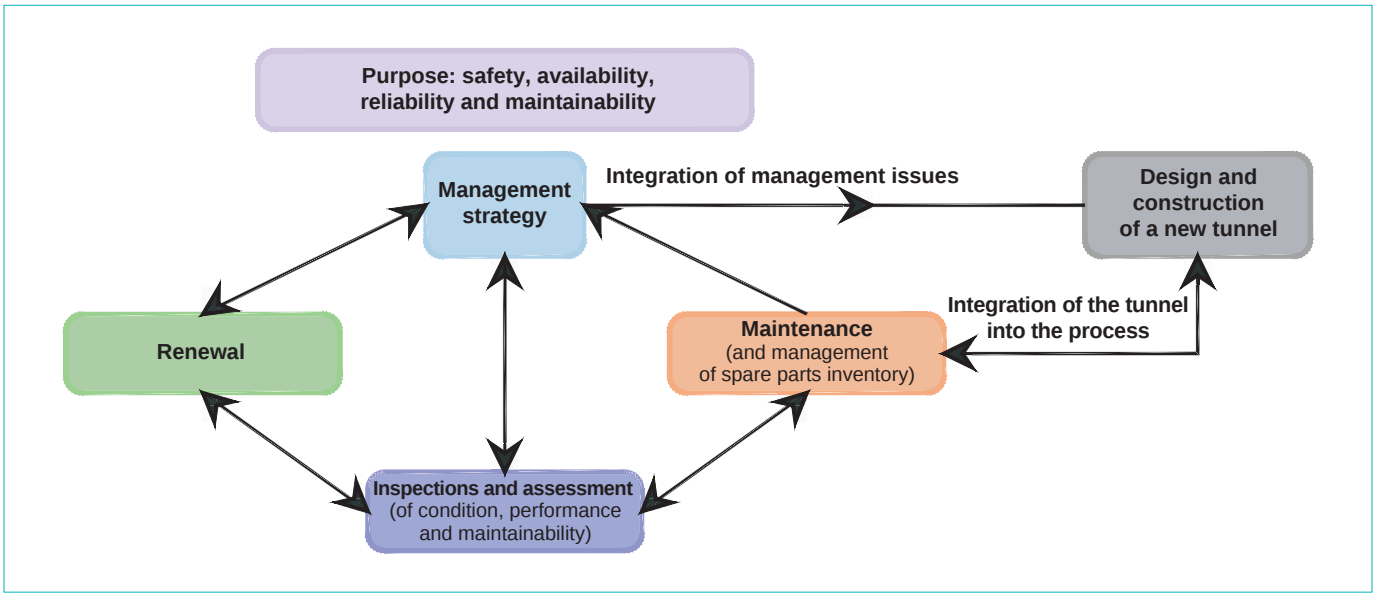
Asset management of structural elements over time

Equipment asset management

Organisation and nature

Like the asset management policy for structural elements, the equipment asset management policy includes at least the definition of key issues and aims not only to preserve the condition of the tunnel, but also to associate it with a performance objective. It helps to plan the budgets necessary for its implementation, but also, when the time comes, those for the more costly operations of renewing major equipment. The target audience and the method of disseminating and sharing this policy are defined. All those involved in equipment asset management must share their expertise and best practices.

Champigny Tunnel (© CETU)

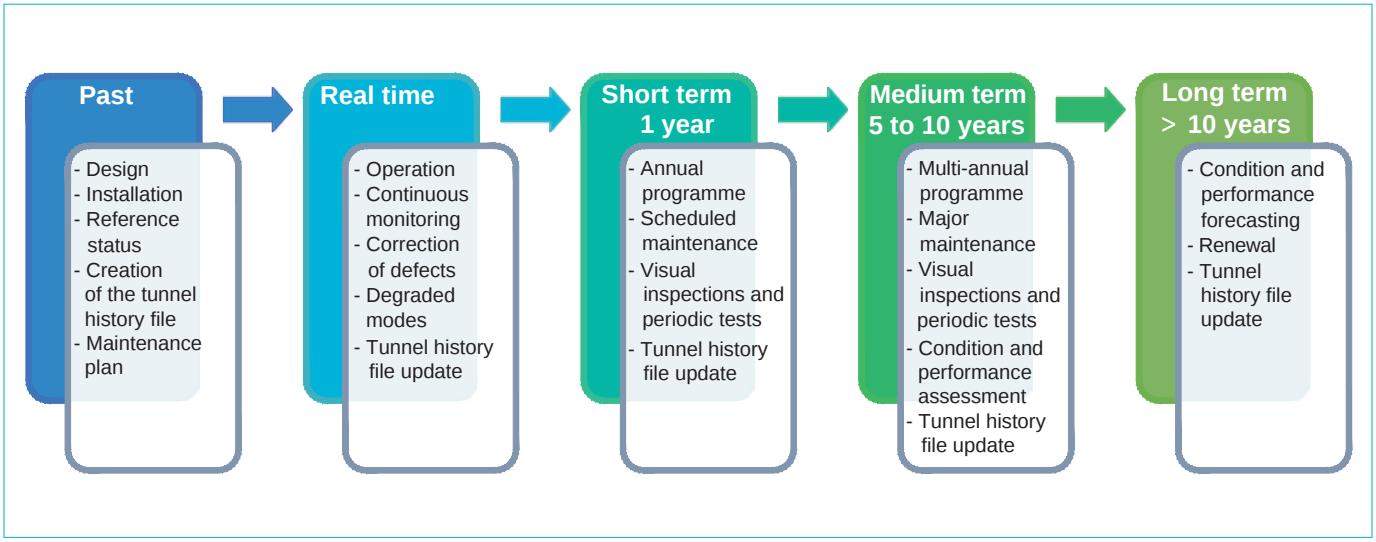


The continuous approach for equipment asset management

Equipment asset management is based on three main areas:

- **Maintenance** refers to all the actions that must be carried out to ensure that a piece of equipment can provide the service expected of it when it is needed. The various tasks to be performed are defined and described in the maintenance plan. There are two main types of maintenance:
  - **preventive maintenance**, carried out according to predetermined criteria in order to prevent equipment failure. It is subdivided into systematic maintenance (interventions carried out according to a schedule based on time or operating hours) and conditional maintenance (interventions based on factors such as wear or performance measurements),
  - **Corrective maintenance**, which occurs after partial or total equipment failure. If the action taken has only a temporary effect, this corrective maintenance is followed by remedial maintenance;
- **checks to ascertain the condition of assets:** these are checks on equipment functioning carried out in the field and from the control room. These checks must be planned and the results monitored by a designated person within the tunnel operating body. There are four types of checks:
  - **continuous checks** by maintenance technicians and operations staff[8], in conjunction with operators at the control centre, or directly by the operators. The operator defines the frequency of these checks and the procedures to be followed for each type of equipment,
  - **regulatory checks** on certain equipment (electrical installations, fire extinguishers, lifting equipment, etc.) that are subject to specific regulations. These checks may only be carried out by authorised bodies,
  - **Initial and periodic detailed inspections** carried out every six years,
  - **specific safety tests:** these are launched from the control centre and enable checks to be carried out to ensure that rarely used equipment (smoke extraction, self-evacuation and emergency closure devices) is working and responding correctly to operator actions;
- **equipment replacement:** a preventive measure that is part of a multi-annual programme.

8. Staff who identified the defect should be provided with feedback on the progress made by the maintenance department in dealing with it; this helps to show them the importance of their checks and prevents them from becoming complacent.



Equipment asset management over time

In this context, good stock management enables the operator to have a stock of spare parts that meets its needs so that it can respond quickly in the event of equipment failure and compensate for equipment obsolescence.

In the same way as for structural elements, as part of the SMS, the operator assesses how the following equipment aspects are managed:

- the organisation, implementation and traceability of maintenance (preventive and corrective), servicing and inspections, in particular:
  – the management, planning and definition of the maintenance and servicing policy,
  – the implementation and monitoring of maintenance and servicing activities, including their traceability,
  – the implementation and monitoring of actions following initial and periodic detailed inspections, including their traceability;
- the scheduling, organisation and traceability of major equipment renewals and repairs;
- the description of the system used to guarantee the described operation.

The practices are described in the procedures (person responsible, frequency, documenting) and the results of equipment asset management actions are archived in the tunnel history file.

Details concerning maintenance

Maintenance planning tables are the operational implementation of the equipment maintenance and inspection policy, in accordance with the requirements of ITSEOA booklet 40. In addition to their role in scheduling, these tables enable the effective implementation of the programme of operations to be monitored and traced.

The maintenance schedule is drawn up annually. In terms of ranges and frequencies, it indicates whether it is based on the manufacturers' recommendations or on the recommendations in the appendices to ITSEOA booklet 40. The SMS manual, or the maintenance plan to which it refers, specifies at what time of year and by whom the schedule is drawn up, who validates it and who distributes it.

The implementation of the SMS enables the operator to clarify maintenance procedures, both internally and with subcontractors, in particular the traceability and monitoring of actions carried out.

Technical malfunctions in strategic surveillance and control equipment can highlight weaknesses (insufficient human resources dedicated to maintenance, certain specialised skills mastered by only a few staff members). An audit of the maintenance organisation can help to analyse whether the resources in place and their organisation are adequate for the volume and technical complexity of the equipment, as well as for the safety functions that this equipment must perform.

The scope of maintenance contracts and their interfaces are specified. The criteria for carrying out corrective maintenance work in-house or through subcontractors are clarified and documented. The SMS manual specifies how maintenance is organised and carried out for technical equipment not covered by maintenance contracts.

In order to ensure continuity of maintenance activities, the operator anticipates the end of maintenance contracts, as well as the production and awarding of new contracts. Where applicable, the operator also anticipates the end of regular service checks and equipment warranty periods, during which maintenance is provided by contractors.

A Computerised Maintenance Management Systems (CMMS) is a management tool designed to increase responsiveness and ensure more reliable maintenance. The use of CMMS and computerised logbooks (CLB) provides real added value in optimising the maintenance process for equipment and ensuring its traceability.

If the CMMS is used internally and also by the maintenance contractor, this allows the operator to accurately monitor all maintenance of tunnel equipment.

Stock monitoring provides detailed information on availability and optimises maintenance: anticipating equipment obsolescence, detecting recurring faults, etc. It also enables the establishment of a multi-annual programme for the replacement of end-of-life equipment, to be reviewed annually. The SMS manual specifies which document deals with spare parts inventory management (availability, ordering, inventory tracking, lead times, etc.) and whether it is part of the CMMS, if applicable.

4.3.4 Documenting asset management in the SMS manual

A chapter of the SMS is devoted to this "asset management" component.
The SMS manual sets out asset management principles that have been put in place and refers to specific documents and procedures (in particular the asset management policy and section 5 "Description of operations: organisation and resources" of the safety documentation, with reference to [4]). The manual also specifies the persons responsible for the various stages, as well as the procedures for review, modification, validation and dissemination.

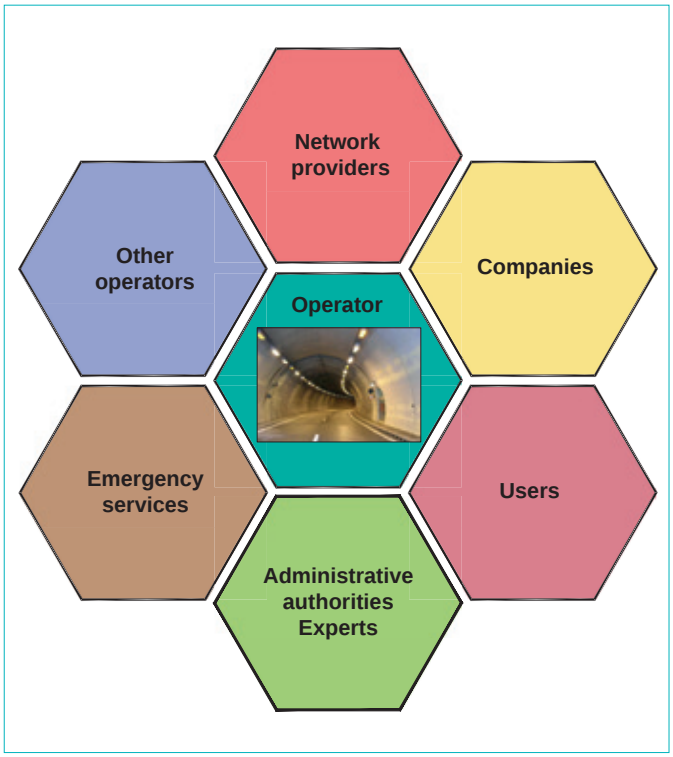
4.4 COORDINATION WITH THIRD PARTIES

Tunnel safety management is not solely the responsibility of the operator. In fact, many different third parties are involved in ensuring safety, both on a day-to-day basis and in the event of an incident.

Third parties are external stakeholders who may interact with the operation of the tunnel in various situations (normal operation, degraded operating modes, maintenance or works). They may differ from one tunnel to another operated by the same operator; this is particularly the case when tunnels or a control centre are located in different geographic locations.

These third parties can be divided into the following six main categories:

- users;
- companies working in tunnels for upkeep, maintenance and works; repair services; Health and Safety Coordinators (HSC); design offices (testing, inspections, measurements);
- suppliers of networks for tunnel use: energy, water, telecommunications, radio communications;
- interface operators (management services and control centres): road network bodies (local authorities, metropolitan authorities, road or motorway concession companies, etc.), mobility authorities (public transport networks), high-rise buildings, public buildings (car parks, shopping centres, etc.), owners of pipes or cables running through or in the immediate vicinity of the tunnel but not necessary for tunnel operation (gas, water, kerosene, electricity, etc.), etc.;
- emergency and rescue services: law enforcement agencies (police, gendarmerie, CRS), public emergency services (fire brigade, emergency medical services such as SAMU and SMUR);
- administrative authorities: prefecture(s)[9], local government offices, mayor(s), advisory committees: National Commission for the Assessment of Road Infrastructure Safety (CNESOR), Local Committee for Infrastructure Safety (CCDSA/SIST), qualified experts; where applicable, tunnel safety officer and, if applicable, the local monitoring committee.



The six categories of third parties

Other partners may also play a role in managing the risks associated with the operator's activity:

- companies involved in operation or maintenance under public-private partnerships (PPPs) or public service delegations;
- the media;
- the concession authority;
- the CETU ;
- neighbouring municipalities;
- etc.

9. For tunnels spanning two geographic French “départements”, the prefectures of both “départements” are involved, but one of the two prefects is designated as the coordinating prefect.

4.4.1 Regulatory provisions

Regulations governing coordination with third parties are mainly derived from the Road Infrastructure Code, the Decree of 18th April 2007 [1] and the Labour Code.

Tunnels in operation longer than 300 m

French Road Infrastructure Code Article R. 118-3-8. – "*The tunnel owner referred to in Article R. 118-1-1 and the emergency services shall organise joint exercises for tunnel personnel and the emergency services.*"

Decree of 18th April 2007

"*4° The emergency and safety plan shall define the organisation and tasks of the operator, as well as the procedures for alerting and coordinating with the emergency services in situations that may jeopardise the safety of persons, including persons with disabilities or reduced mobility.*

For such situations, it shall describe in particular:

a) The organisation of command and coordination of the operator's resources, distinguishing between the different levels of responsibility;
b) Internal and external monitoring and alert procedures;
c) Situations requiring the closure of the tunnel to traffic;
d) The principles of action and resources to be deployed by the operator, as well as the procedures for coordination with external emergency services;
e) Traffic management and diversion arrangements within and outside the tunnel;
f) The systems for recording events, decisions and actions."

Tunnels longer than 500 m on the trans-European network (TEN)

Articles **R. 118-4-2 and 4-3 of the French Road Infrastructure Code** set out the conditions for appointing a tunnel safety officer and each of their duties.

Art. R. 118-4-2. – "*The tunnel owner shall send the prefect the name of the tunnel safety officer referred to in Article L. 118-5 whom they intend to appoint and shall indicate the measures taken to ensure the functional independence of that officer.*

Within two months of receiving this information, the prefect shall give his or her approval for the appointment of the officer. If no response is received within this period, the appointment shall be deemed to have been accepted."

Art. R. 118-4-3. – "*The safety officer shall:*

a) Issue an opinion on the preventive measures and safeguards envisaged in the preliminary safety documentation provided for in Article R. 118-3-1;
b) Issue an opinion on the safety documentation provided for in Articles R. 118-3-2 and R. 118-3-3. His/her opinion shall be attached to this documentation when it is sent to the Prefect;
c) Issue an opinion on any modification to the tunnel that is not substantial in nature and on any modification to the operating conditions that does not significantly affect them, which the tunnel owner forwards to the prefect and the emergency services;
d) Ensure coordination with the emergency services, in particular when drawing up the operational plans for these services;
e) Participate in the organisation and evaluation of emergency response operations;
f) Participate in defining safety principles and the characteristics of the tunnel, equipment and operation, both for new tunnels and for the modification of existing tunnels;
g) Verify that training programmes are established and implemented for operational staff and emergency services;
h) Participate in the organisation and evaluation of the exercises provided for in Article R. 118-3-8;
i) Verify that procedures for the maintenance and repair of the tunnel and its equipment are established and implemented;
j) Participate in the feedback assessment of any significant incident or accident.

The tunnel owner shall provide the safety officer with all documents and information necessary to perform his/her duties."

The amended decree of 8th November 2006, on minimum safety requirements for tunnels longer than 500 m on the trans-European network lists the following requirements concerning users and emergency services:

Emergency stations: "*Emergency stations are intended to provide various safety equipment. They are not designed to protect road users from the effects of fire. This information is brought to the attention of users in emergency stations separated from the tunnel by a door* […]."

Communication systems: "*The radio communication system complies with the above-mentioned decree on radio communications for emergency services operating in road structures.*

Where there is a control centre, a device is provided to interrupt radio broadcasts to tunnel users, where available, in order to broadcast emergency messages.

Shelters and other facilities where users wait before being able to evacuate the tunnel are equipped with loudspeakers to provide information to users."

Tunnel closures: "*In the event of a tunnel closure, users shall be informed of the best possible alternative routes by means of appropriate information systems.*"

Tunnels longer than 300 m on the State-managed road network

The Technical Directive dated 2000 (IT 2000) addresses user information through signage and signalling. It adds that if justified by the length of the tunnel, its specific characteristics or the volume of traffic, additional measures must be taken, such as installing variable message signs (VMS), information signs, distributing explanatory leaflets about the tunnel, its equipment, the procedure to follow in normal conditions and in the event of an incident or accident, etc.

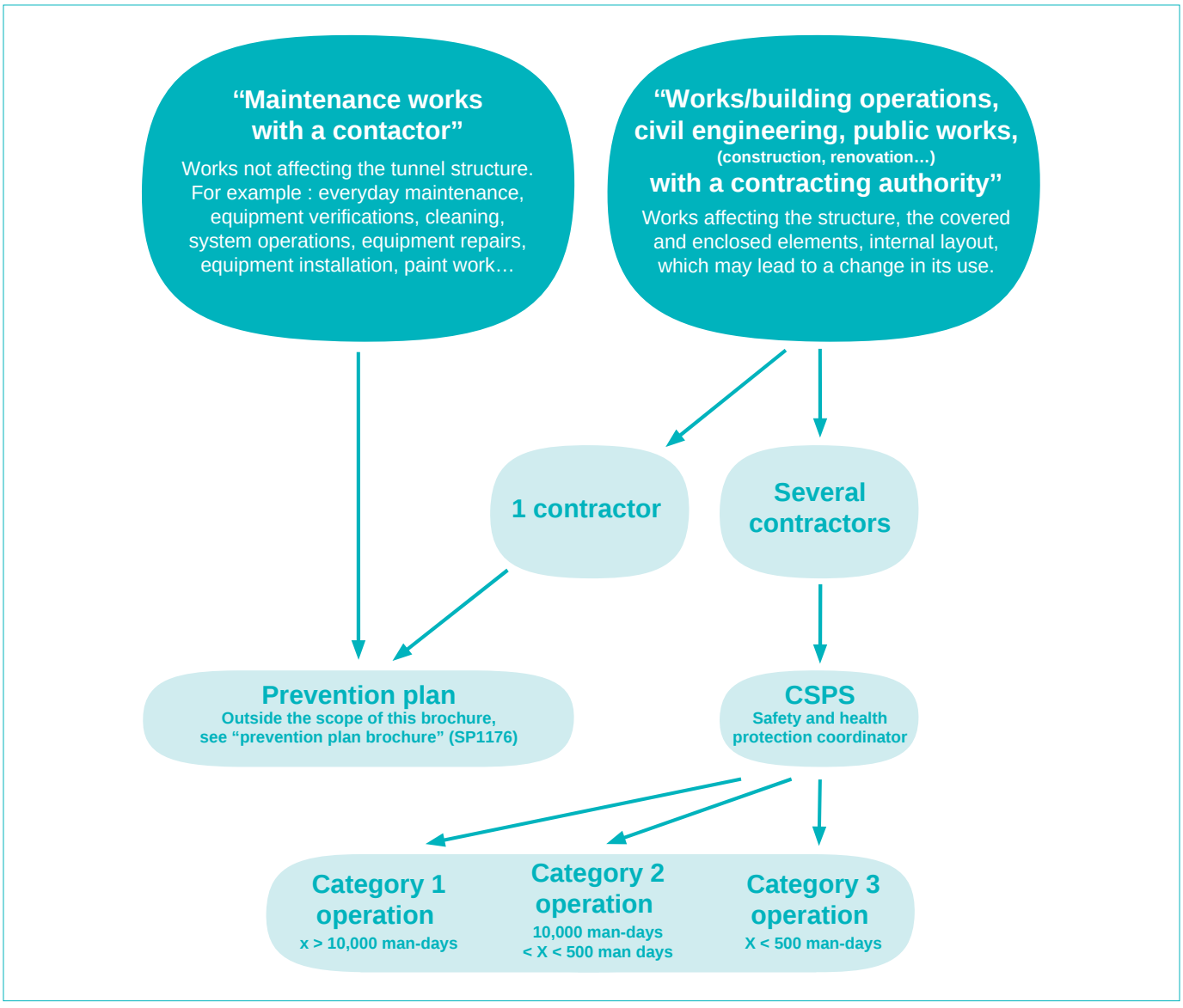
Through technical requirements such as those relating to the continuity of radio communications, fire protection of structures, the implementation of smoke extraction equipment, etc., this Technical Directive presents the issues that must be addressed in coordination with the third parties concerned.

It is also used as a technical reference for tunnels to which it does not strictly apply from a regulatory point of view.

Regulations relating to the prevention of risks to the health and safety of workers (Labour Code)

The involvement of third parties in the tunnel for maintenance, servicing or repair work is subject to the rules of the Labour Code for the prevention of health and safety risks at work. These rules differ depending on the type of work and the risks associated with the simultaneous activities of the parties involved. They do not require any specific comments and are summarised below :

- routine **interventions** carried out by a contractor: Articles R. 4511-1 to R. 4515-11;
- building or civil engineering **sites** where several companies are involved, subject to health and safety coordination: Articles L. 4531-1 to L. 4535-1 of the Labour Code and circular DRT No. 96-5 of 10th April 1996.



Reminder of the regulatory framework for the safety and health protection coordination mission (diagram taken from the document "The safety and health protection coordination mission and the role of the tunnel owner in building and civil engineering operations [10]" published by CARSAT Rhône-Alpes in 2020) (H.J = man-days)

Routine interventions carried out by a contractor– non-structural work related to tunnel operation:

Article R. 4511-1 – "*The provisions of this title apply to the head of the user company and the head of the contractor when a contractor sends workers to carry out or participate in the execution of an operation, regardless of its nature, in a user company's establishment, including its outbuildings or construction sites."*

Article R. 4511-5 [Coordination of prevention] – *"The head of the user company shall ensure the overall coordination of the preventive measures taken by him/her and those taken by all the heads of external companies working in his/her establishment.*"

Article R. 4511-7 – "*The overall coordination of preventive measures is intended to prevent risks associated with interference between the activities, facilities and equipment of different companies operating in the same workplace.*"

Article R. 4512-6 – "*In light of the information and evidence gathered during the joint preliminary inspection, the managers of the user company and external companies shall jointly analyse the risks that may result from interference between activities, facilities and equipment.*

Where such risks exist, the employers shall, by mutual agreement, draw up a prevention plan before the start of the work, setting out the measures to be taken by each company to prevent these risks."

Building or civil engineering sites where several companies are involved, subject to health and safety coordination:

Article L. 4532-2 – "*Coordination in the area of worker health and safety shall be organised for all building or civil engineering sites where several self-employed workers or companies, including subcontractors, are called upon to work, in order to prevent risks resulting from their simultaneous or successive interventions and to provide, where necessary, for the use of common resources such as infrastructure, logistical resources and collective protective equipment.*"

Article L. 4532-3 – " *Coordination in matters of health and safety shall be organised both during the design, study and development of the project and during the construction of the structure.*"

Article L. 4532-4 [CSPS] – "*The project owner shall appoint a health and safety coordinator for each of the two phases of design and construction or for both phases.*"

Article L. 4532-8 [PGCSPS] – "*Where several companies are called upon to work on a site which is either subject to the prior declaration provided for in Article L. 4532-1 or requires the performance of one or more of the works included in a list of works involving particular risks determined by order of the ministers responsible for labour and agriculture, the project owner shall have the coordinator draw up a general coordination plan for health and safety.*

This plan shall be drawn up during the design, study and development phase of the project and kept up to date throughout the duration of the works."

4.4.2 Main expected benefits of the SMS

Good coordination with each of the third parties identified for the project is essential to ensure its safe operation.

Certain interactions, particularly with administrative authorities and emergency services, are already regulated, whether it be the application for the issue or renewal of the commissioning authorisation or coordination with emergency and rescue services through the implementation of the Emergency Response Plan, the feedback mechanism or the carrying out of safety exercises.

Within the framework of the SMS, the aim is to accurately identify, within the six categories of third parties listed above, each external entity involved with the tunnel operator in the context of its various missions.

The expected outcomes of the SMS are as follows:

- all third parties are identified, and their tasks and interfaces are known;
- the methods of interaction and exchange are known and documented in order to ensure the best possible safety on a daily basis and in the event of an incident;
- the safety procedures for external parties intervening in tunnels are documented, disseminated, known and implemented; the procedures for reviewing them are defined.

The accountable manager is familiar with these third parties and their importance, and the staff involved in activities involving third parties are familiar with them. The personnel responsible for relations with third parties are identified, their missions documented and operationally defined. Regulations relating to co-activity must be complied with.

FURTHER INFORMATION

The tunnel operator informs third parties of the SMS, in particular those parties involved in safety such as the prefect and emergency services. Going beyond the links between the SMS manual and the safety documentation, which are explained in section 5.2.3 of the present document, this safety approach implemented by the operator should be promoted. The tunnel operator can thus explain the reasons that led it to implement a Tunnel SMS within its organisation, and the benefits for the operator, other stakeholders and users.

A SPECIFIC THIRD PARTY: THE TUNNEL SAFETY OFFICER

For tunnels located on the TEN (Trans-European Network) that are longer than 500 m, the operator must appoint a safety officer, who provides an external view on safety throughout the tunnel's lifetime. Although this regulatory provision does not apply to other tunnels, it may be implemented by the tunnel operator by appointing a person to act as safety officer.

Within the framework of the SMS, it is useful to communicate internally about the role of the tunnel safety officer, so that all staff know that there is a safety officer, who they are and what their role is.

The tunnel safety officer's duties, as defined by regulations, partly overlap with elements of the SMS: planning, training, exercises, feedback, etc. In fact, the SMS coordinator and the safety officer are required to work closely together in carrying out their respective duties. However, the tunnel safety officer is indeed a third party, as it is necessary for the SMS coordinator and the safety officer to be two separate individuals: the SMS coordinator is involved in the implementation of the SMS, while the tunnel safety officer gives an external opinion on safety matters.

In France, the tunnel safety officer is either a member of the operator's staff, generally attached to the management and detached from operational tasks, or an external service provider commissioned and contractually bound to the operator by a contract. In all cases, the tunnel operator may usefully seek the tunnel safety officer's opinion on the SMS manual, for the regulatory parts that concern it, and provide in its SMS manual for the safety officer to be consulted at the various stages of the construction and life of its SMS (see paragraph 5.1).

4.4.3 Methodological elements

In order to ensure that no third party is overlooked, the operator may work on the basis of the following four activities:

- administrative monitoring;
- day-to-day operations;
- operation in degraded mode;
- upkeep, maintenance and works.

Within the framework of the SMS, external partners who are regularly called upon to work in tunnels must undergo at least an awareness-raising session, or even training, for working in tunnels, in accordance with the specific health and safety plan and the prevention plan (see paragraph 4.2.3).

There are often numerous interactions between the tunnel operator and the various third parties, which can be summarised as in the example provided in Appendix D.3.2.

Administrative monitoring

Administrative monitoring refers to regulatory obligations relating to the preliminary safety documentation or subsequent safety documentation (preparation, review and monitoring, annual update) and the commissioning authorisation (application and renewal at least every six years on the basis of updated safety documentation). For the tunnels concerned, administrative monitoring also covers the appointment of the safety officer. The third parties involved are the administrative authorities, experts and approved qualified bodies and, where applicable, the safety officer.

At a minimum, the person responsible for administrative monitoring must be designated, and a system for monitoring regulatory obligations, observations and their deadlines must be put in place. In practice, the operator has a monitoring tool and prepares meeting reports.

FURTHER INFORMATION

The establishment of a local tunnel monitoring committee allows administrative monitoring and the monitoring of the implementation of reservations and recommendations with associated deadlines to be shared with all the bodies concerned (prefecture, local government offices, municipal authorities, emergency services).

Day-to-day operation

In day-to-day operation, the third parties concerned are mainly users, as well as third parties involved in operational preparation.

Users

Users are third parties who are constantly involved as long as the tunnel is in operation.

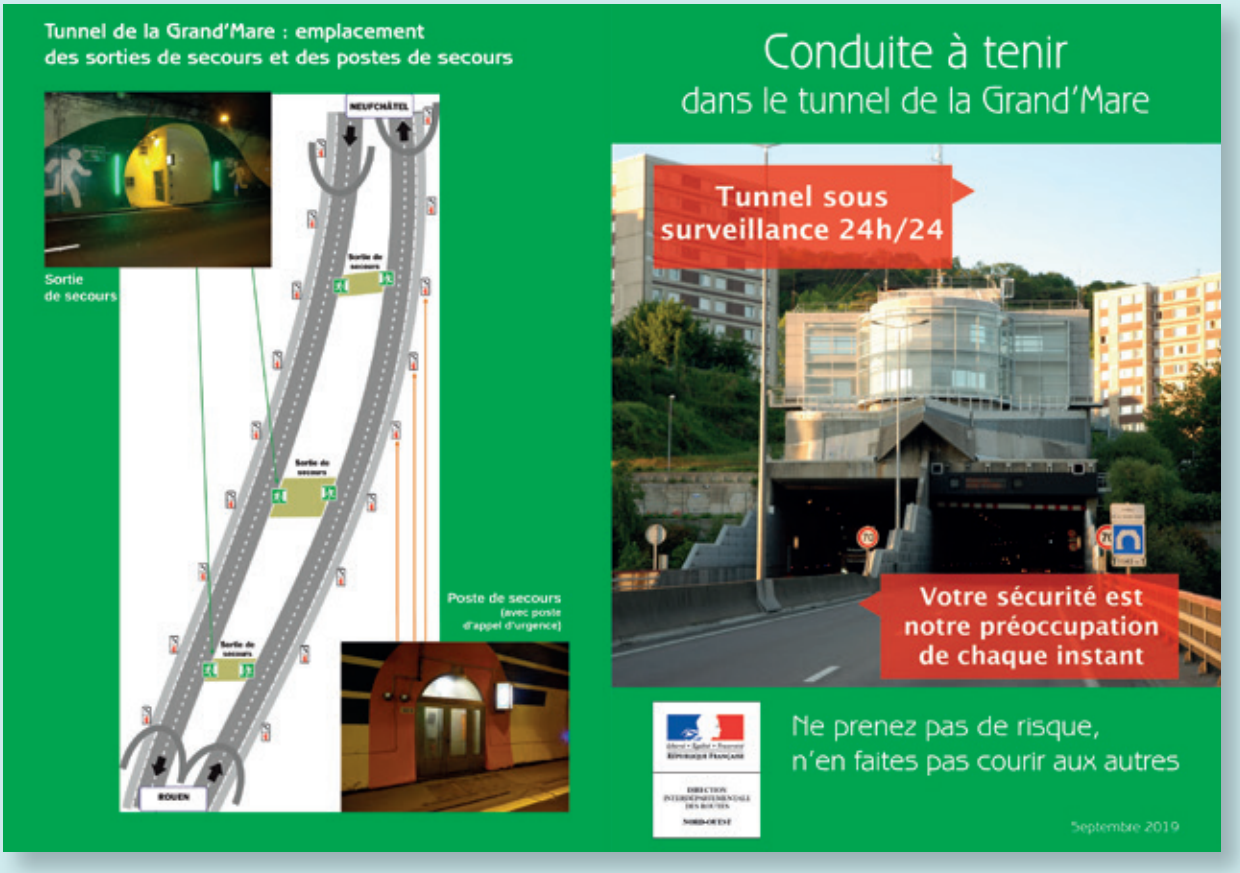
At a minimum, the operator shall notify users of scheduled closures, with the implementation of diversions and any traffic restrictions.

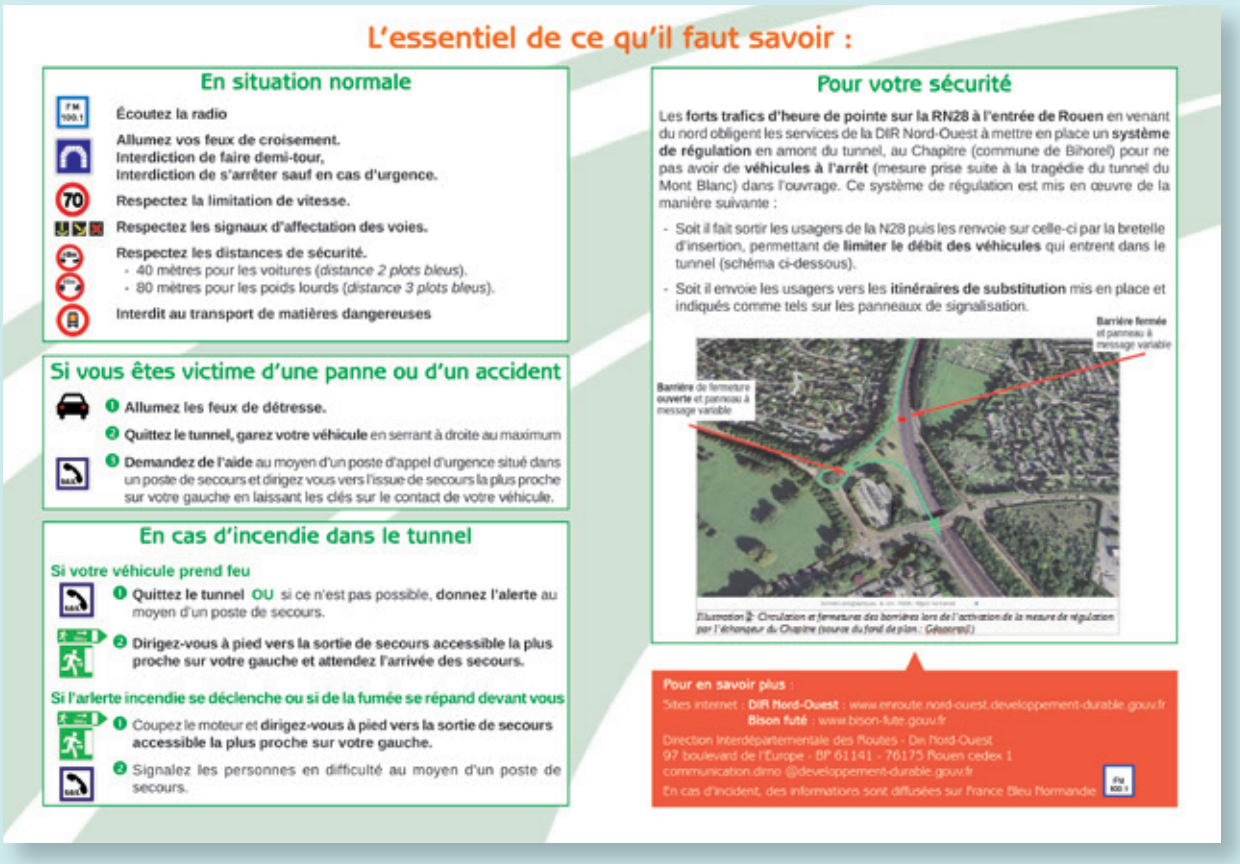
In practice, depending on the duration and frequency of closures, information may be disseminated in paper or electronic form, via a website, local authorities (e.g. by municipalities adjacent to the tunnel) or local media, with the support of the communications department.

FURTHER INFORMATION

The tunnel operator informs users about tunnel operations in normal circumstances and reminds them of the correct behaviour to be adopted in normal driving situations as well as in the event of a breakdown, accident or fire. The aim is to ensure that users are familiar with the main safety principles and the equipment that directly concerns them in the event of an incident: variable message signs, emergency messages broadcast on FM radio, flashing lights and closure barriers, emergency stations, fire extinguishers, emergency exits and assembly points.

Example of a leaflet produced by DIR Nord-Ouest (North West regional roads directorate) concerning the Grand'Mare tunnel:





Brochure on what to do in the Grand'Mare tunnel *(© DIR Nord-Ouest)*

The operator may rely on national information campaigns or carry out a local campaign tailored to a specific tunnel.

Training courses or one-off initiatives may also be provided by the tunnel operator for specific target groups, such as heavy goods vehicle drivers and young people, in order to raise awareness of the risks associated with driving in tunnels, road safety and the risks faced by operating staff when working on the road. Patrol officers may participate in these initiatives to talk about their daily work and the risks and incidents they encounter.

Operational preparation

The third parties concerned are:

- administrative authorities and, where applicable, tunnel safety officers;
- emergency and rescue services;
- other operators;
- network providers: electricity supply, water supply (public or private provider), internet and telecommunications network operators, radio transmission network operators, other networks.

At a minimum, the person in charge of operational preparation is designated. A safety exercise is carried out annually[10] in conjunction with the emergency services; feedback is shared with all relevant third parties. The emergency response plan is kept up to date and distributed to the relevant parties. The terms and conditions for exchanges with third parties are defined and known. Diversion routes are studied in advance of closures, whether scheduled or unscheduled.

Subscriptions, contracts or agreements with network providers exist and include clauses for service continuity, priority and reliability. These documents define the terms and conditions for day-to-day communication and mutual alerting in the event of service degradation or interruption. Tests and checks prove the effectiveness of the service.

For the tunnels concerned, the safety officer has numerous duties relating to operational preparedness and third parties. They are involved in organising emergency responses and coordinating with emergency services, particularly when developing operational plans for these services. They verify that training programmes are established and implemented for emergency services and participate in the organisation and evaluation of safety exercises.

FURTHER INFORMATION

Where a local monitoring committee exists, discussions may take place outside of annual meetings, if necessary.

Visits to the tunnel and the control centre are organised by the operator to consolidate third parties' knowledge of the tunnel, for example during safety exercises and scheduled closures.

Interface operators are operators of structures or networks whose activities are adjacent to the tunnel or for which there is shared use. An exhaustive inventory is carried out and the sharing of day-to-day responsibilities is the subject of public domain occupancy agreements. Interaction procedures are documented in the various operating situations.

A traffic management plan (TMP) is drawn up in coordination with the road managers concerned by the diversion route during tunnel closures. Consultation also takes place with the managers who have defined a diversion route on which the tunnel is located, in the event of closure of their network.

In the absence of a diversion route for all or part of the different types of vehicles authorised in the tunnel, consultation may take place with the administrative authorities and emergency services to define in advance the exceptional measures that may be applied in the event of closure due to below-minimum operating conditions (human, material, organisational) in order to be able to reopen the tunnel, on the decision of the prefect, in degraded mode for a maximum permissible period.

All these procedures are specified in documents referred to in the SMS manual. These documents are drawn up in collaboration with and shared with all relevant third parties.

Finally, contracts with network providers are monitored and the persons to be reached in the event of a problem are known. There is a document indicating the frequency of tests and checks, and how they are monitored.

10. With the tolerance provided for in Article R. 118-3-8 of the Road Infrastructure Code in the case of infrastructures with the same manager, falling under the same intervention services and located in close proximity to each other.

Operation in the event of an incident

The third parties concerned are:

- users;
- companies (breakdown services, maintenance, etc.);
- network providers, which may have networks passing through the tunnel;
- other operators (road networks, public buildings, high-rise buildings, etc.);
- emergency services;
- administrative authorities and, where applicable, the tunnel safety officer.

At a minimum, the Emergency Response Plan is implemented (alert procedures, emergency closure instructions, communication to users, conditions and procedures for reopening). Incidents are subject to feedback shared with all third parties concerned, including the tunnel safety officer where applicable.

The Emergency Response Plan is the central document that governs relations with third parties in degraded operating mode. The logbook, whether computerised or not, enables actions to be traced.

Maintenance, servicing and works

The third parties concerned are companies and network providers.

Users are also affected if maintenance or repair work is carried out while traffic is maintained with traffic restrictions (lane closures, reduced lane width, reduced speed limits, heavy goods vehicles prohibited, etc.). In this case, they are informed of the modified traffic rules.

Contract management

At a minimum, the person responsible for each contract or agreement is identified. There are clauses on service continuity in the agreements (particularly in the case of priority customers).

The list of service providers is known, agreements are signed and clauses on the terms and conditions of intervention are included in the contracts.

FURTHER INFORMATION

Clauses in contracts stipulate the specifics of interventions and evacuation instructions in tunnels.

FURTHER INFORMATION

A document summarising the information to be communicated to third parties in the event of an incident may be useful. The communications unit is involved in press releases to the media.

Entrance to the Montjézieu tunnel (© DIRMC)

Interventions

There are numerous interventions in tunnels, which pose major safety challenges due to the risks associated with simultaneous activities and road traffic, even if the interventions themselves are carried out when traffic is not flowing (risks may persist during closure and reopening operations).

The control centre maintains a role in safety even when the tunnel is closed to traffic and as soon as workers enter the tunnel to carry out work. The tunnel operator records the instructions given to external companies working in the tunnel. This is a matter of both safety and legal protection.

At a minimum, the staff concerned identify and are familiar with the contractors and suppliers authorised to access the tunnel. The staff concerned know the start and end times of the presence in the tunnel of each person from each contractor or supplier. Workplace safety regulations are complied with.

Procedures exist for on-site intervention by companies: a prevention plan signed by the companies or a General Coordination Plan for Health and Safety and a Specific Health and Safety Plan for each of them. These documents contain the necessary provisions for safe intervention in tunnels, particularly with regard to evacuation. There is a health and safety coordinator for works sites with concurrent activities. Operating staff whose activities are related to contractor operations in tunnels must be familiar with the missions of the health and safety coordinator and with safety coordination documents. A schedule of planned closures is drawn up in advance.

Monitoring of interventions

At a minimum, procedures detail the technical scope of the intervention (preparation). The procedures for reporting results are described. Interventions are traceable.

There are procedures for preparing and monitoring interventions, and examples of how information relating to the intervention is transmitted.

FURTHER INFORMATION

There are tools shared between operating staff and companies (e.g. computerised maintenance management system). After their interventions, companies report back to the operator by means of a brief report that informs maintenance technicians of any problems encountered.

4.4.4 Documenting third parties in the SMS manual

There is a chapter in the SMS manual on coordination with third parties, and a "*Who does what?*" section that specifies the roles and responsibilities of each party. Letters, emails and meeting minutes record decisions and actions. The SMS manual refers to documented, implemented and operational procedures and how they are updated.

FURTHER INFORMATION

The health and safety unit is involved.

An annual schedule of planned tunnel closures is drawn up, checking that the planned closures are compatible with the operating procedures of adjacent networks. The schedule is distributed to all parties concerned. The operator checks in advance that the work planned by different contractors for the same period in the same tunnel is compatible.

In order to ensure the safety of operations, each external contractor is informed of the instructions to be followed and undertakes to comply with them when signing the request for intervention. A general intervention framework specifies the main risks in tunnels, intervention instructions (personal protective equipment, signage on vehicles and machinery, works area, speed limits, etc.), procedures for entering/exiting the tunnel, and instructions to follow in the event of an accident (in particular evacuation procedures in the event of a fire).

Contractors fill in intervention forms specifying their intervention request, the impact on safety and the procedures for reopening the tunnel. Intervention requests are coordinated in advance between the operator, the health and safety coordinator, the contractor and, where applicable, the works manager. In the case of major works involving night-time closures, coordination with contractors makes it possible to anticipate any difficulties that may arise when reopening the tunnel in the morning.

Control room operators are informed of any third-party interventions in progress in the tunnel, as they may need to remotely activate equipment that could put them at risk (e.g. fans). The level of information provided to the control room (people present, nature of the intervention, location, etc.) and the procedures for disseminating this information must be defined.

All of these procedures and associated methods (what, who, when, how) are stipulated in documents referred to in the SMS manual.

4.5 SAFETY CULTURE

According to the ICSI[11], "***safety culture is a set of practices and ways of thinking widely shared by the members of an organisation with regard to the control of the most significant risks associated with its activities.***"

Of the four types of safety culture (see box on the following page), **integrated safety culture** is the most relevant to road tunnel operation, as it consists of a combination of:

- compliance with the rules laid down by the organisation, covering most situations that are likely to arise;
- proactive behaviour on the part of staff, enabling them to deal with unforeseen situations.

It stems from the shared belief that no single person within the organisation possesses all the knowledge necessary to ensure good safety performance.

4.5.1 Main expected benefits of the SMS

The objective of the SMS is to lead the organisation towards an integrated safety culture, also known as a positive safety culture, which requires the mobilisation of all stakeholders (internal and external).

Safety culture is built over time, through procedures and operating methods (ways of doing things), but also through beliefs and habits (ways of thinking).

To achieve this, the SMS will primarily draw on existing, and often numerous, safety practices that contribute to the safety culture without staff being truly aware of them.

To carry out its self-assessment, the tunnel operator reviews all internal and external communication activities: meetings, memos, newsletters, brochures and leaflets, online information, etc. The subject of the communication may relate to safety in general or to a specific topic (feedback, regulations, procedures, etc.).

The tunnel operator's safety culture must enable an understanding of how the operator manages safety, based on three pillars: technical reliability, rules and procedures, and human and organisational factors.

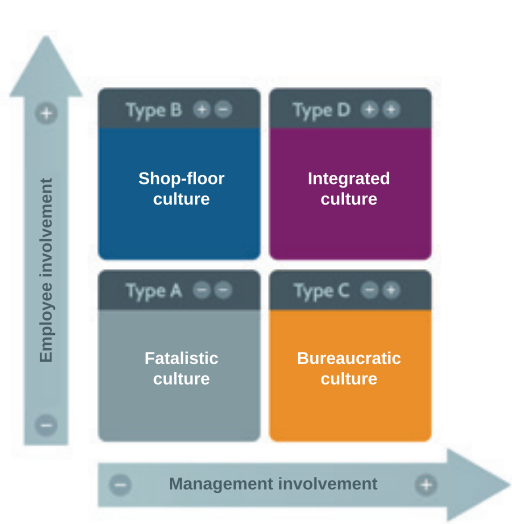
In practice, the SMS aims to understand how organisational culture positively or negatively influences the decisions of all stakeholders in terms of safety and to implement the elements necessary to achieve an integrated safety culture.

Grand'Mare Tunnel – Explanatory emergency exit (© CETU)

11. The Institute for an Industrial Safety Culture (ICSI) is a non-profit organisation created in 2003, born out of a joint initiative by industrialists, academics, researchers and local authorities.

According to Marcel Simard, sociologist and former professor at the University of Montreal, there are four main types of safety culture based on the involvement of employees and management:

- ***fatalistic safety culture***, **which reflects a safety culture in which staff believe that they cannot influence events in any way: "it happened, there's nothing we can do about it";**
- ***managerial safety culture***, **which is a culture in which compliance with the rules prescribed by the organisation takes precedence over everything else. This results in the hierarchical chain taking ownership of the safety level and in exclusively top-down prescriptions, which may be ill-suited to the field and cause difficulties for front-line staff;**
- ***occupational safety culture***, **which is found in an organisation where management attaches little importance to safety and field workers have developed their own rules to protect themselves from accidents and informal rules are passed on through apprenticeship;**
- **integrated safety culture, which consists of a combination of compliance with the rules laid down by the organisation, covering most situations that are likely to occur (regulated safety) and proactive behaviour by staff enabling them to deal with unforeseen situations (managed safety).**



The different types of safety culture according to Marcel Simard (© BP graphisme - ICSI)

In most cases, several types of culture can be found within the same organisation, depending on the departments and topics involved. However, the organisation must generally strive towards an integrated safety culture based on the mobilisation of the entire hierarchical chain on safety issues so that all ways of implementing and thinking about risk control are as widely shared as possible by the staff involved in tunnel safety.

Lilas cover – Emergency exit (© City of Paris)

4.5.2 Methodological elements

An integrated safety culture requires:

- **a commitment from management** that is visible through speeches, decisions, management style and presence in the field;
- **mobilisation on safety issues throughout the entire hierarchical chain:** each manager emphasises the importance of the safety policy to their team and reports any difficulties and suggestions for improvement;
- **the involvement of all staff in their day-to-day tasks:** compliance with procedures, reporting difficulties, asking questions, being proactive, etc.

The integrated safety culture is based in particular on:

- considering safety before making decisions or taking action;
- consistency between words and actions;
- information flow between different levels of the hierarchy;
- a fair culture (see opposite page): it distinguishes between errors (unintentional) and misconduct (intentional) based on a set of standards, shared by employees and management, of what is acceptable and what is not. Management's response to a report must be consistent and coherent;
- transparency with third parties.

Promoting safety within the organisation is an effective way to encourage the development of a positive safety culture. It is important that all stakeholders are aware of their role in safety, regardless of their position in the hierarchy.

Building a shared vision of safety requires a number of promotional tools, such as:

- professional meetings, forums, safety briefings or tips;
- a "just culture", also known as an "error culture" (see opposite);
- encouraging suggestions for improvements related to operations, procedures, etc.;
- providing feedback to the employee who made the suggestion in order to keep the process operational;
- information and awareness-raising on a specific topic;
- wider sharing of feedback on events;
- the display of feedback through specific communication campaigns;
- the intranet, for example by making SMS documentation available to all employees within the organisation;
- an SMS newsletter published regularly for staff and partners;
- dynamic signage (e.g. safety messages on variable message signs);
- awareness-raising and e-learning training (short sessions, lasting around an hour, but on a regular basis);
- co-construction practices that enable the mobilisation of different professions (cross-functional and support functions);
- the presence of "safety" managers in departments other than those specifically dedicated to the topic;
- informal discussions during meals or coffee breaks.

These are broad examples; the format and any materials used must be adapted to the subject and the target audience.

Staff meetings on safety can take place at an interdepartmental or local level. Open to all levels of the hierarchy, it is important to ensure that everyone is aware of them and to enable as many people as possible to participate. They provide an opportunity to disseminate practical information on safety, but should also allow plenty of time for free discussion and the sharing of experiences among participants.

Opportunities that contribute to a better mutual understanding between staff and a better understanding of each other's work enable better collaboration, for example during role-playing exercises between control room operators and other tunnel operator staff, either in the control room or during field visits or visits to the command centre.

A "just culture"[12] is "*a culture in which staff* [...] *are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but in which gross negligence, wilful violations and destructive acts are not tolerated*". This just culture requires that reporting errors be valued: reporting should no longer be seen as whistleblowing when the error is made by a colleague, or result in punishment when it is the employee in question who has revealed it. Feedback to employees who have reported an error is essential to prevent them from thinking that their action was pointless, that their correspondent was not interested, etc.

Also known as the "error culture", this is a fundamental part of the safety culture: encouraged by supportive management, employees do not hesitate to report an error to their superior when they make one, in order to discuss it, understand the causes of the error and learn from it collectively so that it does not happen again.

We now talk about a just and equal culture, adding to the previous dimension the equal treatment of employees, regardless of their hierarchical rank.

For example, following the case of an operating staff member who entered a tunnel where there was smoke to assist those present, awareness-raising activities for all staff serve as a reminder not to enter a tunnel where there is a suspected fire.

4.5.3 Documenting safety culture in the SMS manual

It is very difficult to describe or measure a safety culture. In practice, and as indicated above (paragraph 4.5.2), building a common vision of safety requires numerous promotional tools, such as documents, meetings, communication initiatives, etc.

It is therefore these channels, and the means that the organisation will deploy to sustain them, that should be described in the SMS manual.

12. Definition given in European Regulation (EU) No 376/2014 on the reporting, analysis and follow-up of civil aviation incidents.

4.6 ORGANISATION OF FEEDBACK

This section presents the occupational component of the SMS: "Organisation of feedback".

4.6.1 Regulatory provisions

The regulations governing feedback are mainly derived from the French Road Infrastructure Code and the decree of 18th April 2007. They are detailed in CETU's information note no. 21, particularly in its appendix 5 [1].

The regulations cover both feedback relating to events (significant incidents and accidents) and feedback relating to safety exercises.

Significant incidents and accidents

Tunnels in operation longer than 300 m

The safety documentation must contain a document describing the permanent system for recording and analysing significant incidents and accidents, and another document listing those that have occurred in the previous six years, together with their analysis. This document must be updated annually.

The decree of 18th April 2007 establishes the list of incidents and accidents considered significant in terms of safety, and the information that must be included in the report, depending on the type of event, as well as the procedures for transmitting this report and any other reports.

Significant incidents and accidents are accidents involving personal injury and fires occurring inside the tunnel, as well as events that have required unscheduled closure of the tunnel, with the exception of those related to traffic management outside the tunnel.

Tunnels longer than 500 m on the trans-European network (TEN)

The tunnel owner must draw up a report on any significant incident or accident and send it to the prefect, the tunnel safety officer and the emergency services within a maximum of one month. If an analysis report is produced, it must be sent under the same conditions. The safety officer participates in the assessment of any incident or accident.

Tunnels longer than 300 m on the State-managed road network

The French Technical Directive "IT 2000" requires an analysis of significant incidents and accidents in order to assess whether adjustments to existing safety measures or additional measures are necessary. Appendix 1 sets out the procedures for reporting information ("CETU form").

Saint-Béat Tunnel – Fire test (© CETU)

The following incidents must also be reported for tunnels in which the transit of dangerous goods is authorised:

- "*leakage or loss of more than 200 kg of dangerous goods by net mass*[13];
- *more than 250, 000 Francs*[14] *in material losses (including the costs of repairing the tunnel and the environment)*;
- *events requiring significant precautions to be taken by the public authorities, such as evacuations or confinement of the population, temporary closures of transport infrastructure, etc.*".

Reports of significant events must be sent to the prefect and the CETU within one month of the event. The CETU maintains and operates a national database in which operators must record the characteristics of the incident.

Safety exercises

Tunnels in operation longer than 300 m

Article R. 118-3-8. – "*The tunnel owner referred to in Article R. 118-1-1 and the emergency services shall organise joint exercises for tunnel staff and emergency services.*"

The scenarios for the exercises shall be determined on the basis of the risks in relation to the tunnel.

The safety documentation must contain a document listing the safety exercises carried out over the previous five years and the lessons learned from them. This document is updated annually.

Tunnels longer than 500 m on the trans-European network (TEN)

The tunnel safety officer participates in the organisation and evaluation of the safety exercises.

13. Regardless of the quantity lost for class 7 (radioactive materials), any leakage or loss of cargo will be taken into account, regardless of its significance.
14. Approximately €38,100 (in 2000) or €56,000 (in 2024).

4.6.2 Main expected benefits of the SMS

The purpose of feedback is to learn from what has happened in order to better anticipate risks and contribute to collective competence. It feeds into the overall safety approach with a view to continuous improvement in safety, and is the driving force behind the SMS. It is also a valuable resource for training and communication with all safety stakeholders.

Using feedback data, the tunnel operator analyses the circumstances and sequence of events that occurred, as well as the safety exercises that were carried out, in order to assess how the different elements comprising the "tunnel system" responded to and managed the situations. Feedback thus makes it possible to highlight the strengths and weaknesses of the tunnel operation.

In the feedback process, it is essential to highlight the positive points that have been identified and to promote the strengths. Too often, feedback is perceived as a means of detecting errors, sometimes of reprimanding staff, which generally does not allow for an in-depth analysis of the event.

The scope of feedback is defined (tunnels concerned and events subject to feedback). Feedback organisation and content evolves as the SMS matures, taking into account the available resources and context.

Common points between feedback on events and exercises[15]

The operator has a feedback procedure for both events and safety exercises, which defines the different stages of the process (data collection, analysis, dissemination, implementation of improvement actions, follow-up) and its management by a designated person within the organisation.

The feedback process involves all levels of relevant personnel. It is regularly shared internally, and in particular feedback is provided to the staff concerned. It is also regularly discussed with the third parties concerned (emergency and rescue services, law enforcement agencies, prefecture, local government offices and the tunnel safety officer, where applicable), within the framework of the local monitoring committee, if one exists.

The operator has a tool for monitoring regulatory obligations relating to feedback (what, who, how, when), and the follow-up actions and improvements identified during feedback. Periodic monitoring of the progress of these actions is carried out with all safety stakeholders, and a review is presented during safety reviews. The parts of the safety documentation relating to feedback are updated annually. The Emergency Response Plan must be updated as often as necessary to enable the most effective management of an incident. In particular, this includes any changes made following feedback on significant events or safety exercises.

Specific points relating to feedback on events

The person responsible for feedback takes into account the observations of all those involved in managing the event, for example through interviews, and organises meetings with internal and external stakeholders (emergency and rescue services, law enforcement agencies) for the most serious events.

A report, followed by a final report including improvement actions based on lessons learned from the event analysis, is drafted and distributed to all stakeholders and interested parties.

FURTHER INFORMATION

As part of the continuous improvement process, the scope of feedback can be enlarged and include collection and analysis of data concerning events beyond those strictly required by regulations: weak signals and "non-events", as defined by regulations, can therefore also be reported and analysed.

Example: equipment failures discovered by chance during an event or exercise are subjected to a detailed analysis of their causes and consequences on the system. But it is just as important to question why the malfunction alarm did not go off.

For tunnels on the State-managed road network, reports on significant events are sent to the prefect and the CETU within a maximum of one month after the event and recorded by the operator in the CETU's national database.

For tunnels longer than 500 m located on the TEN, the tunnel safety officer participates in the organisation and assessment of emergency responses, as well as in the assessment of any significant incident or accident. The tunnel owner is required to draw up a report on any significant incident or accident relating to safety and to send it to the prefect, the safety officer and the emergency services within a maximum of one month. Any analysis reports shall be sent under the same conditions within one month of their completion.

15. Safety exercises are not, as such, a component of the SMS; however, they are a regulatory requirement that affects several components: feedback, coordination with third parties, safety culture, skills management, not to mention general organisation, since those responsible for organising them must be identified within the organisation.

Specific factors regarding feedback on safety exercises

Please refer to the CETU Methodological Guide on road tunnel safety exercises [6].

Safety exercises are organised jointly by and for tunnel staff and emergency services personnel. They are subject to a joint assessment. The terms of this assessment are defined in line with the procedures laid down for coordination with third parties.

The scenario for safety exercises is chosen based on feedback from events that have occurred in the tunnel, the main risks involved and the needs of the various services.

Following the exercise, an immediate debriefing, then a later further debriefing, are organised with the participants. A final report, including improvement actions based on the lessons learned from the exercise, is drafted and distributed to all internal and external parties.

For tunnels longer than 500 m located on the TEN, the tunnel safety officer participates in the organisation and evaluation of the exercises.

4.6.3 Methodological elements

Organisation of feedback

The organisation of lessons learned includes the implementation of:

- monitoring of regulatory obligations relating to feedback;
- monitoring the lessons learned from significant events and safety exercises, in addition to the follow-up actions to be taken (what, who, how, when). When corrective actions are decided upon, this allows the operator to justify taking feedback into account but also to cover its legal liability in this area;
- multi-annual planning of safety exercises taking into account feedback, regardless of whether or not each of the operator's tunnels is subject to an annual exercise[16].

Specific feedback training for all relevant personnel enables:

- a reminder to staff of regulatory obligations and internal procedures;
- the usefulness of feedback to be promoted, by using real events and exercise scenarios as practical cases, for the purpose of maintaining skills through traditional training, simulator sessions if available, or educational exercises, such as management exercises;
- exchanges between different hierarchical levels and between different internal departments to be facilitated.

Tende Tunnel – Safety exercise 2025 (© CETU)

It is essential that lessons learned are shared with all stakeholders involved in safety, including external partners.

Internally, it involves all relevant personnel, regardless of their hierarchical level: accountable manager, SMS coordinator, supervisors, local SMS contacts, feedback manager(s), control room operators and manager, field and maintenance staff, etc. Internal debriefings with staff on duty at the time of the event or exercise (operators, response agents, maintenance department) are carried out with a view to collective progress. Individuals receive news on the follow-up given to their contribution to the feedback process. In addition to the fact that this closure keeps teams vigilant and proactive about the feedback process, they may be involved in or even responsible for an area for improvement. This feedback contributes to the safety culture within the organisation.

The local monitoring committee, where one exists, reviews the feedback elements at least once a year. The feedback data can also feed into more informal exchanges and be used for training purposes with operational staff in external services, based on the data it contains and, where applicable, CCTV footage and AID footage (in accordance with legal rules of use). These opportunities for discussion and sharing between different departments of lessons learned from respective feedback help to mobilise the stakeholders concerned and contribute to the development of a common safety culture.

Feedback content

The feedback loop

Taking into account the lessons learned from feedback is the basis of the continuous safety improvement process.

Analysing an event or exercise allows lessons to be learned, such as areas for improvement for the organisation of a future exercise or the improvement of procedures and instructions, etc., to be established after discussions between the stakeholders concerned.

16. Article R. 118-3-8 of the French Road Infrastructure Code: when several tunnels have the same manager, call upon the same emergency services and are located in close proximity to one another, the exercise may be carried out in only one of them.

The follow-up to the analysis of an event or exercise is:

- a list of decisions on the actions to be implemented:
  - what: list of possible improvements to organisation and procedures, training and information,
  - who: resources allocated,
  - how: methods to be followed and technical and human resources allocated,
  - when: timelines and deadlines (which are part of the 6-year periodic safety review cycle);
- an action plan monitoring table, to be completed at a later date;
- updates to safety documentation.

Data collection and analysis

The conditions for creating a feedback file must be defined in line with the scope of feedback as described in the SMS.

The collection of feedback data must be integrated into the continuous improvement process. This involves, for example, diversifying sources, verifying their reliability and improving their accuracy (topographical and chronological).

Sources may be documented (control room and maintenance logbooks) and computerised or not. Where applicable, this may involve recording emergency call conversations, video footage, AID footage, etc. or less formal conversations (information exchanged between operators via the logbook, etc.).

Quantitative analysis of feedback data (detection time, closure time, etc.) allows for comparison with expected data for this type of infrastructure (specific hazard investigations, comparative risk analysis, report on breakdowns, accidents and fires [11]).

Qualitative analysis of events aims to establish how the "tunnel system" responded. Where possible, and depending on the nature of the event, a comparison can be made with a specific hazard scenario to examine whether the event unfolded as expected and to explore any discrepancies.

Where appropriate, these analyses lead to an update of risk identification and the resulting procedures.

FURTHER INFORMATION

TAKING "WEAK SIGNALS" INTO ACCOUNT

In order to enrich the data collected for risk identification, the tunnel operator may usefully extend the feedback process to include non-significant events that are of particular interest or have educational value: "*Events that could potentially trigger feedback are defined as more common, less visible events and incidents that constitute weak signals, indicators of potential deviations or precursors to more significant events.*" [12]

Unlike significant events, for which processing is required by regulations, the tunnel operator itself defines the criteria for identifying incidents that are subject to similar processing as significant incidents.

Here are some examples of criticality factors that may justify triggering feedback for an event:

- if the event is evolving or has changed;
- if there have been complications in managing events, related to user behaviour, the consequences of the event, or interactions with partners;
- if the context or intervention situation was dangerous;
- if the event is related to the monitoring of external contractors.

These may include certain material damage accidents, certain traffic management measures, degraded operation of non-compensable equipment, cases of minimum operating conditions violations or near violations, etc. The operator may also pay attention to situations that did not cause any incidents, but in which staff encountered difficulties or expressed discomfort in carrying out their duties.

The operator also chooses the level of detail of the data collected, depending on how it will be analysed. Initially, data collection may be identical to that for significant events, if the operator wishes to use the existing data collection system.

Extending the scope of feedback to include weak signals requires staff buy-in, particularly as it increases the number of events to be analysed. It is desirable to strengthen staff involvement in the selection of events, the definition of criteria, etc., in order to leverage their day-to-day experience in operating and monitoring the tunnel. "*This is also a question of safety culture, which will enhance individuals' ability to develop an attitude of vigilance towards minor incidents and an awareness of their potential value in terms of learning.*" [12]. An example of how insignificant events are taken into account is given in Appendix D.4.2.

This extended scope of the feedback process will work all the better in a "just culture" environment (see paragraph 4.5.2).

4.6.4 Documenting feedback in the SMS manual

A chapter of the SMS manual must be devoted to the feedback system. However, as specified in paragraph 5.2, reference may be made to existing documents elsewhere. For example, reference to individual documents in the safety documentation [4] may be relevant, in particular:

- document 7: description of the feedback system;
- document 8: list and analysis of significant incidents;
- document 9: list and analysis of safety exercises.

When the SMS is backed by a QMS with a process or sub-process relating to feedback, reference is also provided.

4.7 DOCUMENTATION

The SMS documentation includes all documents contributing to the safe management of the tunnel. There are two types of documents:

- specific SMS documentation describing the SMS and how it works;
- thematic documentation related to the various components of the SMS.

4.7.1 Main expected benefits of the SMS

The organisation shall establish documentation relating to the SMS and its operation. The main elements are the SMS manual, the commitment of the accountable manager, the safety policy and the mission statement of the SMS coordinator – and possibly local SMS contacts.

The SMS documentation also includes risk analysis, the QMS review procedure, documents relating to QMS meetings (e.g. minutes of internal working group meetings), audit reports, etc.

Specific SMS documentation should be distinguished from documentation specific to the tunnel and its operation, as the documents concerned may be linked to a component of the SMS.

Within the framework of the SMS, document management:

- ensures that documents are made accessible to those who need them;
- guarantees that the correct version of the document is available;
- ensures the traceability of successive versions and their archiving.

Saint-Cloud Tunnel (© CETU)

4.7.2 Documenting feedback in the SMS manual

Regardless of the solution chosen for document management, details must be provided in the SMS manual on traceability, archiving of previous versions, information security, management of modification rights, etc. It is important to emphasise that all staff may be required to identify any necessary modifications to the documentation. Examples of situations that may lead to document modifications can also be cited, such as changes in equipment, but also a reorganisation of the structure or modernisation of the work. Whatever the changes, the procedure must provide for the identification of a person responsible for the documents and for making the current version available. In this context, the "*Who does what?*" can be an asset.

4.8 MANAGEMENT OF MATERIAL OR ORGANISATIONAL MODIFICATIONS

Siaix Tunnel – Safety exercise 2024 (© DIRCE)

An important component of the SMS is the way in which the organisation identifies potential modifications or changes to the tunnel, analyses their impact, implements appropriate measures to control the risks that may arise, and learns from them.

The main risks associated with modifications to a tunnel are presented in Appendix B.6.

4.8.1 Regulatory provisions

The regulations governing the management of modifications to tunnels are mainly derived from the French Road Infrastructure Code (see CETU information document no. 21 [1]). They provide for specific procedures, particularly in the event of substantial modifications, which require the safety documentation to be reviewed.

Tunnels in operation longer than 300 m

In general, the tunnel owner/manager is responsible for the tunnels under its charge and must ensure that any modifications to the tunnel or interventions affecting the tunnel or its environment do not damage tunnel assets.

In the event of material or organisational modifications, the tunnel owner/manager must consider the nature of the modification to determine whether a regulatory procedure must be initiated.

Two articles of the French Road Infrastructure Code require the tunnel owner to document the procedure by submitting preliminary safety documentation or subsequent safety documentation:

- Article L. 118-1: "*Work* […] *involving* ***substantial modification of a structure*** […] *may not be undertaken until the State has issued an opinion on a preliminary safety report*";
- Article R. 118-3-4: "*In the event of* ***a significant change in operating conditions, a significant change in risks, or following a serious incident or accident****, the tunnel owner is required to submit an application for renewal of the commissioning authorisation.*"

Circular 2006-20 provides **guidance on assessing whether or not the work is substantial**: "*The concept of works involving a 'substantial modification' of the tunnel requires an assessment of the situation and operating conditions of each tunnel by the tunnel owner and approved experts. This assessment must be carried out with regard to the impact of the works on the infrastructure itself and its operation, as well as best practice. For example, modifications to emergency exits, changes to ventilation systems or the extension of the cover of a cut-and-cover tunnel are presumed to constitute 'substantial modification'.*"

Finally, the Emergency Response Plan must be updated as often as necessary to enable the most effective management of an incident. This includes modifications made following feedback on significant events or safety exercises.

Rond-Point Tunnel – Intertube drilling work (© CETU)

Tunnels longer than 500 m on the Trans-European Network (TEN)

For tunnels longer than 500 m on the TEN, **the tunnel safety officer** shall:

- in the event of a substantial modification: "*issue an opinion on the preventive measures and safeguards envisaged in the preliminary safety documentation provided for in Article R. 118-3-1; issue an opinion on the safety documentation provided for in Articles R. 118-3-2 and R. 118-3-3. His/her opinion shall be attached to this documentation when it is sent to the prefect*";
- in the event of a non-substantial modification: "*issue an opinion, which the tunnel owner forwards to the prefect and the emergency services, on any modification to the structure that is not substantial in nature and on any modification to the operating conditions that does not significantly affect them*".

It should be noted that, for tunnels longer than 500 m located on the TEN, the tunnel safety officer's opinion is the only formal opinion required by the regulations on a non-substantial modification. For other tunnels, no external opinion is required in this case. However, it should be noted that when updated for the periodic safety review, the safety documentation reports on changes affecting safety over the past six years and those planned for the next six years, where these have already been scheduled.

4.8.2 Main expected benefits of the SMS

As soon as a modification is planned, it is necessary to consider its impact on safety, applicable regulations, procedures, etc. The concept of modification should be taken in the broadest sense: it may involve material or organisational changes (including to the SMS itself).

Here are a few examples: change of subcontractor, modification of traffic regulations, modification of minimum operating conditions or instructions, use of a new type of equipment, change of control centre, monitoring of a new tunnel by the control centre, etc.

Within the framework of the SMS, it is essential to specify which members of staff are responsible for or involved in the various stages of the modification. The procedures for monitoring and tracking modifications and the resulting actions (who, what, how, when) must also be clearly defined, as well as those relating to the distribution of related documents.

The implementation of modifications and related actions must be subject to feedback. For significant modifications[17], this may be the subject of a safety review or a specific communication action.

The modification management process itself must be reviewed periodically.

17. Without regulatory connotation, this term refers to any modification that the operator deems necessary to share and communicate.

WORKS

Tunnel works require special attention within the SMS, particularly with regard to the management of modifications. The work to be carried out must be fully integrated into the SMS. All tunnel operations staff involved in the works are identified and their roles are defined for each stage of the works in the Who does what? document. Thus, the components of the SMS, namely internal coordination (in terms of defining roles and responsibilities), coordination with third parties (particularly communication), skills management and training, and safety culture, must be taken into account in the works carried out.

In the case of large-scale works, a governance structure can be usefully put in place to ensure coordination between all parties involved in the works and to monitor decision-making at the level of the various steering and project committees.

The tunnel operator, as the main "user" of the tunnel, must be involved in the design phase to define the project specifications, so that the modified tunnel meets functional requirements and is compatible with operational constraints. The operator contributes to preparing the conditions for carrying out the works during operation, for example by providing an opinion on the works safety plan.

Specific training initiatives are implemented alongside the works in order to adapt tunnel operations to the modifications made to the tunnel. Companies installing new equipment may provide training to future users and maintenance personnel, if stipulated in the contract.

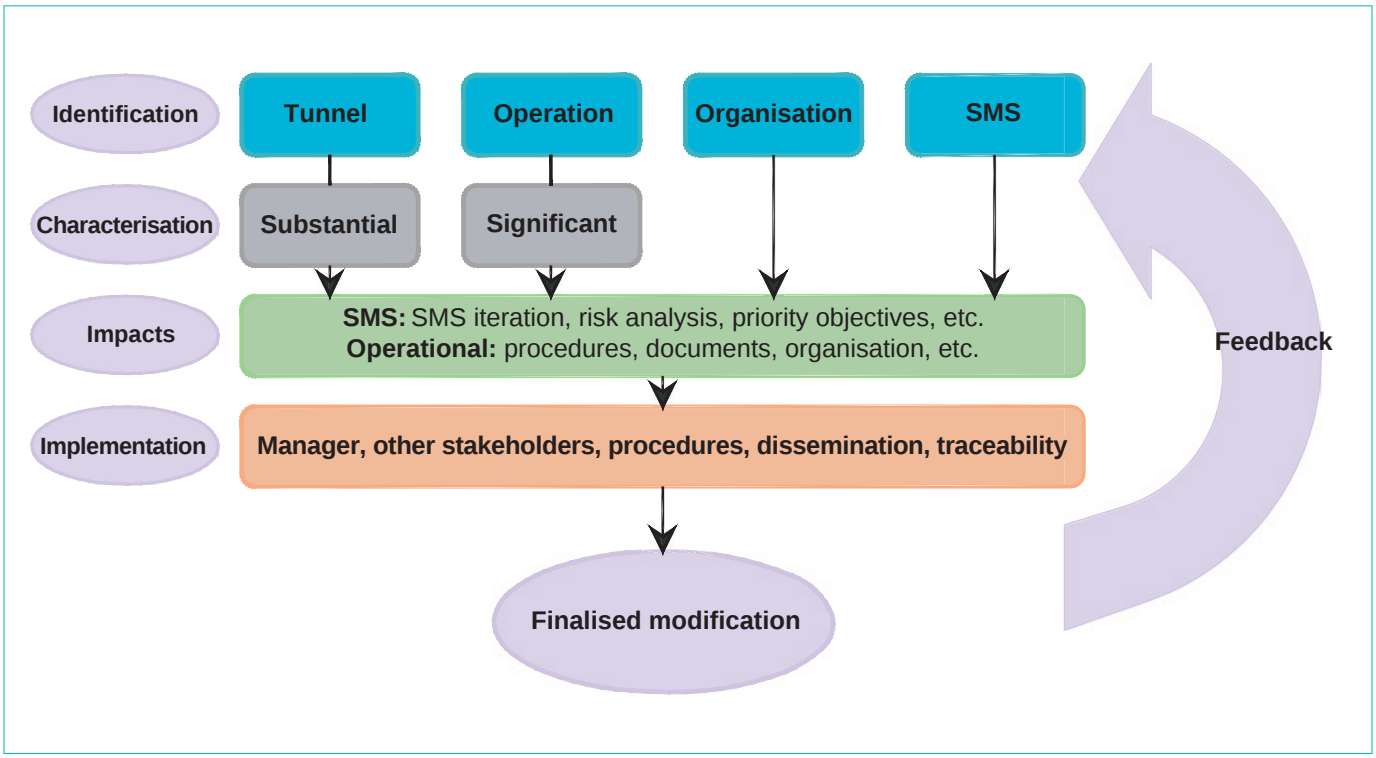
Communication with third parties, including emergency services, allows them to be informed of any modifications to the use of the tunnel during the works, such as restrictions on authorised vehicles in terms of tonnage or size, night-time closures with reopening in the morning with reduced lanes, a reduction in the maximum speed limit, etc. Communication prior to the works helps to raise users' awareness of safety culture, on the one hand by explaining the investments made in terms of safety, which can help them to put the traffic disruption into perspective, and on the other hand by encouraging them to drive appropriately during this particular phase of operation.

4.8.3 Methodological elements

Management of modifications is based on an approach that is broadly similar to the risk assessment described in section 5.1.3.

It comprises four stages:

- identification of modifications;
- characterisation;
- assessment of their impacts;
- the methods for implementing them, including feedback.



The stages of tunnel modifications management

Identification of modifications

As indicated above, modifications may concern the system as a whole (including the SMS) or more operational objects. They may be human, organisational, regulatory, technical, material, procedural, and relate to:

- the tunnel and its equipment;
- the operating conditions of the tunnel;
- the organisational practices within the operating body;
- the documentation (procedures, scope, content, etc.).

It is rare for a modification in one of these areas not to impact at least one of the other areas.

The SMS specifies which members of staff are authorised to identify modifications, to whom the information is communicated, by what means, and how traceability is ensured.

The development of a safety culture within the organisation raises awareness among all staff, who can report any modifications they have identified to the SMS coordinator.

For example, centralising the monitoring of remote tunnels via a single control centre, which constitutes a significant modification in operating conditions according to Article R. 118-3-4 of the French Road Infrastructure Code, will be accompanied by:

- *a change in the organisation within the operating body:*
  - *staff duties: additional tunnels to monitor with different characteristics and therefore different equipment and operating modes (smoke extraction systems, closure mechanisms, etc.),*
  - *working arrangements between different departments and contacts: different field agents and on-call managers, appointment of local maintenance technicians as first responders, etc.;*
- *a change in the coordination of those involved: measures implemented by stakeholders to compensate for the absence of the liaison officer at the local command centre;*
- *a change in documentation:*
  - *the safety documentation, which must be amended and then sent to the prefect for renewed operation authorisation, in particular the Emergency Response Plan and the tunnel's minimum operating conditions,*
  - *the tunnel history file, the maintenance plan, staff instructions, etc.*

Another example: changing the ADR[18] category of a tunnel from category E to category A will involve:

- *a possible modification of the tunnel, in terms of structural elements or equipment (addition of a slotted gutter, for example);*
- *a modification of the documentation:*
  - *the safety documentation, which will include a description of the specific measures planned for the transport of dangerous goods and a specific risk assessment, and will be sent to the prefect for renewed operation authorisation,*
  - *the tunnel traffic regulations,*
  - *the tunnel history file, the maintenance plan, etc.;*
- *a change in coordination with stakeholders due to the potential presence of vehicles transporting dangerous goods, etc.*

Characterisation of modifications

The SMS specifies who is responsible for characterising the modifications and the criteria on which this is based.

The characterisation of modifications is understood in the sense of the regulations presented in paragraph 4.8.1 above:

- modification relating to the tunnel: substantial or not (Art. R. 118-3-1);
- modification relating to operating conditions: significant or not (Art. R. 118-3-4).

Circular 2006-20 provides guidance on assessing whether a modification is substantial or not. It can be noted that any modification that leads to a change in the specific hazard investigation assumptions has a potential impact on safety.

Examples of significant modifications to operating conditions include: authorising heavy goods vehicles in a tunnel previously restricted to vehicles with a gross vehicle weight rating of less than 3.5 tonnes, changing from category E to category A for dangerous goods, a change to the traffic plan that leads to a significant increase in traffic or congestion, etc.

This step may therefore entail obligations with regard to the administrative authority, including the submission of preliminary or subsequently updated safety documentation.

Even if the modifications are characterised as non-substantial or non-significant as per the meaning in the French Road Infrastructure Code, the following steps must be taken to process the modification.

18. *Agreement for the carriage of Dangerous Goods by Road*.

Safety impact assessment

This assessment must be carried out independently of the characterisation, even if the modifications do not trigger a procedure related to French Road Infrastructure Code. It is part of the iterative SMS process based on the risk assessment detailed in paragraph 5.1.3.

The SMS specifies who is responsible for the safety impact assessment, which parties are involved and the criteria on which it is based.

As the modifications may affect all areas of tunnel operation, the consequences in terms of impact can be very varied.

The tunnel operator shall assess the potential impact of modifications on (non-exhaustive list):

- risk analyses, within the framework of the SMS and in the safety documentation;
- organisation and procedures (organisation chart, Emergency Response Plan, instructions, etc.);
- training;
- asset management;
- interface management and coordination with third parties (identification and involvement of internal and external stakeholders affected by the changes);
- documentation (safety documentation, SMS manual, tunnel history file, etc.).

Any modification requires research into its consequences for the entire system. Take, for example, the renumbering of emergency exits in an existing tunnel. The tunnel owner must ask several questions.

1. Identification: does this change affect the tunnel structure, its operation, organisational aspects or the SMS?

➥ The change potentially impacts all areas.

2. Is this modification substantial within the meaning of Article R. 118-3-1 of the French Road Infrastructure Code?

➥ No, it is not necessary to produce preliminary safety documentation.

3. Is this modification significant within the meaning of Article R. 118-3-4 of the French Road Infrastructure Code?

➥ No, it is not necessary to submit an update of the safety documentation to the Prefecture (periodic review), but an update is nevertheless required (reference status, plans, Emergency Response Plan, etc.).

4. What are the impacts of this modification?

- *From a technical point of view:*
  - *➥ The SCADA system will be revised.*
- *From an organisational point of view:*
  - *➥ Emergency services must be informed so that they can update their internal response procedures.*
  - *➥ Maintenance monitoring will need to be updated, as will the examining of exits during periodic detailed inspections.*
- *From a documentation perspective:*
  - *➥ The tunnel history file needs to be updated to incorporate this renumbering.*
  - *➥ Changes to the SCADA, Emergency Response Plan and maintenance monitoring will require changes to documentation.*
- *From a Tunnel SMS perspective:*
  - *➥ Several areas are impacted (coordination with third parties, asset management, documentation, etc.), but the Tunnels SMS remains unchanged. It should be noted, however, that the "Management of material or organisational modifications" component must ensure that the modification is properly taken into account (principle of continuous improvement).*

Other examples of assessing the impacts of a modification:

- *a change in equipment, with identical functionality but different technology, will impact the organisation (training, operational testing, reconfiguration, etc.), documentation (tunnel history file, maintenance plan, maintenance contract if outsourced, instructions, etc.) and possibly equipment (power supply, low-voltage systems, SCADA system, computerised maintenance management, etc.);*
- *modifying minimum operating conditions will impact the organisation (instructions, maintenance plan, etc.), coordination with third parties (if maintenance is outsourced or there is an agreement) and documentation (modification and distribution of the Emergency Response Plan, instructions, etc.).*

Tunnel des Monts – Removal of a jet fan (© CETU)

The assessment does not always conclude that there will be a negative impact on safety; however, any significant change in operating conditions, even if it has a positive impact on safety, must be taken into account. For example, the transition to a D4 surveillance level, i.e. permanent human surveillance, has a positive impact, but it is necessary to take into account the knock-on effects that this will have in various areas of operation.

Furthermore, if the impact assessment concludes that new risks have emerged or that existing risks have worsened in terms of probability or consequences, it is necessary to consider the need to implement appropriate risk mitigation or consequence limitation measures, or even to reconsider the proposed modification or the conditions for its implementation.

The risk map will also need to be updated.

For tunnels longer than 500 m located on the TEN, the tunnel[19] shall submit to the safety officer a presentation of the proposed modification[20], its characteristics and an assessment of its impact on safety. The safety officer shall issue an opinion, which the tunnel owner shall forward to the prefect and the emergency services.

The analysis may also lead to the definition of new safety objectives or a redistribution of priorities.

Implementation procedures

The SMS specifies who is responsible for implementing the proposed modification, who is involved, including third parties, and defines the procedures for monitoring implementation and tracking modifications and related actions (who, what, how, when).

Documentation must be updated promptly, particularly operational documents such as the Emergency Response Plan or specific instructions. The procedures for internal and external distribution of related documents are also defined through the SMS.

The implementation of modifications and related actions is subject to feedback, which allows the actual impacts to be compared with the expected impacts and, where appropriate, the effectiveness of the prevention and protection measures deployed to be assessed.

For very significant modifications, feedback may be subject to a safety review or specific internal or external communication measures.

When updated for the periodic safety review, the safety documentation shall report on non-substantial modifications affecting safety over the past six years and those planned for the next six years, where these have already been scheduled.

4.8.4 Documenting modifications in the SMS manual

The SMS manual details how each type of modification is taken into account. It also specifies how the modification management procedure is reviewed, who is responsible for its implementation and how often it is reviewed.

Rond-Point Tunnel – Painting works (© CETU)

19. Accountable manager, SMS coordinator or other contact person to be defined within the framework of the SMS.
20. Any modification to the tunnel that is not substantial in nature and any modification to the operating conditions that does not significantly affect them.

4.9 PERFORMANCE ASSESSMENT

The permanent system for monitoring and assessing the level of safety ensures that the system operates as described in the SMS documentation.

This component contains elements necessary for measuring the performance of the SMS approach. Readers should therefore also refer to section 5.1.6, particularly with regard to indicators and safety reviews.

4.9.1 Reminder of regulatory provisions

Firstly, it should be noted that regulations introduce the concept of periodic safety reviews, the principles of which are detailed in the CETU Information Document "Periodic safety review of road tunnels – Operation authorisation renewal" [13].

The purpose of this review is to verify whether the conditions under which the tunnel is operated have changed since the previous review – six years at most – and whether safety is still satisfactorily ensured.

It involves reviewing the tunnel's safety documentation as part of a new investigation by the prefect. It results in the documented renewal of the tunnel's operation authorisation, issued by the prefect for a new period of six years from the end of the previous period, possibly accompanied by restrictive conditions for use of the tunnel or specific operating requirements.

This presupposes that the safety documentation has been updated by the tunnel owner and has been subject to a "second opinion" by an external authorised and qualified control entity/ expert, which gives its assessment of the condition of the tunnel and its equipment.

To do this, the expert must have the necessary information in the form of recent field reports, documents, diagnostics, or the results of detailed periodic inspections of structural elements and equipment (see booklet 40 "Tunnels – Structural elements and Equipment" (in French) of the guidelines on implementing the Technical Directive for the Monitoring and Maintenance of Engineering Structures (ITSEOA) [8]).

For tunnels longer than 500 m located on the trans-European network, the tunnel safety officer issues an opinion on the safety documentation as part of the operation renewal request procedure.

This opinion is attached to the safety documentation when it is sent to the Prefect.

4.9.2 Control procedures

Beyond regulatory obligations, the tunnel operator shall establish means to monitor compliance with:

- regulations;
- the provisions defined in the SMS;
- internal instructions.

The operator shall also organise the monitoring of the safety of its operations.

In this context, two distinct tools are to be implemented:

- **internal controls or audits**, which may take various forms depending on the operating body in question and the various elements in place (internal hierarchical controls (IHCs) or internal audits, for example). These controls cover all aspects of the SMS to ensure that it is sustainable;
- **audits involving third parties**, known as "**SMS audits**", which provide operators with an external assessment of the strengths and areas for improvement within their organisation and the measures they have put in place. The principle of the SMS audit is to observe whether the practices implemented on a daily basis by the various stakeholders enable the safe operation of tunnels to be properly controlled, and in particular whether these practices comply with what is expected, i.e. with the reference documents defining the organisation of tunnel safety, and first and foremost with the SMS manual.

4.9.3 Documenting performance assessment in the SMS manual

The SMS manual describes the types of checks planned by the operator, their frequency and the procedures for taking into account any observations that may be made. Paragraph 5.1.6 of the present document details how the SMS is managed and assessed and introduces the concepts of indicators and safety reviews. These elements of the SMS must also be included in the manual when it addresses this component.

5

SMS CONSTRUCTION METHOD

There are eight steps involved in building an SMS:

- assessment of the existing situation;
- designation of key SMS stakeholders;
- risk analysis;
- risk prioritisation, which leads to the definition of priority safety objectives;
- elaboration of the safety policy;
- selection of indicators;
- the development of a permanent system for monitoring and assessing the level of safety;
- introduction of periodic safety reviews.

As part of the development and implementation of its SMS, the tunnel operator ensures that all risks associated with the activity are identified, analysed and prioritised, and that those identified as priorities are addressed. To this end, it conducts a safety management analysis of the system components to assess their ability to function properly in response to events. The operator analyses the risk by determining its probability of occurrence, its severity and, where applicable, its detectability (see paragraph 5.1.3 of the present document). It then uses objectives and indicators to verify that the organisational practices and the human and material resources of the operating body are appropriate and effective for managing the identified risks and enabling safe operation of the tunnel.

All the elements established during the eight construction stages are recorded by the operator in the specific SMS documentation, the main component of which is the SMS manual (see paragraph 5.2). This document describes in particular the procedures for reviewing and updating the risk management process, including the schedule, the management method and the person responsible (see Chapter 6).

Finally, the SMS cannot function without the support of all those involved in tunnel operation. Management buy-in and internal sharing of information are essential elements.

The establishment of a working group bringing together all the operator's key stakeholders on issues related to the operation, safety and life of the tunnel(s) is a strong point of the construction of the SMS. Once the SMS is in place, it can usefully evolve into a monitoring group.

THE 8 STEPS TO BUILDING AN SMS IN BRIEF

Step 1 **– Assessment of the existing situation, in particular the safety approach in place, the presence of a quality management system and the necessary coordination with the tunnel safety officer, if applicable.**

Step 2 **– Designation of key SMS stakeholders (accountable manager, SMS coordinator and local SMS contacts, see Chapter 3).**

Step 3 **– Risk analysis, which includes:**

- **identifying risks related to activities, the tunnel, equipment, the environment, etc., after which a risk map can be presented;**
- **the analysis itself, which consists of determining the causes and consequences of these risks;**
- **assessing their acceptability and defining any prevention or reduction measures that the organisation proposes to implement.**

Step 4 **– Risk prioritisation, which leads to the definition of priority safety objectives, not only in terms of unacceptable risks, but also in terms of balancing cost, time, safety and quality constraints.**

Step 5 **– Elaboration of the safety policy.**

Step 6 **– Selection of indicators to measure the achievement of safety objectives and methods for monitoring these indicators.**

Step 7 **– Development of a permanent system for monitoring and assessing the level of safety to ensure the performance of the SMS.**

Step 8 **– Introduction of periodic safety reviews to ensure the system continues to function properly over time and to enable its reassessment.**

5.1 THE STEPS OF AN SMS CONSTRUCTION

5.1.1 Step 1: Assessment of the existing situation

Existing safety procedures

As previously indicated, the SMS is built on existing practices, adding what is strictly necessary and implementing an approach tailored to the tunnel operator at hand and to local issues.

Once the scope of the SMS has been defined, the tunnel operator must assess the existing situation to identify any gaps in relation to the expectations of an initial SMS, which will then be gradually expanded with a view to continuous improvement.

This assessment may take the form of a self-diagnosis aimed at:

- verifying that regulatory requirements related to safety are met [1];
- assessing what elements of an SMS are already in place in the current operation practices;
- providing the data necessary for risk identification;
- verifying the content of any existing risk analysis;
- assessing strengths and areas for improvement, in order to begin outlining the priorities of the action plan.

This self-assessment makes it easier to take stock of the situation and build a shared overall vision of the starting point. This is a key step in facilitating acceptance of the process. The assessment can then take the form of a table that specifies, for each topic, the different elements, the corresponding documentation, the identification of items that are already completed (C), partially completed (PC) or not completed (NC), as well as any additional information.

An example of a self-assessment grid is provided in Appendix A.

Pas de l'Escalette Tunnel – Works (© DIRMC)

Linking the SMS to the QMS

When developing its SMS, the tunnel operator must also work on the relationship between the SMS and other existing systems within the organisation, such as a quality management system (QMS). As indicated above (see section 2.4), the SMS can then draw on already documented practices and benefit from synergies resulting from these systems, such as process reviews.

Interaction with the safety officer

Tunnels longer than 500 m located on the trans-European road network (TEN) are subject to requirements resulting from the transposition of European regulations. These include the appointment of a tunnel safety officer.

The role of the tunnel safety officer is specific and important for the safe operation of tunnels. He/she has a mission that covers the entire life of the tunnel, coordinating prevention and safety measures and providing an external and independent view on all aspects of tunnel operation.

With regard to coordination with the SMS, there are two distinct phases:

- **during the construction of the SMS**, the safety officer takes a more backseat role, but can usefully give an opinion on the content and form of the first version of the SMS, in particular to verify that the approach accurately reflects the regulatory framework. This discussion with the safety officer allows observations to be incorporated during the development of the SMS;
- **during the life of the SMS** and as part of the safety officer's missions provided for in French Road Infrastructure Code[21], the SMS facilitates exchanges and clarifies the roles of each party, including that of the safety officer, who, thanks to the SMS, can more easily identify his/her contacts. The tables tracking the follow-up given to exercises and incidents, the skills development plan (formerly the training plan), etc., are useful documents for his/her mission. Some operators sometimes call on the safety officer to provide support and advice to the SMS coordinator. The safety officer may also be called upon to participate in various activities, such as certain internal workshops related to the SMS and other meetings related to safety issues.

The tunnel operator must therefore define the tasks to be assigned to the safety officer during the construction phase of its Tunnel SMS[22].

21. Article R. 118-4-3 of the French Road Infrastructure Code.
22. The scope of the SMS and that of the tunnel safety officer (in terms of the tunnels concerned) may differ (e.g. tunnels located on the TEN and between 300 and 500 m long). When the tunnel safety officer does not belong to the staff of the tunnel operator, anything that supplements his/her regulatory duties must be provided for in contractual terms.

5.1.2 Step 2: Designation of key SMS stakeholders

As previously mentioned, there are key roles in the SMS:

- the accountable manager;
- the SMS coordinator;
- local SMS contacts.

The roles of each of these are detailed in Chapter 3.

It is essential to choose persons at the right hierarchical level and with the scope for action and skills appropriate to their role.

The accountable manager must be able to commit to providing the means to achieve the objectives set.

The SMS coordinator must be able to bring the process to life. The role attributed to the person must therefore be acknowledged and accepted by the other parties involved in tunnel operation. In order to give the coordinator legitimacy in his/her role, the mission statement referred to in paragraph 3.2 may be circulated.

Finally, local SMS contacts are the links closest to the field who will implement the SMS from an operational point of view. They must act as genuine relays for the SMS coordinator.

5.1.3 Step 3: Risk analysis

This paragraph provides definitions and highlights the difference between risk management in the tunnel – mainly related to regulatory obligations – and risks related to tunnel operations, which are to be addressed within the framework of the SMS.

This section also provides the reader with methodological elements for risk analysis.

Definitions

In everyday language, the terms "risk" and "danger" are often used without distinction, even though they express different but complementary concepts:

- **danger** is the intrinsic quality of a situation that could cause harm;
- **risk** represents the result of exposure to a danger. It consists of two criteria, its probability of occurrence and its severity, which determine its criticality. Preventive measures aim to reduce the probability of occurrence, and protective measures aim to reduce the severity.

Examples: the danger "Poor knowledge of procedures and intervention methods of the various departments" may lead to the risk of "Failure to comply with regulatory obligations, failure to carry out annual safety exercises".

The danger "Failure to configure equipment controls" may lead to the risk "Failure of the smoke extraction system to activate in the event of a fire".

Based on this definition, it is necessary to set one or more objectives to be achieved in order to identify risks. The common objective is to operate road tunnels safely. The risk inventory therefore covers all malfunctions and vulnerabilities related to the operation of road tunnels, breaking them down into specific sub-objectives: for example, compliance with regulatory requirements, effective training management, inspection, maintenance and renewal of equipment, etc.

Talant Tunnel – Fire test (© CETU)

The various risks related to tunnel operation

The regulations governing risk management are derived from the French Road Infrastructure Code and the Order of 18th April 2007 implementing the provisions of Articles R. 118-3-9 and R. 118-4-4 of the French Road Infrastructure Code and relating to the composition and updating of preliminary and subsequent safety documentation and the reporting of significant incidents and accidents. They are explained in CETU information note no. 21 [1].

Tunnels in operation longer than 300 m

The safety documentation shall include:

- a Specific Hazard Investigation describing the types of accidents, regardless of their origin, that are likely to occur during operation and the nature and importance of their potential consequences. This is a cross-disciplinary approach that considers the tunnel as a comprehensive system consisting of users, vehicles, the tunnel itself with its equipment and environment, the operator, and emergency and rescue services;
- a Quantitative Risk Assessment (QRA) related to the transport of dangerous goods;
- an Emergency Response Plan that defines response scenarios following incidents or technical failures, detailing the various cases of material or human unavailability and the responses to these degraded modes of operation (compensatory measures, maintenance actions and, in extreme cases, closure of the tunnel).

The above-mentioned decree of 18th April 2007 provides details on the development of specific hazard investigation scenarios.

Sections 3 [14], 4 [15] and 5 [16] of *the Road Tunnel Safety Documentation Guidelines* specify the role of these documents and provide guidance on how to draft them.

Tunnels longer than 500 m on the trans-European network (TEN)

For tunnels longer than 500 m on the TEN, the safety officer issues an opinion on the preventive measures and safeguards envisaged by the preliminary safety documentation, as well as an opinion on the subsequent safety documentation. His/her opinion is attached to this documentation when it is sent to the prefect.

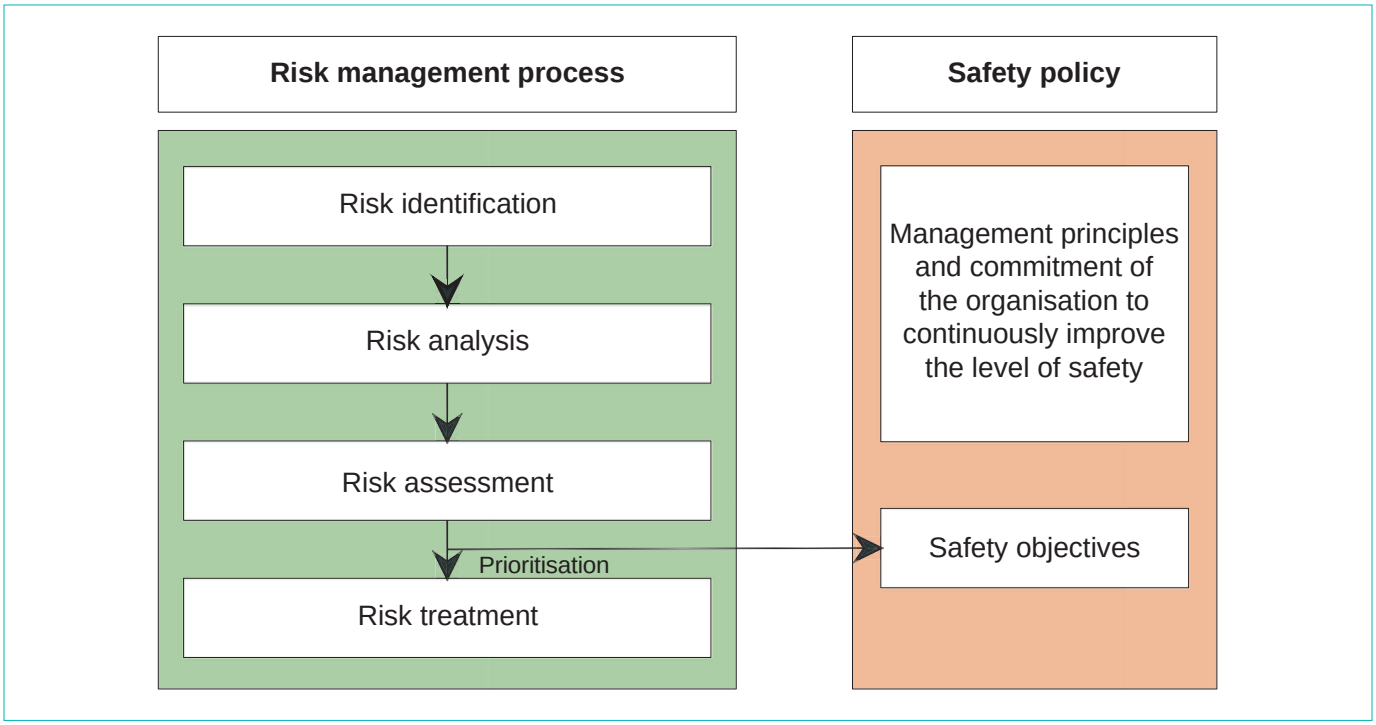
Risk management in the sense of the SMS differs from the specific hazard investigation required by the regulations.

Through scenario analysis, the specific hazard investigation focuses on the nature of certain events, mainly fires, and the importance of their potential consequences. It goes so far as to specify and justify measures to reduce the probability of these events occurring and their consequences. The specific hazard investigation is specific to a tunnel.

The SMS, on the other hand, is based on the system as a whole, viewed from a safety management perspective. It covers risks directly related to the activity and also those related to the operating body. These risks are the subject of the approach set out in this part of the guide.

Risk assessment methodology

Risk assessment is the overall process of identifying, analysing and assessing risks. It must be conducted in a systematic, iterative and collaborative manner, using the best available information and drawing on the knowledge and opinions of stakeholders.



Risk management process and safety policy

Siaix Tunnel – Safety exercise 2024 (© DIRCE)

Data collection

It is essential that the information used is relevant, appropriate and up- to-date.

The data used is mainly that collected for the self-assessment (Appendix A):

- regulatory obligations;
- description of the general organisational arrangements: safety policy, general framework for operational tasks, documenting of roles and responsibilities, etc.;
- collection and analysis of feedback;
- operating procedures in all areas related to safety;
- Quality management system (QMS) data relating to the operation of road tunnels, if any;
- etc.

Risk identification

The purpose of risk identification is to seek out, recognise and describe risks that could prevent the organisation from achieving its objectives.

There are many risk identification techniques. The choice of a technique or combination of techniques will be guided by the objective(s) selected and the means and human resources available.

It is recommended that a working group be set up, composed of individuals with multidisciplinary technical skills and knowledge and experience of the scope of the study.

Within the group, a leader should be appointed to facilitate the process.

In order to cover the entire scope and obtain a structured result, the analysis can be carried out:

- by risk category (legal, financial, organisational, etc.);
- by mission (monitoring, maintenance, traffic management, crisis management, training, etc.);
- according to the elements of the tunnel system (vehicles, users, the tunnel itself with its equipment and environment, the operator, and the emergency and rescue services).

The operator can develop its own risk identification approach or use a generic risk map as a working basis or to supplement an existing map.

Identifying risks requires a certain adaptation. The operator cannot simply use a generic map as it is. For example, data collection may reveal risks that are not identified in the generic map, which does not take into account the specific characteristics of each tunnel. The operator must therefore compare the generic risks with the realities of its activity.

An example of generic mapping is presented in Appendix B1. This mapping is based on the systemic approach usually used for road tunnels, taking into account technical, human and organisational factors.

Risk identification is carried out at a given point in time and must be updated as necessary as part of the continuous safety improvement process. The operator shall periodically update its mapping based on the analysis of practices and lessons learned. The SMS manual describes the procedures for risk mapping revision.

Furthermore, any organisational or functional change is likely to give rise to new risks and may lead to changes in previously identified risks (see paragraph 4.8). It is therefore necessary to at least update the risk map following any regulatory change affecting operations, internal or external organisational change, or following the implementation of new technical systems. This does not mean rewriting the entire risk map, but rather filling in any gaps and removing anything that no longer applies.

The evolution of the risk map is presented during the annual safety review.

Risk analysis

The next phase is the analysis of the risks identified by the operator.

This involves determining the causes and consequences of the risks, which are the data that will then be used to assess and prioritise the risks.

The analysis is generally carried out using the standard criteria of probability of occurrence and severity.

The risk detectability criterion may also be used. This corresponds to the operator's ability to detect the risk through internal operational mechanisms and an appropriate process for collecting and processing information on malfunctions, problems encountered, incidents and errors. The development and implementation of the SMS improves this detection capability through the identification of risks as explained above, and through procedures for managing modifications and the organisation of feedback.

Risk assessment

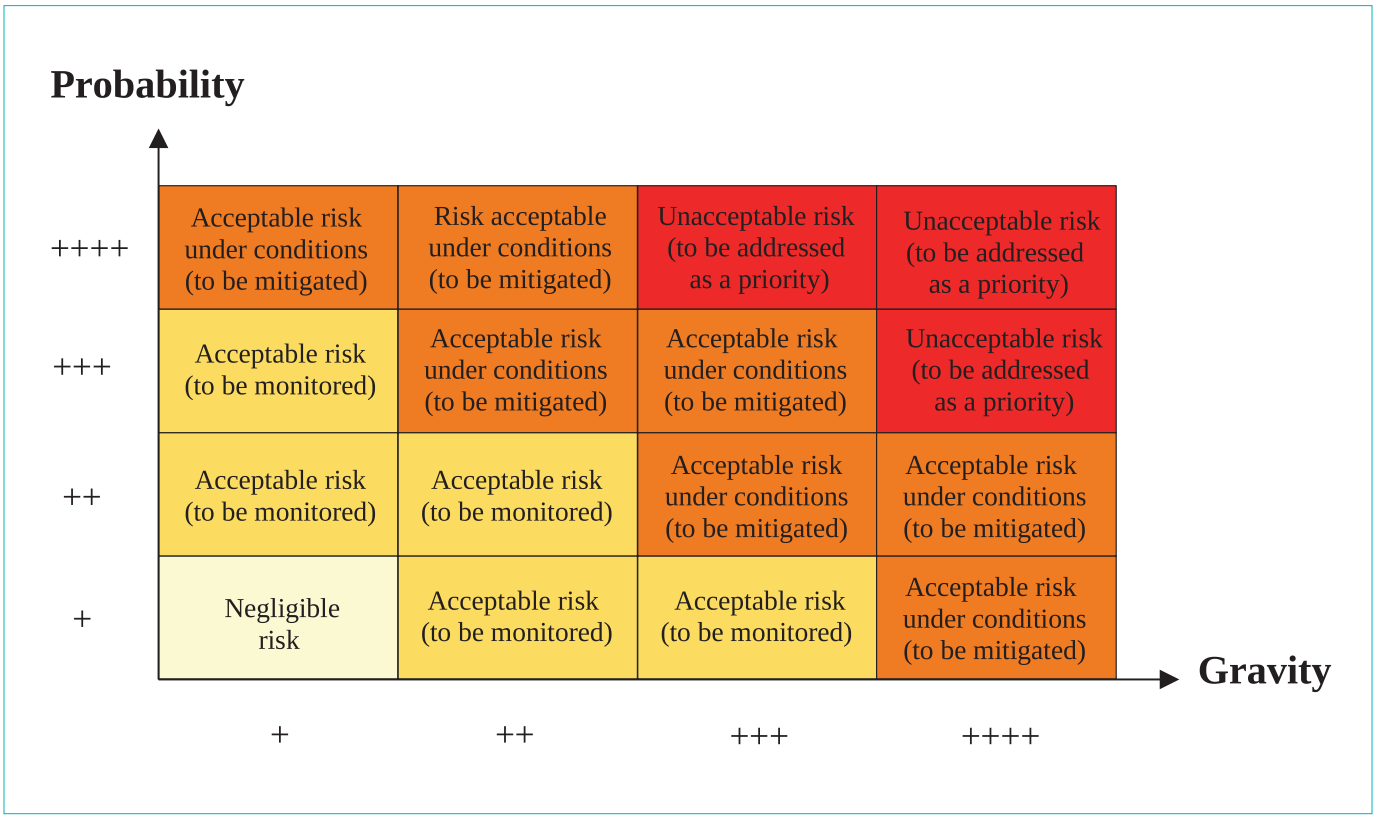
The purpose of this phase is to assess the risks in order to decide whether or not to address them and to determine how to proceed.

The assessment criteria are defined in advance and validated by the accountable manager.

The acceptability of risks is assessed and they are then categorised as "unacceptable", "acceptable under certain conditions" or "acceptable".

Issues for which control tools exist and which do not pose a risk to operations are assigned a low weighting. Where applicable, points for vigilance are associated with them.

Other sources of risk are prioritised according to the frequency-severity matrix.



Example of a frequency-severity matrix

Risk treatment

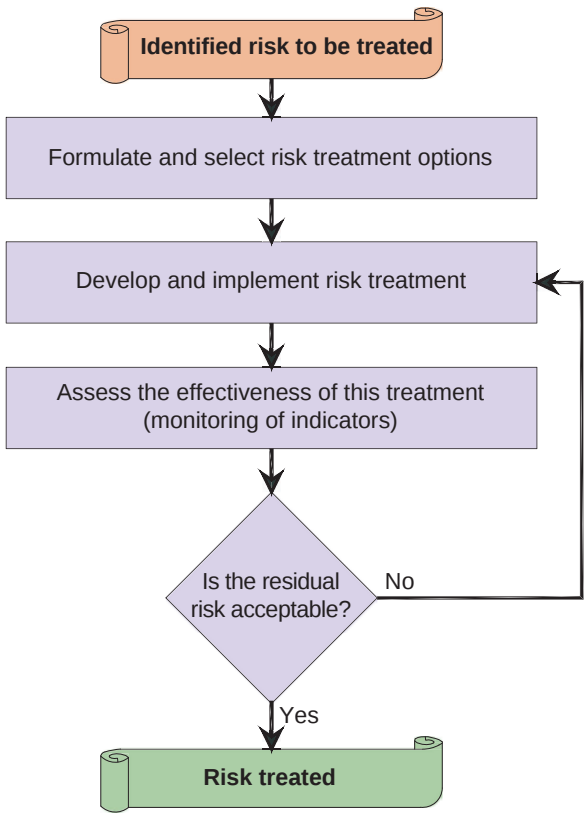
Several approaches are possible:

- risk elimination;
- implementation of preventive measures (reducing the probability of occurrence);
- implementation of protective measures (limiting the severity).

If the risk cannot be eliminated, a combination of prevention and protection measures is generally used. Residual risk is the risk that remains after risk treatment, as it has been deemed acceptable in light of the context and criteria used.

Once the various treatment options have been determined, their effectiveness and relevance are assessed. The measures selected are set out in an action plan. They are part of the continuous safety improvement cycle and are subject to monitoring and review procedures.

Risk treatment involves an iterative process:



Iterative risk treatment process

Examples of risk assessment – with determination of causes and consequences, determination of severity and definition of the associated safety objective – are provided in appendices (B2 to B5).

5.1.4 Step 4: Definition of safety objectives

Risk assessment provides the data needed to decide whether or not to address each risk. Following this assessment, priority objectives are defined, first with regard to unacceptable risks, but also based on a trade-off between constraints such as cost, time, safety, quality, etc. Decisions must be documented and tracked.

The priority objectives are translated by the accountable manager into safety objectives in the safety policy, with a view to preparing an action plan. Objectives deemed to be of lower priority are addressed at a later stage as part of the continuous safety improvement process.

These objectives must be chosen in line with the organisation's challenges and resources. Initially, particularly for organisations that do not yet have sufficient safety data, it is possible to define qualitative (trend-based) rather than quantitative objectives. Documenting them within the safety policy ensures that all staff are aware of them.

Examples of safety objectives with related SMS components:

Examples of safety objectives	Related SMS components
Operating policy Ensure compliance with regulatory requirements (including up-to-date operating authorisation) Control open air/tunnel interfaces to guarantee user safety Improve tunnel operation through better traceability of incidents and modifications	Roles and responsibilities Coordination with third parties Feedback Documentation
Asset management Ensure the proper functioning and permanent availability of the tunnel's equipment	Equipment asset management
Event management Limit the risk of secondary accidents and enable evacuation in crisis situations	Roles and responsibilities Feedback Coordination with third parties
Management of skills, health and safety at work Ensure ongoing skills maintenance (mentoring, network of tunnel correspondents, joint exercises involving all stakeholders) for each stakeholder involved in operations Ensure occupational safety for staff and external contractors	Skills Management Safety culture Coordination with third parties

5.1.5 Step 5: Elaboration of the safety policy

The safety policy includes the organisation's intentions, management principles and commitment to continuously improving safety levels. It incorporates the risks associated with the operation of facilities and also takes into account the risks associated with possible malfunctions of the SMS.

The accountable manager commits to a safety policy. This commitment and the safety policy are documented. All components of the SMS, the documents, the organisation and the accompanying actions complement each other to form a whole aimed at implementing the safety policy.

The safety policy can be described in terms of four main elements:

- safety objectives (see paragraph 5.1.4);
- the safety policy assessment and review cycle (see section 6.3);
- the roles and responsibilities of each party in achieving these objectives (see section 4.1);
- the methods for its dissemination.

The safety policy must be adapted to the size and complexity of the organisation, as well as to the safety issues of the tunnels concerned.

Once set out, the safety policy is disseminated to all SMS stakeholders, whether management or field staff, specifying how it will be implemented in practice.

The dissemination of the safety policy comprises two aspects:

- communicating the link between the safety objectives and their operational implementation;
- incorporating the policy into the SMS documentation (SMS manual or specific document) and informing staff of its existence and where (physically or digitally) it can be consulted.

This policy is regularly reviewed during safety reviews, as safety objectives are gradually achieved, or following modifications that impact risk assessment.

5.1.6 Step 6: Choice of indicators

Indicators are tools used to assess safety objectives. Their role is to verify and measure the achievement of one or more objectives or the margin for progress, in order to review the safety policy if necessary.

Safety indicators must be measurable, relevant, easily accessible, defined in specific SMS documentation, monitored regularly and reassessed periodically. To choose an indicator, the operator must start from the work carried out on risk identification and the associated safety objectives. A great deal of data already exists within the operating body and can be used to construct the indicators.

Landy Tunnel (© CETU)

An indicator must be a simple and easily usable tool that best reflects the achievement of objectives. By reflecting a status or change through the comparison of statuses, it makes it possible to assess the achievement of a set objective in relation to an action plan. Several indicators can be used to monitor the same objective.

Before choosing indicators, it is important to consider two complementary aspects:

- **the burden on the organisation:** the indicators chosen must not increase the workload of staff. The aim is to minimise their burden on the organisation in terms of resources (time, information, staff involvement, difficulty of interpretation). Indicators are tools designed to facilitate the monitoring of objectives;
- **the number of indicators:** it is advisable to limit the number of indicators to around ten to ensure effective monitoring, bearing in mind that they may evolve over time.

Knowledge of the characteristics of indicators enables the selection of appropriate and relevant indicators. In the context of an SMS, the most commonly used are generally:

- **quantitative or qualitative indicators:**
  - the former allow a measure to be quantified and can also be expressed relatively in the form of a ratio or rate,
  - the latter correspond to a categorisation of the measurement; they are qualitative data relating, for example, to opinions, behaviours, attitudes or perceptions; quantitative measurements can be used to construct qualitative indicators and vice versa;
- **monitoring or performance indicators:**
  - the former enable the action to be marked out and its progress measured; they have the advantage of enabling anticipation and rapid response,
  - performance indicators are used to measure the final result of a given action in terms of the degree of performance achieved or the attainment of an objective.

Examples :

Quantitative monitoring indicator: *ratio of number of vacant positions to number of positions identified in the* Who does what?*.*

Quantitative performance indicator: *rate of resolution of reservations and implementation of recommendations on tunnel safety made by the French Commission on the Evaluation of Road Infrastructure Safety (CNESOR) and the Local State Consultative Commission for Safety and Accessibility (CCDSA).*

Qualitative performance indicator: *operators' assessment of the performance of coordination with third parties during interventions.*

The indicators must be consistent with the chosen safety objectives. Their effectiveness depends on several factors, including their relevance and reliability. Few in number and easy to obtain, they must be understood and accepted by all, which is why it is advisable to develop them in a working group, taking into account the workload that their consolidation will require, and to describe them clearly.

For the indicators to be meaningful, it is necessary for the staff who collect the data and the users to acknowledge their usefulness in relation to the objective pursued. It is an advantage if these indicators can be promoted on a daily basis, for example on the intranet, in newsletters or news feeds.

Objectives and indicators that already exist in other systems, such as the Quality Management System (QMS), can be incorporated into the SMS if they are relevant.

The list of indicators is not set in stone. Some indicators that are relevant when they are introduced may become obsolete at a later date. It will therefore be necessary to regularly review whether it is worthwhile keeping them, and whether new, more appropriate indicators should be introduced (see paragraph 5.1.4).

More detailed information on the indicators, the stages involved in their development and examples are provided in Appendix D.5.

5.1.7 Step 7: Development of a permanent system for monitoring and assessing the level of safety

It is necessary to monitor the performance of safety and the SMS and to reassess this performance on a regular basis.

The performance of the system is analysed and monitored continuously by the designated manager(s), in coordination with the SMS coordinator, in order to identify safety strengths and weaknesses and their impact on operations.

To reinforce safety policy and ensure improvements in the safety level of tunnels in operation, safety objectives have been defined (see section 5.1.4), the results of which are monitored using indicators that track the performance of the system. However, indicators are not the only means of assessing whether objectives have been achieved. Audits, organisational assessments and questionnaires are other tools that can be used if necessary, particularly if it proves difficult or impossible to measure the objective using an indicator.

Analysis of the results makes it possible to verify that the level of safety is satisfactory and to determine the extent to which the objectives are being achieved, or, conversely, to detect a negative trend and then encourage the implementation of corrective and preventive actions. The objectives and target values are thus adapted to the situation.

The methods used to evaluate the functioning of the SMS are described in a specific procedure documented in the SMS manual.

5.1.8 Step 8: Implementation of safety reviews

Safety reviews enable a periodic assessment of the SMS over the past year, analysing its operation and taking stock of it in relation to the previous year's action plan. They also enable the objectives to be questioned, looking ahead to the coming year. These reviews provide an opportunity to review the framework within which they operate and their objectives, analyse changes in the context and the SMS approach, and review any new identified risks. They also provide an opportunity to gather the opinions and expectations of those involved in the SMS so that these can be taken into account.

These reviews are therefore an opportunity to verify:

- the performance of the SMS in relation to safety policy and objectives;
- that actions are carried out within the allotted time frame;
- that the organisation in place is effective and that resources are sufficient.

Safety reviews are organised by the SMS coordinator and chaired by the accountable manager. The procedures for organising these meetings (frequency, participants, format, minutes, etc.) are defined in the SMS documentation.

Baza Tunnel – VMS at the tunnel entrance during a safety exercise (© DIRMC)

Safety reviews are held at least once a year. A second review halfway through the year is recommended, as it allows for an initial assessment and more accurate monitoring of objectives, without having to wait for the next safety review to make any necessary adjustments.

The purpose and objectives of the SMS safety review should be explained to staff, particularly those in the field, so that they can comprehend the process and play an active role in it.

5.2 THE SMS MANUAL

5.2.1 What is the SMS Manual?

A strategic document describing the SMS, the SMS Manual is an operational, pragmatic and dynamic framework tool focused on safety management. It is not a plan for future action but a documenting of existing measures.

The SMS Manual is a reference document, a user guide, which is part of the continuous improvement process. Its revision procedures are also defined.

Talant Tunnel (© CETU)

Finally, the SMS manual does not present the details of the work carried out to assess risks, but only the conclusions drawn from it through the definition of priority safety objectives. It describes the procedures for reviewing and updating the risk management process, including the timetable, the management method and the person responsible.

The SMS manual should not be mistaken for the SMS: the SMS manual is a document that describes the SMS and how it works.

5.2.2 Handling of components in the SMS manual

The SMS manual is not intended to repeat what is detailed in other documents, but rather to refer to various documents, in particular the safety documentation and documents that need to be updated regularly (monitoring tables, short-term action plan, etc.).

It addresses each component of the SMS and how the tunnel operating body is organised to manage this issue. For example, the procedures for defining, monitoring, reviewing and disseminating objectives and associated indicators are listed in the SMS manual.

A standard template for an SMS manual is provided in Appendix C.

5.2.3 Link between the SMS manual and the safety documentation

As seen above, the SMS is a tool that is developed and implemented as an extension of the existing safety approach, which itself already contains elements that are part of the SMS. However, it is important to distinguish between the safety documentation and the SMS manual, as each has a different function and scope.

The safety documentation is a reference document specific to a tunnel[23] and is updated annually (or even more frequently for the Emergency Response Plan) and revised every six years, for approval within the framework of the French Road Infrastructure Code procedures.

The SMS, and therefore its manual, are specific to the operator for the defined scope. The system for reviewing and assessing the SMS is not regulated, but it must be subject to internal control measures and internal audits or audits carried out by third parties.

The SMS should therefore be included in the safety documentation for each of the tunnels concerned, as it provides real added value for operations. Document 5 of the safety documentation (with reference to [4]), which describes the organisation and resources for operation, including maintenance and training, is the appropriate document to refer to the SMS. The tunnel owner's report may also explain the reasons that led the organisation to implement an SMS, how it works and the expected benefits. Of course, this communication will be all the easier and understood if measurable results are highlighted as part of the safety approach.

Equally, the SMS manual may refer to parts of the safety documentation, for example, part 5 for the description of operating conditions in normal situations and part 6 "Emergency Response Plan" for operation in degraded situations, while taking care to introduce these references with an explanation related to the SMS (with reference to [4]).

The very functioning of the SMS facilitates the updating and revision of the safety documentation and improves its consistency, for example:

- the history of the tunnel and of the safety documentation, by monitoring the follow-up given to various professional opinions;
- the number and quality of safety documentation input data, by improving feedback;
- the data for the Expert or Approved Qualified Organisation who/which, at the stage of renewal of tunnel operation authorisation must give its assessment of the condition of the tunnel and its equipment, leading to improved asset management procedures;
- the consistency of document 5 by implementing specific procedures for maintenance and training (with reference to [4]).

Beyond the documentary aspect, the SMS guarantees that tunnel operating procedures are structured and robust. These benefits are recognised by institutional tunnel safety bodies, in particular the French Commission on the Evaluation of Road Infrastructure Safety (CNESOR) and the Local State Consultative Commission for Safety and Accessibility (CCDSA).

5.3 INTERNAL SHARING

As indicated in Chapter 6, the life of the SMS is punctuated by meetings, audits, etc., and communication during the construction phase is very important. The accountable manager, assisted by the SMS coordinator and local SMS contacts, must explain the overall approach and share its progress with internal stakeholders. The involvement of all staff is necessary and is a guarantee of success.

Siaix Tunnel – Safety exercise 2024 (© DIRCE)

23. In exceptional cases, the safety documentation may be established by route (itinerary) and shared between tunnels belonging to the same operator if they are very close to each other, located on the same route and covered by the same emergency services and law enforcement agencies.

6 LIFE OF THE SMS

The construction of an SMS is an important step towards its implementation. Once in place, the SMS remains a system that, by its very nature, is bound to evolve continuously over time.

6.1 MODIFICATION OF THE SMS

The SMS is part of a long-term approach and proceeds in stages. Unacceptable risks are dealt with as a priority. When one or more safety objectives, defined in light of the risk assessment, are achieved, the safety policy must be updated or revised in order to address the other identified risks and define new objectives.

The accountable manager and the SMS coordinator must also remain vigilant with regard to changes in risks. Such changes may call into question the risk prioritisation that has been carried out and, at the same time, impact the ranking of objectives. Therefore, the need for reviewing the risk analysis must be raised at least during the safety review. In any case, a review should be considered periodically, at least once during the six-year cycle, corresponding to the periodic safety review [13].

Ponserand Tunnel during a periodic detailed inspection of structural elements (© CETU)

6.2 MODIFICATION OF INDICATORS FOR MEASURING THE ACHIEVEMENT OF SAFETY OBJECTIVES

6.2.1 Monitoring of indicators

Indicators are updated according to the operator's needs and at least once a year, in order to be presented and analysed during the safety review.

It is recommended that target values be defined for quantitative indicators and that the measurement method (who, when, how) be explained in context.

A monitoring mechanism is put in place to identify positive or negative changes in the value of these indicators.

The monitoring procedures (person responsible, data source, calculation method for quantitative indicators or evaluation method for qualitative indicators, monitoring frequency) are defined and listed in the SMS documentation.

6.2.2 Changes to indicators

Indicators are living data. Once selected, they enter a continuous cycle of revisions and updates. Indeed, indicators must evolve if they are to remain relevant, particularly when safety objectives are modified. The annual safety review is an opportunity to re-examine their relevance.

In addition, for objectives that are at risk of not being met, an analysis must be carried out to identify the reasons and take appropriate measures before critical situations arise. If the indicator or target value proves to be unsuitable, it should be redefined to improve the system's performance. The actions resulting from this analysis are monitored over time to verify their effectiveness and ensure the traceability of changes to the SMS.

6.3 SAFETY REVIEW

As previously mentioned, safety reviews are conducted at least once a year. They are prepared by the SMS coordinator and chaired by the accountable manager.

With the assistance of the various operational stakeholders, the SMS coordinator prepares the elements necessary for the safety review prior to the meeting (non-exhaustive list):

- a calculation and critical analysis of safety indicators;
- a summary of the results of internal controls and internal or third-party audits and areas for improvement;
- a presentation of safety-related events and the lessons learned from them, including weak signals;
- the list of changes that have impacted safety;
- a summary of corrective or preventive actions taken or planned.

Discussions during this meeting aim to understand the reasons why certain indicators have not reached their target values and to analyse them so that corrective actions can be taken if necessary. The relevance of the indicators and targets is also reviewed at this time.

The safety review is also an opportunity to re-examine safety objectives. In light of the results to be achieved and the means and resources available, an action plan for corrective and preventive actions is defined, with responsibilities and deadlines assigned to each area for improvement (what, who, when, how). The SMS coordinator is responsible for monitoring this action plan.

6.4 SMS AUDITS

It is advisable to carry out an initial diagnosis of the SMS once it has been deployed to verify that the approach implemented is well underway and that the main principles are known, shared and applied operationally within the organisation. This diagnosis can be carried out in two stages: a documentary diagnosis followed by a field diagnosis. It examines the basic components of the SMS: roles and responsibilities, asset management for structural elements and equipment, skills management and training, and feedback organisation.

The purpose of subsequent audits, the frequency of which is to be defined, is to provide an overview and comprehensive feedback on the SMS at the end of each six-year cycle. In this context, an SMS audit every two years appears appropriate.

These SMS audits provide an opportunity to examine new topics, but also to take stock of the action taken on certain observations made during the initial diagnosis (for the first audit) or previous audits.

From the point of view of coordination with safety documentation examination and approval procedures, the SMS audit can take place before the safety documentation is submitted to the prefecture or after the renewal of the tunnel operation authorisation. The benefits are different:

- in the first case, the expert/ Approved Qualified Organisation, the tunnel safety officer and the prefect can use the conclusions of the SMS audit for the safety documentation review and thus have a recent overview of how the SMS operates within the tunnel operating body;
- in the second case, the SMS audit can examine the procedure for renewing tunnel operation authorisation and the methods used to take into account any observations made during the official safety documentation examination procedure.

In preparation, the SMS audit team reviews certain documents from the operator, sent by the SMS coordinator, which enable it to familiarise itself with the functioning of the SMS. The audit report lists the documents used as audit evidence to support the findings.

The sampling method used in the audits consists of providing an external view of the system in place, without aiming for exhaustiveness in the scope of the examination carried out.

The observations made during the audit are classified as follows:

- **Strength (S):** the elements observed constitute positive practices to be promoted with an interesting or innovative approach;
- **Satisfactory Point (SP):** the elements observed indicate that the subject is being handled correctly;
- **Area for Improvement (AI):** the elements observed, due to the risk they may present, require attention and monitoring over time;
- **Particular Attention Required (PAR):** the elements observed, which may have an impact on the operator's responsibility or the safety of tunnel operations, must be treated with particular attention by the operator.

As part of the SMS, the operator monitors the results of audits, which includes taking appropriate action (who, what, how, by when).

7

CONCLUSION

The regulations introduced since the early 2000s and the significant investments that followed have considerably improved safety levels in road tunnels. In accordance with the regulations, this level of safety is now achieved thanks to the technical measures implemented in the tunnels, the human resources dedicated to their operation and the systems put in place to organise the work of all those involved.

At the same time, safety management systems (SMS) have been extensively developed over several decades in a variety of fields (civil aviation, rail transport, urban guided transport, mountain ski lifts, facilities classified for environmental protection and basic nuclear facilities, etc.). These systems are a tool for making the organisation of operations more reliable and meeting the objective of maintaining the level of safety achieved.

Therefore, the development and implementation of an SMS for road tunnels makes perfect sense, as it provides a means of consolidating the safety measures deployed to date over time. This is why the deployment of SMS for road tunnels began in 2017. Although these new SMS are based on the same fundamentals as those in other areas, their structure and operation have been designed to be adapted to the specific characteristics of tunnels. Tunnel SMS are based on nine components: definition of roles and responsibilities, skills management, asset management for structural elements and tunnel equipment, coordination with third parties, safety culture, organisation of feedback, documentation, management of modifications and performance assessment.

The initial lessons learned from the deployment of SMS for road tunnels show that the success of a Tunnel SMS is strongly linked to the involvement of all stakeholders, particularly those within the tunnel operating body. These stakeholders are, of course, the staff directly involved in handling the tunnel structure or its equipment, but also the departments in charge of human resources, communication, document management and quality.

It also appears that the commitment of management and of each individual is a guarantee of success, and that collective work within the operating body makes it possible to achieve an integrated safety culture. External stakeholders must also be taken into account, in the context of coordination with third parties.

Finally, the SMS must be promoted as part of the overall safety approach, in particular through the safety documentation.

Of course, from a pragmatic point of view, the approach may seem time-consuming to implement. Indeed, a minimum level of involvement is required, particularly in terms of time, but organisations with a Tunnel SMS agree that the benefits are significant and manifold. Firstly, in the short term, departments work together during the construction of the system and, as such, the SMS improves mutual understanding of their roles, responsibilities and constraints. Then, in the medium and long term, the SMS makes the organisation more resilient, particularly when there are staff changes. In addition, a legal analysis of the Tunnel SMS has also highlighted the benefits in terms of judicial robustness. The SMS is an effective management tool that allows choices made and commitments undertaken to be traced and monitored over time.

The present guide provides the keys to building an SMS for tunnels, in terms of method and content. Each tunnel operator is thus able to build an SMS, which must of course remain consistent with the specific challenges of the operating body and the tunnels operated.

This guide can also be of assistance to operators wishing to adopt a simpler, more targeted approach, limited to certain areas that they consider to be priorities within their organisation, without embarking on a full SMS process, while still focusing on continuous safety improvement.

8

BIBLIOGRAPHY

[1] CETU, Information Note No. 21, « *Le cadre réglementaire de la sécurité des tunnels routiers* » (*The regulatory framework for road tunnel safety*), 2011 (available in French).

[2] Instruction technique relative aux dispositions de sécurité dans les nouveaux tunnels routiers (*Technical directive relating to safety provisions in new road tunnels (design and operation)* – Appendix 2 to interministerial circular no. 2000-63 of 25th August 2000, repealed (Appendix 2 remains in force under circular 2006-20 (available in French)).

[3] Economic Commission for Europe, Economic and Social Council, *Recommendations of the Group of Experts on Safety in Road Tunnels, Final Report*, 10th December 2001 (available in English).

[4] CETU, Guide to road tunnel safety documentation, *Booklet 1 – Safety documentation objectives*, 2003 (available in English).

[5] ITSEOA - Instruction technique pour la surveillance et l'entretien des ouvrages d'art (*Technical directive for the monitoring and maintenance of engineering structures* (available in French) – Circular of 16th February 2011 and its application booklet, Fascicule 0: Dispositions applicables à tous les ouvrages (*Booklet 0: General provisions applicable to all structures*), 2010 (available in French).

[6] CETU, Guide, *Methodological guide on safety exercises in road tunnels*, 2017 (available in English).

[7] CNESOR – Bilan et principaux enseignements des dossiers examines sur la période 2013-2017 (*National Commission for the Assessment of Road Infrastructure Safety – Review and main lessons learned from cases examined during the period 2013-2017*), 2021 (available in French).

[8] ITSEOA - Instruction technique pour la surveillance et l'entretien des ouvrages d'art (ITSEOA) (*Technical instruction for the monitoring and maintenance of engineering structures* – Circular of 16th February 2011 and its application booklet, *Booklet 40: Tunnels: Structural elements and equipment*, 2012 (available in French).

[9] ITSEOA - Instruction technique pour la surveillance et l'entretien des ouvrages d'art (ITSEOA) (*Technical directive for the monitoring and maintenance of engineering structures (ITSEOA)* – Circular of 16th February 2011 and its application booklet, *Booklet 1:Tunnel history file*, 2016 (available in French).

[10] CARSAT Rhône-Alpes, La mission de coordination SPS et le role du maître d'ouvrage (*The health and safety coordination mission and the role of the project owner in building and civil engineering operations*), 2020 (available in French).

[11] CETU, Information document, Pannes, accidents et Incendies en tunnel routier – Élements statistiques (*Breakdowns, Accidents and Fires in Road Tunnels – Statistical Data*), 2022 (available in French).

[12] C. Casse, Thesis, Concevoir un dispositive de retour d'expérience integrant l'activité reflexive collective : un enjeu de sécurité dans les tunnels routiers (*Designing a feedback mechanism incorporating collective reflection: a safety issue in road tunnels*), defended on 12th November 2015 (available in French).

[13] CETU, Information document, L'examen périodique de sécurité des tunnels routiers – Renouvellement de l'autorisation de mise en service (*Periodic safety review of road tunnels – Renewal of operation autorisation*), 2016 (available in French).

[14] CETU, Guide to road tunnel safety documentation, *Booklet 3 – Assessing risks related to the carriage of dangerous goods*, 2018, available in English).

[15] CETU, Guide to road tunnel safety documentation, *Booklet 4 – Specific Hazard Investigations*, 2003 (available in English) and CETU, Information Document, Étude spécifique des dangers (ESD), compléments au fascicule 4 du guide des dossiers de sécurité (*Specific Hazard Investigations, supplement to Section 4 of the Guide on road tunnel safety documentation*), 2023 (available in French).

[16] CETU, Guide to road tunnel safety documentation, *Booklet 5 –The Emergency Response Plan 2006* (available in English).

[17] INERIS, Guide, Pilotage de la sécurité par les indicateurs de performance – Guide à l'attention des ICPE (*Safety Management through Performance Indicators*), 2015 (available in French).

9 OTHER DOCUMENTS ON THE SAME SUBJECT

DGAC, Guide relative à la mise en œuvre d'un système de gestion de la sécurité par les exploitants d'aérodrome (*Guide to the implementation of a safety management system by aerodrome operators*), 2008 (available in French).

EPSF, Guide d'élaboration et de mise en œuvre d'un système de gestion de la sécurité (*Guide to developing and implementing a safety management system – Guide for railway operators*), 2015 (available in French).

STRMTG, Guide d'application RM-SGS1 : Contenu du SGS pour les exploitants de remontées mécaniques en zone de montagne (*RM-SGS1 Application Guide: Content of the SMS for ski lift operators in mountain areas*), 2016, revised in 2024 (available in French).

STRMTG, Guide d'application RM-SGS2 : Contrôle périodique du SGS pour les exploitants de remontées mécaniques en zone de montagne (*Application Guide RM-SGS2: Periodic Inspection of the SMS for operators of ski lifts in mountain areas*), 2016, revised in 2021 and then in 2024 (available in French).

STRMTG, Guide, Systèmes de transport publics guides urbains de personnes – Règlement de Sécurité de l'Exploitation – Explicitation de l'annexe 5 de l'arrêté modifié du 23 mai 2003 (*Urban guided public transport systems for passengers – Operational Safety Regulations – Explanation of Appendix 5 to the amended decree of 23 May 2003*), 2009 (available in French).

ICSI, L'essentiel de la culture de sécurité (*The essentials of safety culture*), 2017 (available in English).

ICSI, La culture de sécurité – Comprendre pour agir (*Safety Culture – From understanding to action*), document produced as part of the "Safety Culture" working group, edited by D. Besnard, I. Boissières, F. Daniellou and J. Villena, 2017 (available in English).

A

APPENDIX A
SELF-ASSESSMENT CHECKLIST

The self-assessment checklist provides a framework for monitoring the construction of the SMS by listing the items in the manual.

From the outset of the SMS development process, as indicated in paragraph 5.1.1, this checklist is a tool that provides an overview of how the safety approach is implemented within the organisation. When used as the starting point for developing an SMS, it enables an assessment of the current situation to be shared and a roadmap to be established for developing the tunnel SMS.

Topics			**Details regarding content** *Each paragraph may refer to existing useful documents (link)*
Chapter (outline of the manual)	**Paragraph (manual structure)**		
Modification and revision of the manual			Persons responsible for drafting, validation, distribution, and monitoring updates
Purpose of the SMS manual	Introduction		Description of the manual's content
			Reference to requirements and this methodological guide
			Reference to applicable regulatory requirements
	Identification of the operator		Identification of the tunnel operating body (detailed description of this organisation in the following paragraphs)
	Description of the SMS		Definition: "*The Tunnel SMS is the organisation and provisions established to optimise the safe operation of road tunnels by managing risks in an efficient manner that is appropriate to operational safety issues.*"
			Describe the limits of the system and external interfaces (links with other procedures within the operating body, e.g. the Quality Management System known as the QMS)
	Scope of the SMS		Geographical scope: list of tunnels and main characteristics
			Functional scope: operation, maintenance, etc. Scope limitations and specific choices made by the operator (e.g. all tunnels or only those longer than 300 m)
Operator's safety organisation	General overview		Functional organisation indicating the various departments and their general responsibilities, particularly those playing a role in the SMS: operations, maintenance, skills management, internal control, etc.
			Presentation of any certifications, particularly if the SMS is based on the corresponding organisation and documentation relating to its operational activities (e.g. existence of operational or maintenance procedures linked to any ISO 9001 or other certification held by the operator).
	Description of operating conditions		Description of the different operating modes: • normal operation; • degraded mode operation; with particular emphasis on operating conditions, specific features that are likely to pose a particular risk (remote entities/offices, lack of redundancy, etc.), the transition from one mode to another, etc. *Importance of referring to existing organisational documents (Emergency Response Plan, instruction manuals, etc.)*
	Organisation of safety		Organisational chart listing at least the operator's accountable manager and the SMS coordinator (names are to be provided), local SMS contacts, where applicable, staff with safety-related duties and all bodies involved in the SMS
	Safety-related duties and responsibilities	Accountable manager	Describe his/her role and responsibilities Highlight the commitment of the accountable manager
		SMS coordinator	Name of the SMS coordinator or job title (if not specifically named in the SMS manual) Refer to the SMS coordinator's letter of assignment Detail his/her duties and responsibilities in order to make them known to their contacts, particularly those who will be involved in the SMS (for feedback, documentation, etc.)

Topics			Details regarding content *Each paragraph may refer to existing useful documents (link)*
Chapter (outline of the manual)	**Paragraph (manual structure)**		
Operator's safety organisation	Safety duties and responsibilities	Local contacts	Designation of local SMS contacts by name Reference to the letters of assignment for local SMS contacts List of their duties and responsibilities in order to make them known to their professional relations, particularly those who will be called upon in the context of the SMS (for feedback, documentation, etc.)
		Managers of operational and maintenance departments	Description of the roles and responsibilities of those in charge of organising operations (scheduling, staffing, work organisation, arbitration bodies, etc.)
		Personnel in charge of operational tasks	Description of the roles and responsibilities of personnel in charge of performing tasks related to tunnel operation
		Other departments involved within the organisation	Description of the roles and responsibilities of external parties who are not involved in operations but have a role to play in the SMS: the human resources department (recruitment), the training department (skills management), the quality manager (internal controls)
Safety policy			Commitment of the accountable manager
			Procedures for taking into account the priority safety objectives defined following risk analysis
			Procedures for reviewing the safety policy, including timetable, management, person responsible
Risk management			Description of the risk management process: • risk identification; • risk analysis
			Prioritisation of risks and selection of the top risks to be addressed
			Definition of the resulting safety objectives and any measures taken to meet them
			Procedures for reviewing and updating the risk management process, including timetable, management, responsibility, traceability
Skills management			Identification of tasks and activities that impact the safety of users and staff concerned
			Methods for developing a skills map
			Process for establishing a skills development plan by profession
			Description of the initial training programme
			Description of the continuous training programme
			Description of procedures for monitoring staff skills
			System for ensuring the implementation of the elements described above
Monitoring of structural element and equipment assets			Organisation, implementation and traceability of monitoring, maintenance and major structural element repair operations, as well as equipment inspection, maintenance (preventive, corrective and remedial) and renewal operations: • management, planning and definition of maintenance and servicing policy; • implementation and monitoring of maintenance and servicing actions, traceability; • implementation and monitoring of actions following initial detailed inspections and periodic detailed inspections, traceability; • scheduling, organisation and traceability of major renewals and repairs
			Inventory management system (for equipment assets)
			Description of the system used to ensure the implementation of the elements described above
Coordination with third parties			Identification and description of the roles of each external stakeholder who may interact with the operation of the tunnel (normal operation, crisis situation, maintenance or works): • users; • companies (routine maintenance and works); • network providers; • interface operators (road network, energy, water, car parks, etc.); • emergency services; • administrative authorities and, where applicable, the tunnel safety officer.
			Means of communication with these parties (refer to specific procedures)
			Existing safety procedures for on-site intervention by responders

Topics		Details regarding content *Each paragraph may refer to existing useful documents (link)*
Chapter (outline of the manual)	**Paragraph (manual structure)**	
Safety culture		Internal and external communication actions (meetings, memos, newsletters, etc.) and monitoring of their implementation Details of topics covered (feedback, regulations, general safety policy and safety objectives, role and responsibility in the SMS, human factors, etc.)
Organisation of feedback		Description of the system deployed within the organisation (safety exercises and incidents, internal and regulatory feedback)
		Means for ensuring the described system
SMS documentation		Scope covered by SMS documentation
		Method for managing SMS documents, modification, traceability, history, distribution
		Documentation review procedures, including management and responsibility
Management of material or organisational modifications		Identification and characterisation of modifications, impact assessment, implementation procedures, in particular for the following types: • changes relating to the tunnel or its operating conditions (substantial or not, significant or not, other, etc.); • changes relating to the organisation in place within the operating body; • changes to the SMS (scope, content, etc.)
		Identification and involvement of internal and external stakeholders affected by the modifications
		Method of reviewing the modifications management process, person(s) responsible
Performance assessment		Monitoring the implementation of measures relating to the priority objectives set
		Monitoring the effectiveness of these measures, in particular through indicators
		Regular reassessment of measures and the relevance of indicators
		Method for reviewing the performance monitoring process, responsible party
Permanent control and assessment of the level of safety	Internal controls	Appointment of a manager and description of implementation procedures
	Periodic safety review every 6 years	Appointment of a manager and description of implementation procedures
	SMS audits	Appointment of a manager and description of implementation procedures

B

APPENDIX B
RISK ANALYSIS

As presented in section 5.1.3 of the present Guide, to identify risks, the operator may use a generic operational risk map, either as a basic tool to be adapted to the context, or to supplement an existing map.

After a general presentation of risk mapping, this appendix provides a draft risk map for several components of the SMS and examples of the risk assessment method.

B.1 GENERIC RISK MAP

B.1.1 Presentation

The generic mapping presented here is based on the systemic approach usually adopted for road tunnels to take into account technical, human and organisational factors. This systemic approach comprises four elements. The system cannot be understood in a sectorised manner, as the elements communicate and interact with each other. It is also open to its external environment.

The tunnel system interacts to a varying extent with its immediate environment. These local interfaces must be taken into account in the potential risks.

All of the elements and interfaces are illustrated in the figure presented in section 2.2.1.

Montgenèvre cut and cover tunnel (© DIRMED)

B.1.2 System components

Organisation

In conjunction with the tunnel owner, the operator is responsible for managing the safety of tunnel users on a daily basis, as well as maintaining the tunnel in working order with a predefined level of safety.

To maintain this level of safety, a coherent and structured organisation must be established: application of the regulatory framework, general organisational means, operating resources, skills management, procedures management, etc.

Infrastructure

The term infrastructure encompasses both structural elements and equipment.

It must be adapted and maintained to allow traffic to flow under predefined safety conditions. This requires the monitoring and maintenance of structural elements as well as the inspection, maintenance and renewal of equipment.

The constraints associated with the construction phases must not be overlooked.

Users

Users travel through the tunnel for their journeys. They are responsible for complying with traffic regulations and maintaining their vehicles.

When users travel in a motor vehicle, from a safety management perspective, they can be treated as part of the traffic flow. This is why, in this particular case, they are treated in the "vehicle" component.

Siaix Tunnel – Safety exercise 2024 (© DIRCE)

When users travel on a non-motorised two-wheeled vehicle or on foot (particularly in degraded operating mode), from a safety management perspective, they can no longer be considered as part of the traffic flow.

Users are the first stakeholders capable of taking action to ensure their own safety (driving manoeuvres, emergency phone calls, self-evacuation, possible attempts to extinguish a fire, etc.). It is therefore essential to take into account accessibility for users and communication with them.

Vehicles

Vehicles represent the traffic flows circulating within the tunnel.

They have their own characteristics, which can vary greatly from one vehicle to another: calorific potential and vehicle load, age, maintenance, kinematics, etc.

They are subject to traffic regulations and the Highway Code. Knowledge of vehicle traffic and possible diversion measures in the event of a tunnel closure, whether planned or unplanned, helps to control this flow.

B.1.3 Local interfaces

Safety stakeholders

This local interface is closely intertwined with the tunnel system. In coordination with the operator, safety stakeholders contribute directly to event management. These include emergency and rescue services, the police and the prefecture.

There is a high level of interaction with this interface, which plays a key role in risk management.

Interface with third parties

Interface with third parties, whether they are likely to be affected by the event or whether an event on their network may have an impact on the tunnel, must be carefully listed. These include operators and users of interface structures: slabs or high-rise buildings above a cut and cover tunnel, adjoining car parks, road or metro tunnels in proximity with the tunnel portals or interior zone, buildings near smoke extraction chimneys, etc.

Issues concern communication means during normal operation and in degraded operating mode (transmission of alerts, etc.), procedures, etc.

Persons compromising the level of tunnel safety

Persons outside the traffic circulating in the tunnel who compromise the safety of the structure include:

- persons who commit malicious acts, causing damage to safety equipment or the road surface, or partial destruction of the tunnel with the aim of causing material damage or injury to persons;
- persons who illegally occupy premises related to safety, potentially preventing their use.

The media

Although their direct impact on safety management is limited, the media must be taken into consideration.

Firstly, the media are a vehicle for communicating good practices and safety culture to the general public.

Secondly, during crisis management, all tunnel safety stakeholders are required to collaborate with them to provide information and, if possible, to coordinate it, in order to avoid the possible dissemination of misinformation and confusion.

B.1.4 Examples of risk analysis grids

A risk analysis grid can take the form of a table. It is a structured but non-ranked presentation, with any ranking being determined by the operator.

The first column defines the main categories of risk, which correspond to the main shortcomings that may be encountered.

A shortcoming represents an absence or an insufficiency.

The sources of risk associated with these categories are listed in the second column.

Through these first two columns, the risk is identified and characterised.

The third column contains a series of questions to help the operator explore the risks listed.

Risk category	Source of risk	Questioning aid
System element: organisation		
Non-compliance with regulatory obligations	Lack of authorisation for commissioning	Do all tunnels have a valid operating authorisation? Was the time required to update the safety documentation and the five-month period between submission to the prefecture and expiry of the authorisation anticipated?

B.2 RISK ASSESSMENT FOR THE SKILLS MANAGEMENT COMPONENT

B.2.1 Risk map

The table below presents a generic mapping of risks related to skills management, **which is neither exhaustive nor ranked**: the ranking must be established by the operating body as part of the risk analysis specific to its organisation.

Risk category	Source of risk	Help with questioning
System element: organisation		
Inadequate skills management	Absence of a skills development plan	Does the existing skills development plan take into account the specific characteristics of tunnels?
	Inappropriate skills development plan	Is the skills development plan consistent with the listed roles and responsibilities? Does the skills development plan cover all staff (operators, patrol officers, maintenance staff, management, etc.)? Is it being implemented? Who is overseeing it?
	Lack of knowledge and skills	Do the training courses enable participants to acquire the expected knowledge and skills? Is there a process for assessing and monitoring these acquisitions? What assessment tools are available?
Lack of resources	Insufficiency of human resources (vacant positions, insufficient skills, etc.)	Does the available workforce enable all tasks related to tunnel operation to be carried out under normal operating conditions? Under degraded operating conditions? Does the organisation have a skills development plan that is consistent with its operational activities? Does this plan cover all operational staff roles? Is it monitored? Have critical positions in terms of skills been identified? Are there any specific recruitment requirements? Is it necessary to develop staff skills for certain operational activities?
	Poor allocation of human resources in relation to needs and skills	Are job descriptions clearly defined according to needs and skills?
Local interface: users		
Inappropriate behaviour in tunnels	Lack of training and awareness	Is there a list of inappropriate behaviour in tunnels (driving in the wrong direction, keys left in the ignition, returning to the smoke-filled tunnel, etc.)? Have any awareness campaigns been conducted to promote appropriate behaviour?

B.2.2 Example of the risk assessment method applied to skills management deficiencies

Example of an analysis of skills management deficiencies:

Staff concerned:

- *control room operators;*
- *maintenance technicians;*
- *operations agents;*
- *on-call managers...*

Possible causes:

- *lack of a training policy:*
  - *lack of a skills development plan or an inadequate skills development plan;*
  - *training schedule not adapted to dates of staff starting their positions;*
  - *lack of training provision (non-existent, insufficient funding);*
  - *lack of support from the training department;*
  - *lack of training time due to staff workloads;*
  - *lack of recruitment and management of departures and arrivals;*
  - *lack of simulation and training tools;*
  - *lack of monitoring of tool development;*
- *lack of or poor updating of documentation:*
  - *documentation not made available to staff.*

Possible consequences:

- *poor knowledge of the tunnel, its structural elements and the operation of its equipment;*
- *lack of knowledge of the specific characteristics of tunnels;*
- *poor knowledge of the organisation;*
- *incorrect treatment or characterisation of an event;*
- *failure to apply the Emergency Response Plan (poor knowledge);*
- *insufficient or excessive maintenance;*
- *incorrect budget assessment;*
- *poor monitoring of structural elements and tunnel equipment;*
- *contradictory instructions;*
- *endangering of staff.*

This makes it possible to define one or more objectives, for example:

- *ensure that needs and skills are matched;*
- *define a skills development plan for each job role and adapt it for each employee;*
- *identify specific skills and ensure that they are maintained.*

B.3 RISK ASSESSMENT FOR THE ASSET MANAGEMENT COMPONENT

B.3.1 Risk map

The table below presents a generic mapping of risks related to asset management. **It is neither exhaustive nor ranked:** the operating body must carry out ranking as part of the risk analysis specific to its organisation.

Risk category	Source of risk	Questions to consider
System component: infrastructure		
Failure of operating and safety equipment	Non-functional or unavailable equipment	Is the tunnel equipment functioning correctly? Does the tunnel equipment meet the needs of external stakeholders (suitable fire hydrants, etc.)? Is the equipment available (false AID alarms, different connected lighting systems, etc.)? Is there a periodic assessment of equipment availability?
Failure to monitor and maintain structural elements (including repairs, renovation, etc.)	Failure to plan monitoring and maintenance of structural elements (walls, roadway, etc.)	Is there a monitoring and maintenance plan for structural elements? Are inspections scheduled? What is the frequency and methodology for each element of the structure? Have the roles and responsibilities of operating personnel and external service providers been defined (in-house or outsourced services)? How is information exchange facilitated between the department responsible for tunnel monitoring (traffic management and equipment supervision) and the department responsible for tunnel maintenance? How are operational constraints taken into account? Is staff made aware of these issues (patrols, etc.)?
	Failure to implement monitoring and maintenance	Are maintenance and monitoring actions for the structural elements implemented? Are the provisions set out in booklet 40 of the ITSEOA implemented (in relation to corrosion, convergence measurement, water ingress, cracking, etc.)?
	Failure to implement continuous improvement	If necessary, are monitoring actions followed up? Are maintenance actions analysed? Is this analysis followed up? Are deadlines set?
Failure to inspect, maintain and renew equipment	Failure to plan equipment inspection, maintenance and renewal	Is there an equipment inspection plan? Is there an equipment maintenance plan? Is it consistent with the minimum operating requirements defined in the Emergency Response Plan? Does this plan include preventive maintenance? Corrective maintenance? Curative maintenance? Are initial detailed equipment inspections and periodic detailed equipment inspections planned? Is there an equipment renewal plan? Are the roles and responsibilities of operating personnel and external service providers for equipment inspection, maintenance and renewal defined? How is the exchange of information between traffic management and equipment supervision staff and the maintenance department facilitated? How often does this take place? How are operational constraints taken into account? Is staff made aware of these issues (patrols, etc.)?
	Failure to implement equipment inspection, maintenance and renewal	Are equipment inspection, maintenance and renewal measures implemented? Are the provisions set out in booklet 40 of the ITSEOA implemented? How are any discrepancies between the contractual specifications and the services actually provided by the companies assessed?

Risk category	Source of risk	Questions to ask
Inspection, maintenance and equipment replacement deficiency	Inventory shortage	Is there an inventory management procedure in place? Is there an inventory management tool? Are the parts needed for maintenance available? Are the parts used obsolete? How is the equipment evolving to compensate for obsolescence?
	Failure to implement continuous improvement	Are equipment inspection measures followed up on? Are faults and malfunctions taken into account? How is this documented? Are maintenance and renewal subject to analysis? Is this analysis followed up? Have deadlines been set?

B.3.2 Example of the risk assessment method applied to asset management deficiencies

Example of an analysis of failure to plan or implement equipment maintenance and renewal:

Possible causes:

- *lack of knowledge of booklet 40 of ITSEOA;*
- *lack of technical documentation;*
- *large number of items of equipment to be inspected and maintained;*
- *limited access to equipment (restricted to certain nights during scheduled closures);*
- *insufficient human resources in relation to the workload;*
- *lack of skills (temporary or permanent loss);*
- *insufficient budget (particularly for renewal);*
- *insufficient inspection resources;*
- *lack of policy and centralised management of equipment monitoring and maintenance (wait-and-see approach);*
- *lack of documenting of actions undertaken or to be undertaken;*
- *lack of tools for tracking service requests and follow-up actions;*
- *lack of follow-up on maintenance reports;*
- *operational constraints;*
- *visits scheduled too late to obtain the necessary operating measurements.*

Possible consequences:

- *inappropriate, poorly installed or incorrectly configured equipment;*
- *obsolescence of equipment;*
- *failure to comply with defined schedules;*
- *failure to carry out regulatory inspections;*
- *loss of credibility, legal liability;*
- *varying approaches in different sectors;*
- *serious breakdowns, corrective interventions;*
- *emergency interventions following ineffective or insufficient preventive maintenance;*
- *excessive corrective maintenance;*
- *decreased effectiveness of maintenance actions;*
- *cost or deadline overruns (inconsistencies between technical specifications and actual services provided);*
- *lack of documenting of actions undertaken (in-house or outsourced) to verify their effectiveness, lack of reporting;*
- *lack of tools for monitoring intervention requests and data;*
- *failure to address defects identified during inspections;*
- *operational constraints;*
- *operation below the acceptable minimum operating conditions or closure of the tunnel;*
- *decreased user safety (if the problem is not detected).*

B.4 RISK ASSESSMENT FOR THE COORDINATION WITH THIRD PARTIES COMPONENT

B.4.1 Risk map

The table below presents a generic mapping of risks related to coordination with third parties. **It is neither exhaustive nor ranked:** ranking must be carried out by the operating body as part of the risk analysis specific to its organisation.

Risk category	Source of risk	Questions to ask
System element: organisation		
Failure to comply with regulatory obligations	Inadequate safety documentation	Does the safety documentation for each tunnel contain the documents required by regulations (Emergency Response Plan, feedback, safety exercises, etc.)? Does this safety documentation accurately reflect the reality of the tunnel's operations and the operating body's organisation? What about distribution? To whom? How? Which version?
Lack of general organisation means	Failure to define roles and responsibilities consistent with those of external partners	Are the roles of management and leadership, supervision and operational execution clearly defined? Are the roles and responsibilities of each person in outsourced tasks clearly defined and documented?
	Lack of monitoring and control of operational activities	Is there a system in place to track decisions and actions taken? Have measures been put in place to control operational activities? Who is responsible for monitoring? If there is a safety officer, what is his/her specific role? What is their contract? Is he/she assigned on an ad hoc basis?
Poor procedure management	Lack of procedure implementation	Are procedures implemented? If necessary, do these procedures include third parties? How are they communicated?
System component: infrastructure		
Failure to comply with traffic regulations	Failure to comply with rules	Are the facilities consistent with the applicable traffic rules? Are traffic regulations being observed (safety distance, speed, prohibition of certain types of vehicles, prohibition of overtaking, red lights, etc.)? Was it necessary to implement sanctions?
	Failure to implement preventive measures	Are awareness campaigns being implemented? Are users aware of the meaning of the tunnel sign?
Lack of an efficient diversion	Failure to implement a traffic management plan (TMP)	Is there a traffic management plan in place? What measures are implemented when there is no reliable diversion route?
	Failure to implement the TMP	Has this plan been tested? With external stakeholders? Is it implemented when necessary? What feedback is provided after implementation?
System component: users		
Failure to comply with traffic regulations by pedestrians and cyclists	Failure to comply with rules	Are traffic regulations being complied with? What measures have been implemented?
	Lack of signage	Is adequate signage in place? Is there advance warning signage? Is it visible? Is it understandable? Are pedestrians and cyclists taken into account when they are permitted?
Lack of communication with users	Lack of means of communication	What means are available to communicate with users (emergency call stations, signage, mobile phones, FM message overlay, etc.)? In degraded operating mode? For a return to normal? Are they operational? Do users use them? Are the messages pre-recorded or on demand?
	Lack of understanding (information relating to foreseeable disruptions, such as works)	Are the means of communication audible during normal operation? During degraded operation? Who communicates with the user? Are they trained to understand the message? Do they have the right instructions? Is the response given to the user appropriate? Is the language used appropriate (foreign language, overly technical language, etc.)?
Inappropriate behaviour in tunnels	Lack of training and awareness	Do you have a list of inappropriate behaviour in tunnels (driving in the wrong direction, keys left in the ignition, returning to the smoke-filled tunnel, etc.)? Have you carried out any awareness-raising activities on appropriate behaviour?

Risk category	Source of risk	Help with questioning
Local interface: safety stakeholders		
Lack of interaction with safety stakeholders	Lack of coordination with safety stakeholders	Have the various stakeholders been taken into account (emergency services, law enforcement, prefecture, safety officers, etc.)? Are they involved at all levels of the system (policy, procedures, feedback, etc.)? Does taking the individual practices into account enable safe intervention?
	Lack of assistance for intervening stakeholders	What resources and actions are implemented to facilitate the work of stakeholders who are external to the operating body? (consider the provision of documentation and intervention requirements in the field) What resources and actions are implemented to facilitate their access to the tunnel, and their subsequent actions?
	Failure to take into account the return to normal operating conditions	What are the reopening procedures conducted in interaction with safety stakeholders?
Local interface: third parties at interface with the tunnel		
Failure to take third party interfaces into account	Poor communication	Is there a procedure for communicating information about a specific event (works, public protest, etc.)? Is there a procedure for communicating information in degraded operating mode? Are third parties aware of "tunnel-specific issues"?
	Deficiencies in procedures	What procedures are in place for third parties who may be impacted by works? What procedures are in place in the event of a fire (cut-and-cover tunnel with buildings above, etc.)?
Local interface: media		
Failure to take media into account	Failure to manage communication with the media	Is there a media communication plan for degraded operating mode and normal situations (best practices, dissemination of information, etc.)?

B.4.2 Example of the risk assessment method applied to deficiencies in the coordination with third parties

Example of an analysis of deficiencies in the coordination with third parties:

Possible causes:

- *poor identification of third parties involved;*
- *lack of communication with identified third parties;*
- *poor knowledge of the organisation of the third parties involved;*
- *poor consideration of the needs of emergency services;*
- *shortcomings in defining the roles and responsibilities of the operator's personnel with regard to managing contractor interventions;*
- *lack of communication between the person in charge of scheduling the intervention and the staff managing the intervention in the field;*
- *lack of communication with users regarding traffic restrictions made necessary by works or an incident.*

Possible consequences:

- *poor management of an incident;*
- *endangerment of tunnel users (e.g. presence of a gas pipe in the tunnel that is inadequately protected and not shut off in the event of a fire);*
- *endangering users of a connected network (e.g. users of a railway line crossing the tunnel that is inadequately protected or a network with aeraulic interfaces);*
- *interventions made impossible by lack of organisation or coordination (simultaneous presence of workers whose tasks are incompatible: periodic detailed inspection and cleaning of the tunnel walls);*
- *traffic management made difficult by a lack of anticipation (traffic congestion near the tunnel due to the failure to implement a traffic management plan).*

B.5 RISK ASSESSMENT FOR THE FEEDBACK COMPONENT

B.5.1 Risk mapping

The table below presents a generic mapping of the risks associated with the organisation of feedback. **It is neither exhaustive nor ranked:** the ranking must be established by the operating body as part of the risk analysis specific to its organisation.

Risk category	Risk source	Questioning aid
System element: organisation		
Failure to comply with regulatory obligations	Inadequate safety documentation	Does the safety documentation for each tunnel contain the documents required by regulations (Emergency Response Plan, feedback, exercises, etc.)? Do these components of the safety documentation accurately reflect the reality of the tunnel's operations and the operating body's organisation? What about distribution? To whom? How? Which version?
Lack of general organisation means	Lack of coordination or management or facilitation of feedback	How are staff mobilised and involved in feedback? How is this implemented? Are there information, discussion and consultation meetings? Are staff members properly embracing the approach? Is feedback provided to all staff involved in the event?
	Failure to continuously improve the general feedback system	Is there an internal feedback system? What is its scope (significant events or beyond)? If the scope extends beyond significant events, what types of events are taken into account and according to what criteria? How often? In what form (debriefing, monitoring committee, etc.)? Who leads it? Who participates? Have corrective, remedial and preventive actions been defined where necessary? Has a manager been appointed for each of these actions? Are they accompanied by a deadline for completion/implementation? How are they monitored?
Failure to manage procedures	Procedural failure	Are the tasks broken down into procedures for actions related to feedback and safety exercises? Are these procedures consistent with the safety documentation? Is there a standard template for immediate and delayed debriefings? For reports on lessons learned from events and safety exercises? For personnel shift changes? Is there a process for validating and updating procedures?
	Failure to implement procedures	Are the procedures being implemented? Are these procedures coordinated with external parties, if necessary? What about dissemination?
Local interface: safety stakeholders		
Failure to interact with safety stakeholders	Lack of coordination with safety stakeholders	Are the various stakeholders taken into account? (emergency services, law enforcement, local authorities, etc.) Are they involved at all levels of the feedback system on events and safety exercises? Are there procedures in place for the participation of external stakeholders? Is there consistency in practices among all stakeholders? Is there a difference in the dissemination of lessons learned and information depending on recipients?

B.5.2 Example of the risk assessment method applied to deficiencies in feedback organisation

Example of analysis of feedback organisation deficiencies:

Possible causes:

- *lack of awareness of the benefits of the approach;*
- *lack of a documented procedure;*
- *lack of sharing of the procedure;*
- *limitation of the process to internal stakeholders within the tunnel operating body;*
- *gaps in the definition of the roles and responsibilities of each participant in the feedback mechanism;*
- *failure to take into account or poor consideration of feedback from staff involved in an event;*
- *failure to provide feedback to the staff involved;*
- *lack of clarity in the use of feedback.*

Possible consequences:

- *failure to take into account or poor consideration of the changes necessary for the proper management of an event;*
- *poor management of subsequent events (whether similar or not);*
- *poor coordination between the services involved in managing an event;*
- *occurrence of a similar event with more serious consequences;*
- *concealment of errors made by the staff in charge of managing an event;*
- *loss of trust between stakeholders (internal and external);*
- *systematic definition of exercise scenarios that are inconsistent with the events that occurred in the tunnel.*

B.6 RISK ASSESSMENT FOR THE MANGEMENT OF MODIFICATIONS COMPONENT

The main risks associated with modifications are:

- failure to take into account the consequences of modifications, underestimating or misjudging their impact on safety;
- failure to take them into account in documentation or practices;
- their non-traceability.

The causes may include insufficient training in SMS and risk management principles, a punitive or inadequate safety culture, excessive workload, staff shortages, poor organisation of documentation, etc.

The consequences may include a deterioration in safety (endangerment, increased probability of occurrence or consequences of an event), insufficient or inadequate training, poor operational preparedness, poor internal or third-party coordination, loss of information, and legal risks.

C

APPENDIX C
EXAMPLE OF A TYPICAL SMS MANUAL STRUCTURE

The proposed table of contents is a tool that operators must adopt and adapt to their specific context and issues.

- Purpose of the SMS manual
  - Identification of the operator
  - Description of the SMS
  - Scope of the SMS

- Operator's organisational practices for safety
  - General overview
  - Organisation for safety
  - Description of operating conditions

- Safety duties and responsibilities
  - Accountable manager
  - SMS coordinator
  - Local SMS contacts
  - Duties and responsibilities of operational and maintenance department managers
  - Additional duties and responsibilities
  - Responsibilities of all staff in charge of operational tasks

- Safety policy, if not covered by a specific document

- Risk management

- Skills management

- Management of structural elements and equipment assets

- Coordination with third parties, including, where applicable, the safety officer

- Safety culture

- Organisation of feedback

- Documentation

- Management of material or organisational modifications

- Performance assessment

- Permanent system for monitoring and assessing the level of safety
  - Internal controls
  - Periodic safety review every six years
  - SMS audits

- Appendix: list of reference documents

- Glossary

D

APPENDIX D
ADDITIONAL INFORMATION RELATED TO SMS COMPONENTS

D.1 SKILLS MANAGEMENT

D.1.1 Definitions

To address the "Skills Management" component within the SMS framework, the following definitions should be shared:

Aptitudes	Characteristics inherent to the individual: physical, physiological, psychological.
Competencies	A competency is the individual or collective ability to achieve results in a given professional situation by mobilising knowledge, skills and interpersonal capabilities.
Knowledge	Culture, professional knowledge, knowledge of the professional environment.
Soft skills	Set of behaviours and attitudes in a given situation.
Know-how	Technical, procedural capabilities, etc.
Task	The task, which is the basic unit of work activity, is part of a chronological sequence of operations necessary for the performance of the activity.
Assessment	This involves measuring the gap between a desired level and an achieved level in a professional or training situation. To assess, it is necessary to: • set up an assessment situation appropriate to the objectives to be assessed (questionnaire, interview, practical simulation, etc.); • measure observable elements using predefined criteria. Assessment allows training to be monitored and adjusted according to the results obtained.
Accreditation	Accreditation is recognition of a person's ability to perform specific tasks or activities. This recognition officially authorises the person to carry out these activities.

D.1.2 Assessment of existing systems

To assess the systems in place, the operator refers to the document in each safety documentation file entitled "Description of operations: organisation and resources".

Where available, the following documents are useful:

- skills development plan for the various professions concerned;
- for each existing training course: the topics covered, the objectives and the target audience;
- annual reviews of the skills development plan; failing that, a list of training courses taken by the various categories of personnel with safety-related duties;
- recent reports from the local training committee;
- documents relating to individual skills assessments;
- documents relating to a possible "tunnel" authorisation.

The aim is to assess:

- whether all tasks and activities that impact safety have been identified;
- whether there is a description of the initial training programme and the continuous training programme;
- whether there is a system for monitoring staff skills;
- whether there is a system in place to ensure that the described procedures are followed.

Monts Tunnel – Safety exercise 2025 (© DIRCE)

D.1.3 Initial training

As part of staff skills management, the tunnel operator first defines the recruitment procedures for the personnel it wishes to hire and in particular considers the desirable profile for each position. For example, it will need to determine whether it wishes to recruit people for control room positions who already know how to manage stress well, or whether it considers this to be something that the employee can learn later.

The tunnel operator then establishes a process to ensure that staff involved in safety receive initial training as soon as they arrive. This includes the minimum level of knowledge of the tunnel required for all staff called to work in it, particularly staff who are called in as temporary workers.

This induction training includes a presentation of the tunnels, their equipment and safety principles (emergency procedures, Emergency Response Plan and minimum operating conditions, etc.) as well as a technical tour of the tunnel and the control centre.

It also includes a section specific to each profession concerned, which may consist of off-the-shelf professional training, tailored training and mentoring, depending on the case. Various training courses may already exist or they can be developed and scheduled. Their content and level of detail vary according to the profession (control room operators, patrol officers, maintenance staff, management), ranging from presentations of general principles to specific training courses, or even courses whose content is defined with the applicant.

Some tunnel operators have already developed a skills management process for certain professions, by implementing an initial training validation process or even an accreditation system, particularly for control room operators and maintenance technicians.

Initial training for control room operators must enable them to acquire the qualities (soft skills) required for the job of operator, to have the specific technical and operational knowledge needed to hold an operator position (knowledge) and to acquire practical experience of the job through mentoring (know-how).

Maintenance technicians (MTs) are recruited, where possible, from fields such as electrical engineering, electrotechnology, electronics, IT, etc., as their work requires highly specialised skills. In addition, there are few suitable training courses available other than apprenticeships, which is why it is important to provide specific training when new equipment is deployed. A good understanding of how all the systems work together should also be provided.

The initial training of field agents or patrol officers includes training in the specific nature of tunnel interventions and the risks involved. It enables them to acquire best practices in terms of signage for scheduled works or unforeseen events (accidents, breakdowns, etc.). All their tasks must be taken into account; for example, their role in the continuous monitoring of structural elements needs to be integrated into their skills development plan.

It is necessary to ensure that all **on-call managers** who may be called upon to intervene in an emergency situation in the tunnel have the minimum knowledge required to deal with the situation appropriately using the resources at their disposal. Training on safety issues should be provided for local on-call managers and more senior on-call managers. When senior managers undergo training specific to their role as on-call managers, additional training on specific tunnel-related issues can be useful (theoretical input or simulation exercises).

D.1.4 Continuous training

The tunnel operator shall establish a process to ensure that the skills of personnel involved in safety-related tasks and activities are maintained. The operator shall ensure that they receive continuous training to maintain their skills in specific safety-related areas, in line with their responsibilities, as well as on the SMS itself.

In addition to renewing tunnel-related authorisations for its personnel, the tunnel operator shall define the procedures for regular internal verification of the knowledge and skills of staff performing certain functions for which training is regulated (work on electrical equipment, working at height, driving forklift trucks, etc.).

During scheduled tunnel closures for inspection visits, personnel not performing their duties in the field, particularly control room operators, are invited to participate in site visits in order to familiarise themselves with the tunnel and its equipment.

Safety exercises play an important role in ongoing training. Participation in exercises, whether field exercises or table-top exercises, constitutes ongoing training in itself. When scheduling exercises, the tunnel operator takes into account, where possible, the rotation of control room operator's' shifts so that as many staff as possible can participate and benefit from this experience. In addition to annual joint exercises with emergency services, internal safety exercises can enable staff to train regularly (role-playing, use of models, simulators, etc.).

Feedback from safety exercises and incidents also contributes to the continuous training of staff, providing concrete examples and case studies to supplement training tools. It also allows staff who were not on duty at the time of the exercises or incident to benefit from the experience.

In addition to the annual regulatory exercise, tunnel operating bodies regularly conduct internal scenario-based exercises for control room operators, possibly using simulators. These exercises aim to place the control room operator in a real-life situation:

- *re-enactment for the operator on duty at the time of the event if feedback has shown that he/she encountered difficulties in managing it (incorrect application of instructions, stress, etc.);*
- *role-playing for other operators when the event appears relevant to staff training (e.g. reminder of procedures for a rare event or one newly included in the Emergency Response Plan).*

This approach contributes to staff training and, as such, is documented in the skills development plan.

Lilas cut and cover tunnel – Emergency exit (© City of Paris)

On-call managers are called upon on an ad hoc basis for events that occur infrequently but have high stakes. In particular, for those whose basic duties have little to do with tunnel issues, regular reminders of safety issues in this type of infrastructure should be provided.

In practical terms, ongoing training consists of participation in safety exercises and refresher sessions on the lessons learned during initial training. Various tools can also be used, such as simulator training, e-learning platforms, role-playing, etc.

In the specific case of refurbishment or work modifying tunnel equipment, specific training measures are implemented to accompany the work, in order to adapt operations to the changes made to the tunnel. Training on equipment should be provided as part of works contracts. This training is intended for maintenance staff and equipment machinists and is tailored to each individual's duties. The tunnel operator may usefully give prior notice of their content to ensure that they fully meet operational needs.

Note: although not linked to the skills to be developed by an employee, the management of rare skills must be handled with care, particularly when preparing for a possible change in personnel.

D.1.5 Example of skills mapping for staff responsible for maintenance and interventions

Competencies	Personnel concerned		
	Head of maintenance and intervention centre	Supervisor	Other staff
Authorisations			
Driving licence			
Driving licence type B	x	x	x
Driving licence types C and CE		x	x
Electrical work authorisation			
Electrical work authorisations adapted to the characteristics of the tunnel and the missions of the staff	x	x	x
Other authorisations			
CATEC (Certificate of aptitude for work in confined spaces)		x	x
ACES (Authorisation to drive works/intervention vehicles)		x	x
ATEX (Authorisation to work in an explosive atmosphere)		x	x
QUAPODES (authorisation to install and remove temporary signage)		x	x
Authorisation to work in a bucket truck		x	x
Knowledge			
Monitored tunnels and neighbouring road networks			
Technical characteristics of tunnels	x	x	x
The basics of tunnel safety	x	x	x
Risks in tunnels	x	x	x
The basics of an Emergency Response Plan (ERP)			x
The ERP in effect (actions, alerts, minimum operating conditions	x	x	
Basic characteristics of monitored tunnels (visible equipment, structural elements)	x	x	
Basic knowledge of structural elements	x	x	
Basic knowledge of equipment	x	x	x
Tunnel procedures	x	x	x
The network (routes, diversion routes, turning areas, speed, authorised vehicles, visibility zones...)	x	x	x
Operating provisions			
Regulatory framework for tunnel operation	x		
Organisation and internal documents	x	x	x
Activity logs	x	x	x
Labour and field intervention regulations			
Administrative rules and minimum guarantees in terms of labour regulations	x	x	x
Personal protection equipment needed for field interventions	x	x	x

Competencies	Personnel concerned		
	Head of maintenance and intervention centre	Supervisor	Other staff
Knowledge			
Temporary signage			
Signage procedures and specifics for tunnels	x	x	x
Available material	x	x	x
Visibility zones	x	x	x
Operating strategies (reversal of traffic direction in a tube, in bidirectional mode)	x	x	x
Surrounding area (peak traffic hours)	x	x	x
Alternative routes	x	x	x
Intervention scheduling and intervention by contractors			
Works files and orders (Who? What? How? To do what? Required personal protection equipment...)	x	x	x
Works supervisor manual	x	x	x
Available material – fixed signage	x	x	x
Health and safety coordination regulations	x	x	
Risks related to coactivity	x	x	x
Maintenance contracts	x		
Intervention following an event			
Alert process and chain	x	x	x
Intervention procedures and means (checklists, list of recommended actions)	x	x	x
General event management principles	x	x	(x)
Alternative routes	x	x	x
Maintenance (roadside vegetation and ditches, signage, accessible equipment)			
Equipment to be maintained and its role	x	x	x
Maintenance procedures and the differences between the tunnel portal and the rest of the route, e.g. vegetation cutting needed)	x	x	x
Equipment functioning, drainage networks	x	x	x
Water basin maintenance procedures (by-pass functioning)		x	x
Equipment verifications			
Equipment condition and nominal performance	x	x	(x)
Equipment maintenance plan	x	(x)	
Inspection procedures for each type of equipment	x	x	(x)
Know-how			
General know-how			
First-aid	x	x	x
Safety at work		x	x
Implementation of procedures and recommendations		x	x
Conflict management	x	x	x
Team management and contingency organisation	x	x	
Location on the road network	x	x	x
Understanding a map and locating the tunnel(s) on it	x	x	x
Guiding users and third parties	x	x	

Competencies	Personnel concerned		
	Head of maintenance and intervention centre	Supervisor	Other staff
Know-how			
Safety patrols			
Identification of equipment anomalies or faults	x	x	x
Detection of anomalies on structural elements	x	x	x
Planning and adapting of patrols	x	x	
Communication			
Recording of information in log books	x	x	x
Forwarding of information to senior staff, to the control centre, to the maintenance team (which messages to be sent)	x	x	x
Reporting	x	x	x
Use of adpated communciation tools	x	x	x
Documenting activity (monitoring and traceability)	x	x	x
Adapting information to the recipient	x	x	x
Works planning and monitoring			
Use of suitable material for the task at hand (high pressure hose, grass-cutter, slope tractor)		x	x
Organisation of works	x	x	
Monitoring and supervision of contractors	x	x	
Verification of finsished works	x	x	
Collaboration with third parties	x	x	x
Organisation of co-activities	x	x	
Implementation of co-activities		x	x
Logging of information following contractor intervention		x	x
Verification of signage (when this is the responsibility of the contractor)		x	x
Intervention following an event			
Providing information aimed at users, depending on the type of event		x	x
Choice of procedure, depending on the event		x	
Implementation of procedure		x	x
Feedback implementation and participation	x	x	x
Participation in event management (closure, user guidance, reopening, coordination with internal and external intervention parties, law enforcement or other firefighters)		x	x
Handling exchanges with the media if necessary	x		
Use of the log book		x	x
Setting up a diversion		x	x
Taking up position at the right location (exchanges with law enforcement and other emergency services)		x	x
Use of temporary signage		x	x

Competencies	Personnel concerned		
	Head of maintenance and intervention centre	Supervisor	Other staff
Interpersonal skills			
Thorough	x	x	x
Observant	x	x	x
Responsive	x	x	x
Communicative	x	x	x
Sense of analysis	x	x	x
Organised	x	x	x
Team-oriented	x	x	x
Critical mind	x	x	x
Source of proposals	x	x	x
Good listener	x	x	x
Attentive	x	x	x
Sense of organisation	x	x	x
Ability to adapt	x	x	x
Efficient at managing stress	x	x	x
Diplomatic	x	x	x
Able to work under pressure	x	x	x

D.2 MANAGEMENT OF STRUCTURAL ELEMENTS AND EQUIPMENT

D.2.1 Assessment of existing asset management

Before constructing and implementing the SMS, the tunnel operator assesses its existing asset management system and how it works.

To do this, the tunnel operator gathers:

- from the safety documentation, a description of the organisation of human and material resources and the measures planned by the tunnel owner to ensure the safe operation and maintenance of each tunnel and, in addition, from the preliminary safety documentation, a similar description during the construction period;
- from the safety documentation, the reports from experts and Approved Qualified Organisations including their assessment of the condition of each tunnel and its equipment;
- where applicable, reports from the safety officer, including his/her opinion on maintenance and repair procedures for the tunnel's structural elements and equipment;
- tunnel history files;
- the tunnel management policy, which may be included in the infrastructure management policy;
- the maintenance policy for dynamic equipment and tunnel equipment;
- the annual schedule for monitoring and maintaining structural elements (including monitoring orders for initial detailed inspections and periodic detailed inspections);
- the annual schedule for the maintenance, inspection and renewal of equipment (including monitoring orders for initial detailed inspections and periodic detailed inspections);
- reports from initial detailed inspections and periodic detailed inspections, for both structural elements and equipment;
- the implementation and monitoring procedures for actions following initial detailed inspection and periodic detailed inspection reports;
- logbook recording technical faults and incidents;
- event logs;
- a completed table for monitoring defects and follow-up actions;
- the procedures for managing stocks;
- procedures for subcontractors' intervention and monitoring of equipment;
- etc.

A14/A86 complex – Detailed periodic inspection of equipment (© CETU)

D.2.2 Examples of maintenance-related actions that constitute key points within the framework of the SMS

A maintenance tracking and planning table defines the quarterly, half-yearly and annual operations to be carried out. For each operation, it indicates the nature of the work to be carried out (visual inspection, cleaning, testing, measurements or intervention), the coordinator, whether the operation is subcontracted, and the control sheet to be referred to (see example on the next page). This table may also specify the equipment required, whether a lane or tube needs to be closed for the operation, and include operations to be carried out every six years.

Contracts with subcontractors usefully provide for the establishment of centralised, shared, computerised, accessible and updated maintenance files for all tunnel equipment; this approach makes it possible to retrieve all the characteristics of the equipment as well as the inspection and maintenance actions carried out.

As part of the maintenance technicians' work, the maintenance manager organises regular meetings between the technicians working on the various tunnels; diagnostic errors are tracked using an intervention tracking table. Beyond simply verifying interventions, this action is carried out with a view to ensuring the efficiency of interventions and the training of staff, and is part of a "just culture" environment (see paragraph 4.5.2).

Example of a quarterly control sheet:

Quarterly Inspection Sheet

Visual checks:			Inspector	Comments
Low-voltage main circuit breaker	General condition	☐		
Inverter	General condition	☐		
Generator	General condition	☐		
Low-voltage switchboard	General condition	☐		
Programmable logic controller	General condition	☐		
Technical rack in plant room	General condition	☐		
Air conditioning in plant room		☐		
Service telephone	General condition	☐		
Fire alarm in plant room	Condition	☐		
Fire hydrant plugs	Bracket verification	☐		
Luminance meter	Bracket verification	☐		
Photocell	Bracket verification	☐		
Indoor camera	Bracket verification	☐		
Outdoor camera	Bracket verification	☐		
Water basins	Verification of inlet and outlet, valve	☐		
Anchor rings	Bracket verification	☐		
Fire extinguishers	Bracket and case verification	☐		
Safety recess	Verification if damage to the side wall	☐		
After-sales service	General condition	☐		
R24 flashing red signal	General Condition	☐		

Cleaning:				
Generator	Cleaning of the surrounding area	☐		
Low-voltage distribution board	Cleaning	☐		
Fire hydrant plug	Cleaning of surrounding areas	☐		
Luminance meter	Verification of opening threshold and cleaning	☐		
Photocell	Cleaning	☐		
Marker posts	Cleaning	☐		
CE2a and CE29 signs	Cleaning	☐		
Lane allocation signs	Cleaning	☐		
R24 flashing red signal	Cleaning	☐		
Indoor camera	Cleaning	☐		
Outdoor camera	Cleaning	☐		
Fire hydrant	Cleaning of surrounding areas	☐		
Fire extinguishers	Cleaning of case	☐		
Emergency call box	Cleaning	☐		

Functional tests:				
Low-voltage main circuit breaker	Reset test	☐		
Tunnel inverter	Battery discharge (30 mins)	☐		
Tunnel generator	Tunnel operation with generator	☐		
Service telephone	Call to control room	☐		
Fire alarm in plant room	Test and reset	☐		
Variable message sign	Functional verification	☐		
Lane allocation sign	Functional verification	☐		
R24 flashing red signal	Local operation verification	☐		
	Remote operation verification	☐		
Lighting	Verification of lamps	☐		
	Dimming operation verification	☐		
Fire hydrant plugs	Power supply verification	☐		
Water basin	Valve operation test	☐		
Emergency call box	Operational test	☐		
Fire extinguishers	Operational test	☐		
Internet connection between SCADA and control room		☐		

Additional information (if required)		

D.3 COORDINATION WITH THIRD PARTIES

D.3.1 Assessment of existing coordination with third parties

In order to work on the "coordination with third parties" component, the tunnel operator must first identify all third parties likely to interact with the tunnels, for administrative monitoring purposes, during normal operation, in degraded mode or during periods of works.

The self-assessment therefore covers:

- the identification and description of the tasks of each external party which may interact with the operation of the tunnel in different situations (normal operation, degraded mode of operation, maintenance or works);
- means of communication with these parties and alerting them in the event of an incident (reference to specific procedures);
- existing safety procedures for on-site intervention by responders.

To assess the system in place for the coordination with third parties, the operating body shall compile:

- the safety documentation: in particular the Emergency Response Plan (including alert plans), documents relating to feedback following events and safety exercises, reports from experts and Approved Qualified Organisations;
- the opinions of the prefect, the National Commission for the Assessment of Road Infrastructure Safety (CNESOR) and the local safety and accessibility commission (CCDSA) on the preliminary safety file and the subsequent safety file;
- the reports on lessons learned from events and annual safety exercises;
- where applicable, tunnel safety officer reports and opinions.

Where available, the following documents will also be useful:

- minutes of local monitoring committee meetings;
- temporary public space occupation agreements;
- minutes of works coordination meetings;
- conditions of external intervention, contracts, and means of monitoring interventions by external companies.

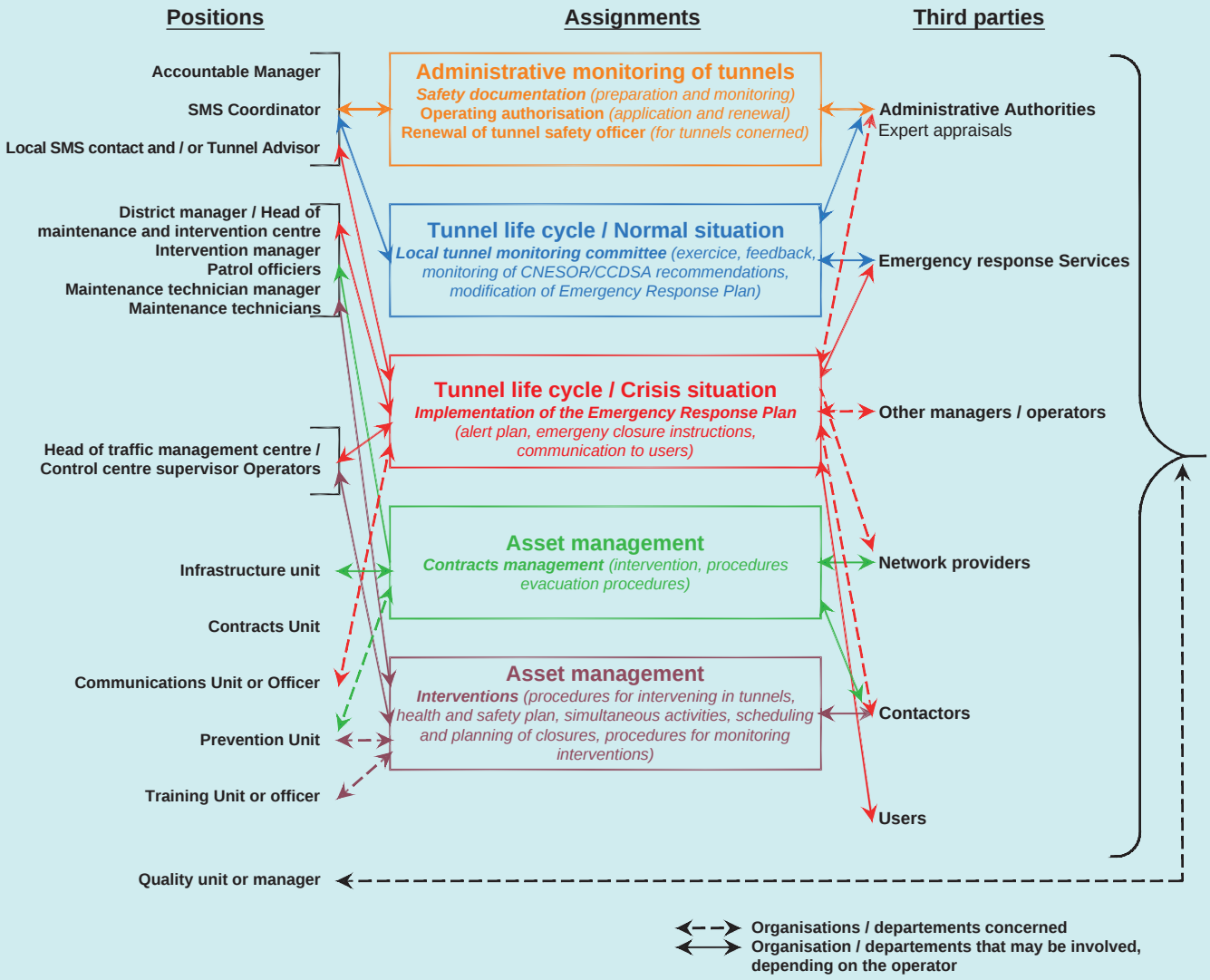
Coordination with third parties raises issues that overlap with the main themes of the SMS, for example:

- roles and responsibilities: who is responsible for relations with third parties and partners depending on the activities?
- management of modifications: how are relations with third parties handled when there is a change in activities or documents?
- asset management: how are interventions by companies and network suppliers prepared and carried out?
- documentation: what are the procedures for distributing information to third parties?
- skills management: how are companies and network providers working in tunnels trained?
- experience sharing: which third parties participate in safety exercises and share feedback on safety exercises and events?

Saint-Béat Tunnel – Fire test (© CETU)

D.3.2 Example of a summary diagram

The relationships between the various parties involved in tunnel safety can be summarised in a diagram depending on the different stages in the life of a tunnel. The diagram below is an example, as relationships vary depending on the operator.



D.4 ORGANISATION OF FEEDBACK

D.4.1 Evaluation of existing feedback procedures

Before constructing and implementing the SMS, the tunnel operator assesses its existing feedback system and how it works.

To evaluate the feedback system in place within the organisation, the tunnel operator gathers:

- the three documents relating to feedback (description of the system, safety exercises, events) in the safety documentation for each of its tunnels;
- examples of internal feedback reports on an incident, reports sent to the prefecture on an incident, internal reports on a safety exercise;
- examples of incident reports that take into account feedback from other organisations involved.

Where available, the following documents will also be useful:

- the internal procedure for tunnel safety exercises;
- the internal tool for monitoring regulatory obligations relating to feedback on events and exercises;
- the tool for monitoring improvement actions;
- CETU incident reports;
- examples of improvement actions with internal deployment.

D.4.2 Inclusion of weak signals in feedback

Example of consideration of events that are not significant as defined by regulations:

This procedure defines the system that has been set up within the organisation for reporting incidents occurring in tunnels. Its purpose is to record and analyse such incidents in order to feed into the continuous improvement process provided for in the organisation's management system and to meet regulatory requirements.

This system covers all incidents in tunnels, distinguishing between three types of incidents;

A. Significant incidents and accidents as defined by regulations (Article 2 of the Order of 18th April 2007), defined as follows :

- *all accidents involving personal injury;*
- *all fires occurring inside the tunnel;*
- *other events that required unscheduled closure of the tunnel, with the exception of those related to traffic management outside the tunnel.*

B. Incidents that are not significant as defined by regulations but are of interest to the tunnel operator:

- *material accidents in tunnels during non-standard operating conditions (e.g. bidirectional traffic in a unidirectional tube);*
- *events that should have resulted in an unscheduled closure of the tunnel;*
- *the minimum operating conditions being reached.*

C. Minor non-significant incidents.

For each of these types of event, the tunnel operator has detailed:

- *the methods used to characterise the event (person responsible, criteria, etc.);*
- *the degree of analysis of the event;*
- *the definition and monitoring of the action plan;*
- *the dissemination methods, where applicable;*
- *the personnel in charge of each stage.*

D.5 PERFORMANCE ASSESSMENT

As presented in section 5.1.6, safety indicators make it possible to verify and measure the achievement of one or more safety objectives or the margin for improvement, in order to review the safety policy if necessary. The choice of relevant indicators is essential. This chapter provides guidance on defining appropriate indicators.

D.5.1 Indicator characteristics

The essential characteristics of a useful indicator are:

- **relevance:** the indicator is representative of the chosen field and criterion; it aids decision-making and helps identify potential for improvement;
- **validity:** the indicator accurately reflects what it measures;
- **reliability, objectivity and reproducibility:** a measurement is considered reliable if it produces similar results when repeated by another person using the same data source;
- **acceptability of the measurement collection:** particular attention is paid to the person who will "produce" the indicator: the indicator is formulated clearly and unambiguously and it is produced independently and requires an acceptable workload. It is also advisable that the indicator be integrated into the daily work of the person who will produce the measurement.

D.5.2 Indicator construction

In order to define the most relevant indicators for monitoring the achievement of objectives, the following steps can be taken:

1. **Identify potential indicators:** for each objective, identify candidate indicators based on as broad a brainstorming process as possible, for example with the help of a working group. Existing practices (QMS or informal indicators) within or outside the organisation and individual reflections are all sources to be considered.

2. Select indicators:

- put objectives and indicators into perspective: select the most relevant indicators to meet the objectives. For example, the number of inspections carried out compared to the planned number allows an assessment of compliance with respect to the schedule but not the quality of the inspections or the relevance of the maintenance policy in place;
- check the weighting of each indicator for the organisation: select the indicators with the best ratio in terms of measure of the achievement of objectives/consequence for the organisation (time required for data collection, information, staff involvement, difficulty of interpretation);
- additional aspects to be taken into account: limitations, interpretation methods, updating methods, etc.

This information, which helps in choosing the most relevant indicators, will also facilitate the description of the indicators, with the option of using the "indicator identity card" proposed in paragraph D.5.4.

The difficulties encountered in choosing an indicator or aggregating it may be related to the fact that the objective cannot be measured by an indicator. In this case, it is possible to review its wording or consider another assessment method (e.g. audit, questionnaire, etc.).

3. Finalise the description of the selected indicators:

It is not enough to name an indicator or write down its formula to describe it. The criteria for an indicator must be clearly defined:

- purpose of the indicator;
- frequency of measurement;
- method of calculating the indicator (numerator and denominator, standard deviation from an average);
- method of data collection (e.g. manual or automatic);
- person responsible for validating the indicator.

To this end, it may be useful to produce an indicator identity card (see section D.5.4).

Please note: raw indicators are not sufficient on their own and must be supported or supplemented by explanations that contextualise the results and whether or not the objectives have been achieved. Examining the evolution of indicators over time is also part of interpreting indicators.

4. Validating indicators:

Validating indicators with the accountable manager requires the presentation of at least the following elements:

- SMS objectives to be covered by indicators;
- list of indicators;
- list of methodological choices made and their justifications;
- representation of the cost to the organisation in terms of working time and investment.

D.5.3 Examples of safety objectives and indicators

Safety objectives	Related safety indicators
Comply with applicable legal requirements	Percentage of valid operating authorisations Percentage of safety documentation submitted to the prefecture five months before the expiry of the current tunnel operating authorisation Number of safety exercises conducted annually in conjunction with emergency services
Take into account the reservations and recommendations of the National Commission for the Assessment of Road Infrastructure Safety (CNESOR) and the local safety and accessibility commission (CCDSA) with regard to the safety documentation	Percentage of resolved reservations or requirements issued by the CNESOR and CCDSA on the safety documentation and implementation of recommendations
Have the human resources necessary to operate the tunnels safely	Number of vacancies among the positions identified in the Who does what? tunnel / Number of positions
Assess and monitor individual and collective training needs	Percentage of staff with a personalised skills development plan (minimum requirement)
Improve availability of the tunnel to traffic	Number of unscheduled closures due to falling below minimum operating requirements
Analyse the impact of operation and maintenance actions on user safety	Accidentology during interventions
Take into account the actions recommended in reports following detailed periodic inspections on structural elements and equipment	Percentage of implementation of follow-up actions, taking into account the performance and condition rating assigned to the equipment family to reflect the severity of residual defects (Without taking the score into account, equipment in very poor condition and with insufficient performance may not yet be taken into account in the follow-up actions)
Organise feedback and ensure follow-up with a view to improving safety levels	75% of actions identified more than a year ago implemented following feedback on exercises and events
Improve safety information campaigns	Number of safety bulletins issued during the year

D.5.4 The "indicator identity card"

The "indicator identity card"[24] is a useful tool for describing an indicator.

General information	
Name	Each indicator must be given a unique name and code to avoid confusion.
Safety objective	The safety objective to which the indicator is linked.
Description and objectives	Describe what the indicator covers and what it does not cover in relation to the objective in question (contribution and limitations).
Source	Existing internal practices, brainstorming, best practices in the profession, bibliographical references.
Technical information	
Formula and unit	Methods for aggregating the parameters describing the calculation formula and the associated unit.
Min, max and target values	Whether the chosen scale is qualitative or quantitative, it is important to characterise it (minimum possible value, maximum possible value) as well as the target value or range representative of satisfactory performance. The target value is not necessarily 100% of the objective.
Measurement frequency	Time interval for taking measurements. Frequency of calculation, collection or publication of the indicator.
Related indicators	Where the value of the indicator should not be analysed in isolation but within a network (system) of indicators, the list of indicators whose values should be cross-referenced with it should be identified here.
Organisational information	
Indicator manager	Person responsible for the day-to-day management of the indicator.
Input data sources	Description of the sources (information system or persons) providing the input data for calculating the indicator value.
Interpretation methods	Identify the persons with the necessary knowledge to interpret the indicator and, if possible, provide guidance on how to interpret it.
Communication methods	Define the internal and external persons who have access to the indicator values. Distinguish in particular those who are called upon to make decisions based on them.
Revision (updating) procedures	As changes within the organisation may render an indicator obsolete, procedures for updating each indicator must be defined.
Information system	
Availability of operational tools	List any operational tools that exist to simplify data collection, calculation and communication of the indicator.
Level of compatibility with the information system	Assess the compatibility of the indicator (particularly its input data) with the data already made available by the information system.

24. From the document *Safety management using performance indicators – Guide for ICPEs*, INERIS Guide, December 2015 [17].

NOTES

NOTES

CONTRIBUTORS

Editing coordinated and supervised by Pascale PIQUEREZ.

Louisa BADOR, Jean-Baptiste MALAVIALLE, Marie-Noëlle MARSAULT, Bérénice MOREAU, Pascale PIQUEREZ, Sandira SANIEL and Christine SESSOAFIO contributed to the drafting of this document.

The following individuals also contributed to the finalisation of this document: Véronique AURAND, Sébastien BOUTEILLE, Jean-François BURKHART, Patricia LE CHEVERT, Isabelle LEROUX, Jean-Claude MARTIN, Hélène MONGEOT, François PAILLETTE, Didier SUBRIN and Christophe WILLMANN.

SMS coordinators, accountable managers and local SMS contacts of operators with an SMS at the time of publication of this guide also contributed to its drafting and provided examples from their organisations.

Finally, the group of French-speaking tunnel safety officers proofread the document.

Photos: CETU, DIRCE, DIRCO, DIRMC, DIRMED, City of Paris – Content coordination: CETU – Graphic design: PAO Concept – Printing: VASSEL GRAPHIQUE

Centre for Tunnel Studies

25 avenue François Mitterrand
69500 BRON - FRANCE
Tel. +33 (0)1 40 81 30 30
cetu@developpement-durable.gouv.fr

MINISTÈRE
DES TRANSPORTS
Liberté
Égalité
Fraternité

CETU

www.cetu.developpement-durable.gouv.fr