2. PRACTISE OF INCIDENT DATA COLLECTION

2.1. INTRODUCTION

Data generated from feedback from experience can provide a basis for the specific analysis of significant incidents; and for risk analysis in general.

The term "*significant incident*" as defined in *chapter 1* was addressed for the first time in PIARC's Technical Report 2009R08 [54] "*Tools for Tunnel Safety Management*" recommending that data be collected at least on the following incidents:

- collision causing at least one fatality or one injured person (requiring medical attention or hospitalisation, even for a short period);
- fire in a vehicle which began to burn in the tunnel but was able to exit without assistance;
- fire in a vehicle which burnt (totally or partly) within the tunnel;
- leakage or loss of dangerous goods (whether dangerous goods are authorised or not).

For tunnels with a "*high*" degree of attendance and supervision (i.e. with CCTV coverage and permanent supervision) in order to have sufficient data for risk analyses, the collection of additional data is recommended for the following types of incidents (in addition to that collected for the significant incidents as described above):

- Collision with material damage only (involving no fatalities or injuries);
- Breakdowns;
- Technical failures of tunnel systems (with or without unscheduled closure of the tunnel).

This chapter focuses on significant incidents but, where necessary, will consider data collection as a whole (including for incidents that are not defined as significant);

The objective of this chapter is to better understand how data are collected, including difficulties arising in practise and proposals for improvements.

Observations, analyses and proposals mainly target tunnel operating bodies, but will also concern other parties involved in collecting and processing tunnel incident data.

Chapter 2 focuses on the collection of tunnel incident data whereas *chapters 3, 4 and 5* show what could be obtained by analysing data: statistics (*chapter 3 & 4*), learning from real incident analysis (*chapter 5*). *Chapter 2* does not cover data analysis and the distribution of the information derived from the analysis in the entities involved unless these aspects relate directly to collection.

2.2. BACKGROUND

This chapter is based on feedback from tunnel operating bodies all around the world regarding their data collection practises.

A questionnaire concerning data collection was prepared in the context of this report and sent to many countries. The objective of this questionnaire was to better understand how "*data collection methods*" are being used worldwide when dealing with non-significant and significant incidents (questionnaire in *appendix 2*). Tunnel operating bodies from eight different countries answered the questionnaire, some enclosed their own data forms as well. This practical information was evaluated and taken as a basis for the development of this chapter.

Answers to the questionnaire were received from Colombia, France, Greece, México, the Netherlands, Singapore, Spain and the United Kingdom.

The following types of documents were also received:

- Two types of forms for relevant incidents:
  - Operator's incident data entry form (used during the incident)
  - Operating body's report form for the administrative authority (used to forward the information required by this authority).
- Biannual European reports (from 11 countries)
- Multiannual statistical reports (from 4 countries)

These additional documents in particular have provided precious insight into data collection methods and how the data collected are used in practise.

2.3. THE DATA COLLECTION CHAIN

2.3.1. Main data collection objectives/applications

Information on tunnel incidents may serve many different purposes. The main data collection targets are explained below, derived from the answers received from the tunnel operating bodies:

- For those involved in an incident (tunnel operating body, police, fire service, etc.), these data are helpful for the detailed analysis of the occurrence of the incident, and particularly the actions by the different parties involved (operating bodies, internal or external emergency team, maintenance team, etc.). The aim is to assess the quality of the actions taken by the teams (reactivity, organisation, coordination, management, application of procedures, etc.) the pertinence and performance of procedures and the technical system used, and the interaction between this technical system and the involved stakeholders (especially the tunnel operating body's team). Initial internal analysis can be carried out and the parties involved generally and systematically coordinate together;
- For tunnel operating bodies and/or tunnel managers, data can also be used to obtain statistics on incidents or the use of equipment;
- For regional or national authorities: statistical knowledge (often based on statistics which are different from those used by operating bodies) and/or input to risk analysis.

These objectives do not have the same timing. Generally, a detailed analysis of an incident is conducted in the short or medium term and leads to minor changes in procedures and equipment, (more important changes could take more time). Statistics are established over the long term because many years of collection are needed to obtain significant results and significant analyses.

Examples of statistical knowledge are given in *chapters 3* (tunnel collisions) and *4* 4 (tunnel fires). Examples of lessons learned from detailed analysis of incidents are given in *chapter 5*.

Other data collection objectives, such as those for judicial purposes (determining liability) and directly collected "*in the field*" by the police or experts are beyond the scope of this report. Generally, the purpose of the judicial procedure is to determine liability and not to improve safety.

2.3.2. Different possible levels of data collection

The main levels of data collection are:

- Local level: data needed by the local stakeholders. This collection level applies for all data which can be obtained directly or indirectly (for example through emergency response services) by the operating body.
- Network level: data needed by network operators or authorities. This collection level applies for all information required at regional or national level (especially by authorities). To provide useful data at network level, some processing of the information collected at local level is required.

In some countries, only one database exists for the tunnel operating body and the authority. In this case the data available to both the operating body and the regional or national authority are therefore identical.

2.3.3. Reports based on the collected data

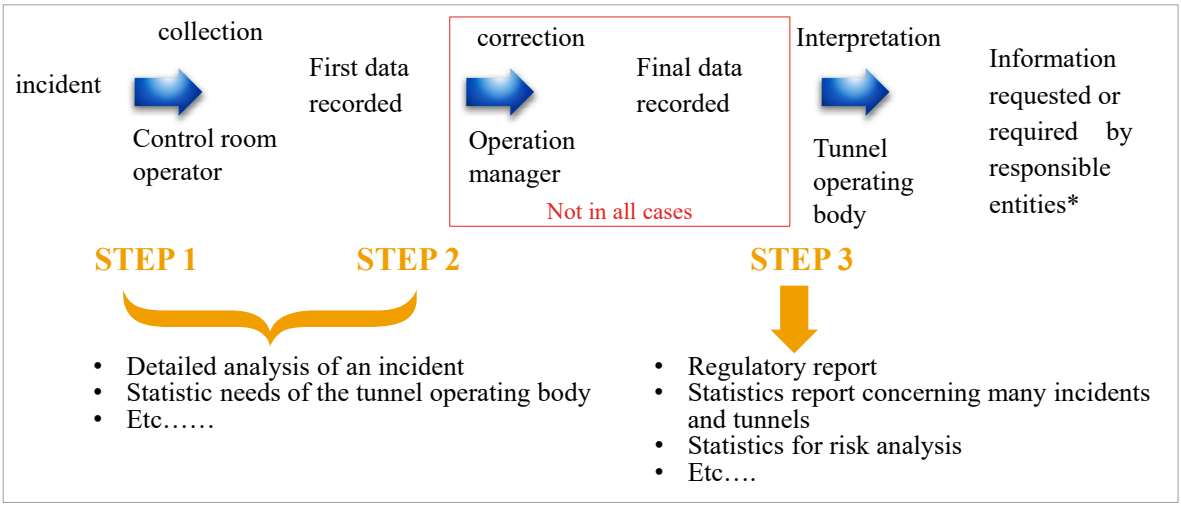
According to the objectives and levels of data collection, the main reports resulting from the analysis of data are:

- Detailed report on an individual incident: this report formally records the detailed analysis of an incident. This document is generally drafted by the tunnel operating body;
- Internal report by the tunnel operating body, either for its own requirements, or for the tunnel manager. This report may, for example, cover the quality of management and the performance of teams and equipment in terms of incident management, but also the level of service provided for users and internal statistics;
- Regulatory report for the supervising authority. For example, the biannual European report, which is used by member states to forward an analysis of fires and collisions which clearly affected the safety of road users (frequency, causes, evaluation, role and effectiveness of safety facilities and actions) to the European Commission in accordance with article 15 of the European Directive 2004-54;
- Multiannual report (statistics such as incident rates) established periodically by some countries, mainly for the analysis of statistics: frequency of incidents, causes, correlation, etc.

In some countries, incident reports and associated data are confidential.

2.3.4. Establishing a data collection chain

As seen previously, incident data are collected for several different purposes that require different collection levels and different outputs to produce effective feedback. In practice, a data collection chain from gathering information on the initial incident to providing incident data to the authorities, can be established. The basic structure of this data collection chain is shown below:



* A responsible entity could be the tunnel manager or a national or regional authority.

Illustration 3: data collection chain

As seen previously, the quality of the output and consequently the value of the lessons learned from feedback strongly depend on the quality of data collection and the functioning of the data collection chain. Consequently, studying how the data collection chain works in practice and how it could be improved is beneficial.

The data collection chain shown in *illustration 3* is suitable in most cases (type of incident, feedback practises, etc.) although some variations can occur. In most cases, these variations will not modify the chain as a whole, but they are worth considering. Ignoring rare exceptions (only one or two operating bodies in one country) these variations are integrated in the following description of the different stages in the chain.

STEP 1: Initial data are collected via the tunnel control centre of the operating body. The parties involved either carry out direct observations using different types of equipment (CCTV, phone calls from the public and radio communications, etc.), or use SCADA records (sensor records, video recordings, etc.). The control centre operator is generally in charge of this task but it may be carried out jointly with the tunnel manager in some cases. When external operating teams (e.g. police, fire service) are involved, they often collect data in the field which may either be redundant or supplementary to that collected by the operator. The means of data exchange between the operating body and external parties varies. In some cases, a formal data sharing process may be in place (automated or other), in other cases the tunnel operating body (generally the control centre manager) organises interviews after incidents. Control centres can also be used jointly by the tunnel operating body and another entity, whose teams are likely to take action in the event of an incident and/or to manage traffic (generally police). In such cases, data exchange may be simplified.

STEP 2: Initial data collected are checked modified and completed if necessary. The aim is generally to avoid errors (distorting reality), missing data, inconsistencies and the risk of conflicting or redundant data from different sources. Several levels of checks may be carried out at different hierarchical levels within the operating body.. The different hierarchical levels correspond to the control centre room supervisor, the control room manager (or tunnel centre coordinator), the operations manager and the safety manager. This checking stage is not used by some tunnel operating bodies.

STEP 3: The information required by the national or regional authority is taken from the data prepared by the tunnel operating body. It may be necessary to interpret data if the information requested by the authority is not directly available from the data prepared after the collection phase. Normally, the tunnel operating body (generally the operations manager) will prepare a report, with interpretation if necessary. In some countries the tunnel operating body only submits prepared data and the report is issued by the authorities themselves. In some cases when a report is written by the operating body, this report will be checked, or even drafted (rare), by the safety officer. Data are then generally issued by the tunnel manager after checks (in some countries and for certain authorities, the tunnel operating body issue data). In some cases, a similar process may be followed for data and reports issued 'internally' between the tunnel operating body and the tunnel manager and/or the tunnel owner.

2.4. POSSIBLE DIFFICULTIES IN EACH STEP OF THE DATA COLLECTION CHAIN

The objective of this chapter is to provide a short explanation of the main difficulties for each stage in the data collection chain.

2.4.1. Data collection by control room operator – step 1 of the feedback chain

The quality of the data collection for an incident can be affected by various factors. To begin with, the workload of the operator when collecting the data will have a significant impact, particularly where large amounts of data are required to be collected. Even for data collected automatically, the operator or the operation manager has to check and select the relevant data (air velocity, etc.). For certain data which cannot be saved with an automatic tool and/or that must be collected during the incident, the data collection activities interface with other tasks which must be carried out simultaneously. These other tasks are generally urgent, important and high priority as they relate directly to managing the safety of users involved in the incident; putting pressure on the operator.

In the context of this multi-task management, data collection is not generally a priority. Enthusiasm for data collection and hence its quality is also affected by how the operator perceives the benefits of the process. This perception will depend on his or her understanding of the relevance of the data requested and the relevance of the incident behind the data. The number of types of incident data sets to be collected may be high, ranging from simple technical incidents to collisions and fires. Furthermore, some tunnel operating bodies and administrative authorities request the same level of detail for incidents with widely varying importance (from failure of a tunnel system to the other extreme of serious collision with fire).

Data collection must generally continue after the incident, because the data collected initially has to be supplemented by the data collected automatically by SCADA and data from other sources (e.g. internal and external emergency teams). In particular, some important items of information can only be obtained after the event, e.g. death of victims within a period of 30 days[1] or information gathered from external services (fire service, police etc.). If a data transmission procedure (possibly automated) is unavailable, it may be necessary to contact these services, or even to interview those involved in the incident. However, these players often have little time to spare, particularly in the emergency services. It can therefore be difficult to obtain the necessary information and to ensure the reliability of these data (even key information).

Automated data collection could be useful to discharge the operator from a part of the collection task. It also allows the operator to verify or supplement data after the incident based on his or her own observations. But automation is not always "*the perfect solution*". Indeed, automated data collection without verification may lead to errors directly linked to the ability of the system in terms of detection, false alarm management, measurements, acquisition quality and recording (e.g. if camera spacing is excessive). It can also be totally or partially inoperative if the appropriate technical system or a subsystem fails. Certain important data cannot be collected automatically (for example those related to the driver and/or vehicle performance) and should be collected by qualified personnel.

If these initial data are not recorded or if the summary is unclear or difficult to understand, this can lead to errors later in the process. Handwritten records can also be a problem from this point of view.

All these aspects can affect the completeness and reliability of initial data in the data collection chain.

2.4.2. Correction by operation manager or tunnel manager – step 2

The objective of this step is to identify contradictions, errors and lack of data; and to correct them. In practice, this phase is sometimes skipped or not systematically performed so redundancy can remain and affect the clarity and value of data. Furthermore, contradictions (in data coming from different sources) as well as missing and erroneous data in each source may persist. This can affect the subsequent analysis, hence the quality of the statistics derived from such data is limited. Experience has shown that even data recorded automatically can include errors.

It is important to minimise the period between initial collection and the correction of data. Feedback has demonstrated that the longer the period, the harder it is to apply checks/corrections. It is then often necessary to interview internal teams (the operator in particular) or external teams to verify data. Under these circumstances, memories of the event will have faded with time and parties may be busy, particularly the emergency services, making checks more complicated.

[1] The definition of death subsequent to a road accident varies widely depending on the country, and, in particular, the period considered between the accident and the death is not always the same. According to the definition currently recommended for standardisation purposes, a person killed in a road accident refers to: "*Any person killed instantaneously or who dies of the consequences of the accident within 30 days of the accident*"

There are different types of errors to check: from the obvious mistakes (for example: an incident which was registered initially as a simple breakdown but in reality caused casualties) to more complicated cases in which it is difficult to determine if the data are right or wrong and where attempts of correction could manipulate facts.

As was the case in the previous stage, the scale and associated burden of the checks required is proportional to the amount of data and the number of types of incidents concerned; if these are high, negative effects may result.

2.4.3. Interpretation and transmission to authorities by tunnel operating bodies or tunnel manager – step 3

Some items of information required by authorities can be directly obtained from the initial data collected (e.g. number and types of vehicles). However, other information may require the correlation of several data, and even interpretation and analysis (e.g. factors contributing to a collision).

In some cases, this information can be difficult to determine and this difficulty will increase in proportion to time since the incident.

This interpretation/analysis phase also creates an additional work load for the tunnel operating body.

Finally, as the tunnel operating body and its teams may not be able to use data directly, they may not appreciate the benefits. Personnel in charge of developing and transmitting this information may therefore fail to carry out this task properly, particularly if they are responsible for other tasks elsewhere. Information may then only be partially transmitted, or may even be omitted.

2.5. IMPROVING DATA COLLECTION PROCESSES AND THE DATA COLLECTION CHAIN

2.5.1. Ensuring data consistency between each step of the data collection chain

For the reasons explained in *chapter 2.4.1*, if types of incidents (including non-significant incidents) to be covered and data to be collected are numerous, the resulting workload for the team involved in the data collection chain can be high, which may be demotivating. Such a situation can downgrade the quality of data processing (collection, checks, interpretation, transmission) and ultimately the quality of the final outputs.

This problem may be addressed by increasing operational staff resources or by providing additional equipment and automation subject to financial restrictions and clear identification of the wider benefits.

Before considering increasing the resources dedicated to data collection, it is necessary to consider the pertinence of data and the level of detail required; and to ensure consistency between each step in the data collection chain. Consistency is particularly important between:

- Relevance of data and level of detail with respect to the feedback objectives (including output objectives) for the tunnel operating body, tunnel manager and authorities;
- Relevance of the incident with respect to the feedback objectives. Evaluation criteria should be established (e.g. level of severity, new factors, etc.). For instance, some items of data may be relevant for a collision with causalities involving several vehicles, but less relevant for an impact with equipment involving one single vehicle and material damage only;
- Focussing on data which can be obtained with reasonable effort by the tunnel operating body taking into account the other obligations during an emergency and the abilities of the safety system. The same refers to data acquisition from other internal or external sources (fire service, police, etc.);
- Focussing on data which can be handled with reasonable effort by the tunnel operating body (correction by the operations manager or tunnel manager, interpretation and transmission by the tunnel operating body to the authorities).

To improve the consistency between the steps of the data collection chain, it is of particular relevance to define feedback objectives (including output requirements). This will help to determine the data to be collected, their exhaustiveness and degree of detail.

The different stages in the data collection chain are interdependent. It is therefore preferable for the different entities involved (tunnel operating body staff, tunnel manager and authorities) to cooperate closely and to define the feedback objectives and the evaluation criteria (for example: incident relevance, data item and details, etc.) together. It is necessary for each entity involved to identify beforehand which kind of benefit they expect from data evaluation then to clearly define their feedback objectives. If necessary, these targets should be reconsidered after some time in order to optimise the incident data management process.

Although this report is only related to significant incidents (which may also align with the objectives of the authorities), it is important to ensure that considerations are not limited to this type of incident, particularly at the operating body level (see also definitions in *chapter 1.2*). In fact, it is preferable for data collection to be considered as a whole, if only to assess the inherent workload. This consideration process must therefore preferably integrate data collection for all types of incidents whether defined as significant or not.

These considerations can lead the tunnel operating body to increase the resources (both human as well as technical) dedicated to the data collection chain. However, this increase may be justifiable where each set of data can be tied to clear objectives.

This consideration should, as far as possible, involve representatives of those in charge of the effective accomplishment of tasks (collection, checks, etc.) in a just cultural [45] context. The idea is to ensure that no barriers exist to the full completion of these tasks.

This consideration of the scope of data collection and evaluation must be an active process over time. For example, a few years of practice can demonstrate that one (or several) items of data are ultimately hardly ever used or have low relevance with regards the feedback objectives. Such data could then be omitted from the collection process or be replaced by other, more relevant information.

The right balance is needed with a focus on the objectives of data collection. It may be preferable

to acquire less data per incident, but to improve the quality of data and increase the number of incidents for which data are collected, in order to get a better overview. It could even lead the stakeholders to check once again the objectives of the data collection and maybe to refine objectives to those that are more achievable in terms of resources and valuable in terms of safety benefits. A cost-benefit approach could be used to inform such objective setting.

Automatic data collection can help to reduce operator workload. However, care should be taken that an automated approach does not lead to a less careful selection of the data which is collected. In fact, data collected automatically still requires processing and checking. This approach indeed has its limits in terms of reliability, as already discussed in *chapter 2.3.1* (for instance, it may be difficult to reconcile a requirement for a good level of detection with a low level of false alarms; sensor uncertainty, etc.).

As indicated in *2.3.4*, in some countries with few tunnel operating bodies and a certain degree of homogeneity between the bodies, one single database is used for the entire data collection chain (from the operator to the authorities). The Step 3 export, interpretation and transmission of data by the tunnel operating body to the authority can thus be simplified. However, in these cases, it is necessary to directly export all information required by the authority from this database or for the authority to interpret the data (preferably in coordination with the tunnel operating body). Furthermore, in countries with many tunnel operating bodies with a wide range of practices and resources, it can be complicated to adopt this practice. The minimum aim, as far as possible and based on targets, is to attempt to harmonise the data collected and the information requested by the authority, i.e. minimise the workload inherent in step 3 of the data collection chain.

2.5.2. The importance of convincing those involved of the relevance of data collection

Regulatory requirements are not always adequate to ensure the quality of data collection and transmission. Some strategies (which have been observed), involve targeting the minimum data to be provided to appear to be compliant, for example, by only reporting a certain percentage of significant incidents.

So, during the entire tunnel life, it is important for all stakeholders and all personnel of tunnel operating bodies, especially those directly involved, to be convinced of the importance and relevance:

- of the data collection chain and its objectives,
- of the data to be collected and the information to be transmitted to the authority.

All participants, from the tunnel operating body to the head of the organisation, must be involved.

A few methods of convincing those involved are described below.

To begin with, the objectives and benefits of the data collection chain must be explained and highlighted as well as the role of each party in the data collection process and/or the transmission of the information to the authority.

Secondly, it would appear necessary to justify the relevance of each type of data requested.

Informal interviews and practices have, for example, demonstrated that operating bodies and tunnel managers tend to be less disciplined with data which they consider of little value. However, these data can be important for reasons which go beyond the activities of their organisation and which may not be immediately obvious to them. It is therefore recommended that these justifications should be based on the data selection processes explained in *2.5.1*. It would be very useful to explain by showing what benefits have been derived from the data collection, such as improved measures, better risk assessment, less severe incidents, less technical failures, less downtime of the tunnel, etc.

Thirdly, under some contractual arrangements there are penalties for a tunnel operating body relating to accidents, incidents and road closures. These penalties may mislead a tunnel operator to not record or transmit details of an incident (of course if there is a fatality, it cannot be hidden). So, it would be preferable to avoid these kind of penalties and to prefer a "*just culture*" approach which will on the contrary help to establish an atmosphere of trust in which people are encouraged (even rewarded) for providing essential safety-related information.

Finally, it should be highlighted that there may be legal implications of inadequate feedback that could be significant. Some of the court proceedings concerning major fires in tunnels have demonstrated that the verdicts are more serious if the improvements and evaluation process for the safety management system is inadequate. .Feedback is the cornerstone of this improvements process and incident data management its foundation.

2.5.3. Practical advice

Some practical recommendations are likely to improve the data collection process. Some of these are already implemented by certain tunnel operating bodies.

It would appear appropriate for the safety officer[2] to be consulted in the data check process (and clearly on feedback more generally), particularly before transmitting the information required by the supervising authority. In view of the safety officer's necessary independence and assignment, it is preferable that he or she is not involved directly in any data processing tasks (exports, interpretation, drafting of reports, etc.).

Simple data collection timing strategies can be developed. For example, when the control room operator is managing the event, he will focus on collecting certain data by bearing in mind that the first priority is safety management. Other data will be obtained at a later stage using other sources of information, e.g. automatic system recordings.

This timing strategy must be prepared with attention paid to reliability and exhaustiveness priorities for the different sources of data. The strategy should be part of a global approach involving all data collection stakeholders where the aim is to determine the right balance between redundant collection (in which stakeholders could collect the same data) and a distribution of specific collection tasks. Redundancy will increase the data collection workload, but guarantee higher levels of reliability by enabling cross-checks. On the other hand, whilst distribution helps

[2] The Tunnel Manager will nominate one Safety Officer, who will coordinate all preventive and safeguard initiatives to ensure the safety of users and operational staff for each tunnel with a length of more than 500 m in the Trans-European Transport Network. The Safety Officer will operate independently for all road tunnel safety issues and will not receive instructions from an employer with respect to these issues.

to share the collection workload between stakeholders, data reliability risks may be higher. These aspects must be considered on a case-by-case basis, with reference to resources, priorities and objectives of data collection.

Considerations can be guided by the importance of data and the difficulty in obtaining data later (after the incident). Data which are more difficult to obtain after the incident shall be collected during the incident and critical data must be systematically collected with adequate redundancy.

Data may be subjective, depending on personal observations of control room operators. This could justify distinguishing factual data (for example: value of a parameter such as CO concentration) from observations (for example circumstances of a collision). To make the distinction, observation could be defined as data put into context.

Concerning the correction step (*chapter 2.4.2*), to handle the errors that are not so obvious; and the risk of "*wrong corrections*", it is recommended to have a simple, clear procedure (even short) in which it is explained how it could be decided that "*suspect data*" are wrong and must be eliminated or replaced. Using different available sources may help but for more critical data, it may be necessary to undertake additional surveys. For example, if the stated number of fatalities is not the same from the different sources (due to the fact that all injured persons dying within a period of 30 days after an incident are counted as fatalities), it could be necessary to discuss with the police authority[3] which number should be selected.

For all tunnel operating bodies on which this chapter is based, this "*correction step*" is done internally by the operation manager or externally by the tunnel manager. It is also possible to call upon a third party: an entity that is independent from the tunnel operating body and the tunnel manager to be involved in this "*correction step*".

[3] Generally, in an accident with fatalities, it is the police authority who decides which value should be selected as number of fatalities.