1. BACKGROUND AND BASIC PRINCIPLES

1.1. THE ROLE OF LESSONS LEARNED IN THE INTEGRATED APPROACH TO ROAD TUNNEL SAFETY

In several previous PIARC reports the role and importance of an integrated approach to tunnel safety has been discussed. In PIARC report 2007/R07 Integrated Approach to Road Tunnel Safety [51], a schematic representation of the proposal for an integrated approach to the safety of new and in-service tunnels is presented (see *illustration 1*). In this *illustration* the feedback from lessons learned to changes in the definitions of the safety features of a tunnel is illustrated.

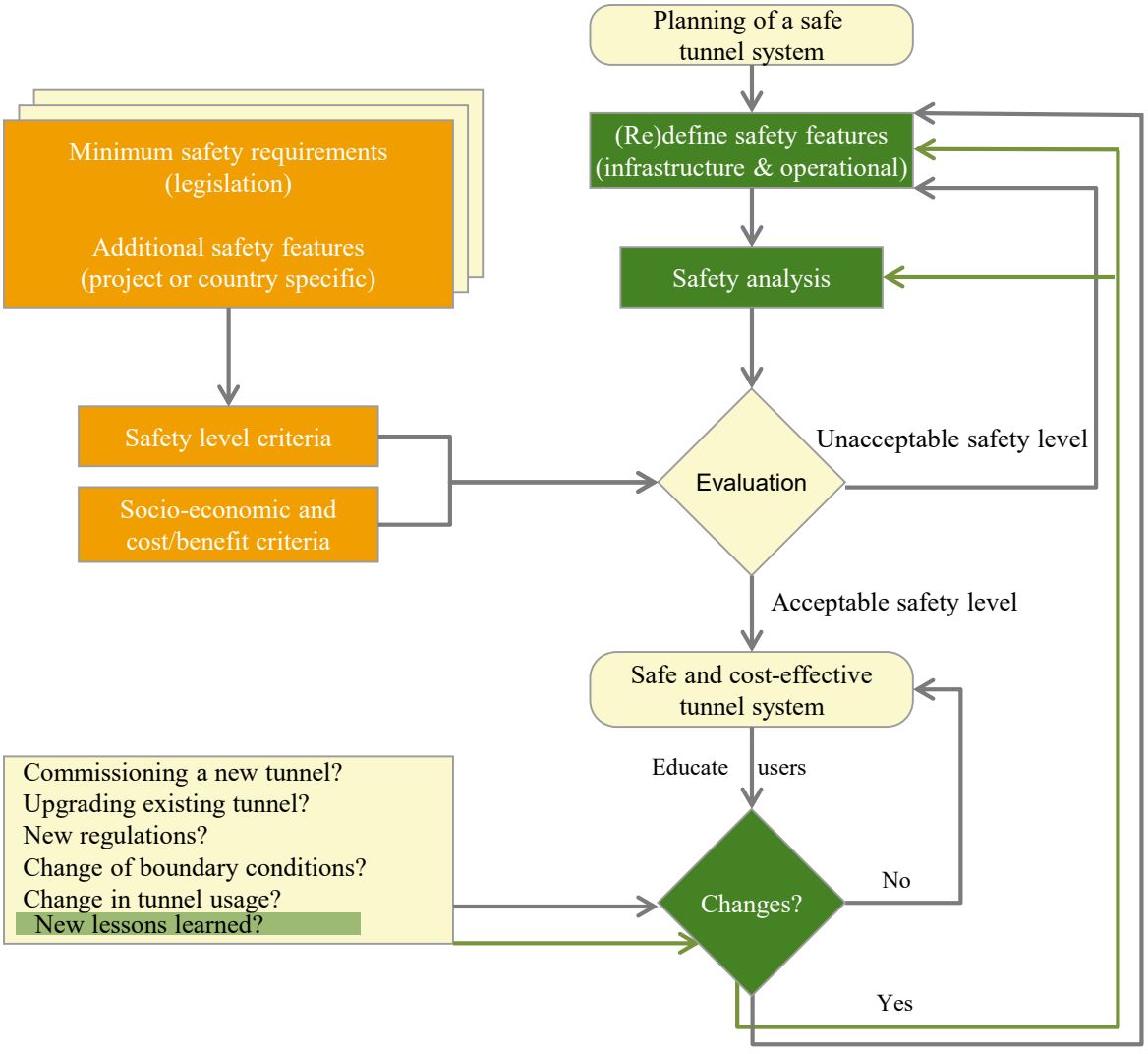

Illustration 1: integrated approach to road tunnel safety (piarc 2007/r07)

An interesting question is whether this PIARC recommendation had any follow up in practise. In this report we focus on the loop in the figure above starting from "*new lessons learned*". Do "*new lessons learned*" actually lead to changes in the safety features of the tunnel system? Is there systematic data collection on incidents in tunnels from which information can be drawn? Are these data used for evaluation and redefinition of the safety features? How do lessons learned influence the safety analysis performed in order to continuously improve the tunnel system?

Lessons learned can be a result of inspections and audits, conclusions from incident evaluations and improved knowledge on risk assessment. In the present report we focus on lessons learned as a result of incident evaluation and risk assessment. Information has been gathered to find out if the recommended approach has been applied in practise since the publication of the PIARC report 2007/R07 [51] and how this feedback influences tunnel safety management. Information has been gathered on:

- How data and the process of data collection is organized in different countries and how this information is used (*chapter 2*)
- Lessons learned and recommendations for tunnel safety management as a result of an evaluation of more than 30 international individual tunnel incidents performed by the experts of the Working Group (*chapter 5*)
- Statistical data on tunnel collisions and parameters specifically influencing frequency and consequences of tunnel collisions (*chapter 3*)
- Statistical data on tunnel fires and parameters specifically influencing frequency and consequences of tunnel fires (*chapter 4*)
- How safety analysis is applied in practise in the different countries; how these methods and their application are improved based on experience of their use; and how these methods and their application are improved based on new information gathered from the collection and evaluation of incident data (*chapter 6*).

At first sight these aspects seem to be quite independent but a closer look reveals a strong interrelation: incident data collection requires resources to be provided by the tunnel operators, therefore it is important to demonstrate the benefit of this activity. However, this benefit can only be achieved, if the type and volume of the information gathered corresponds to the requirements of data evaluation.

There are different options for the evaluation of tunnel incident information: at the level of an individual tunnel, information can be used to identify tunnel-specific problems with respect to traffic, equipment, operation, emergency response etc. in order to improve safety management. These aspects are addressed in *chapter 5*; the annex to this chapter provides illustrative examples including conclusions drawn for tunnel safety management on the basis of the evaluation of specific individual incidents.

At network level, the data can be used to calculate safety metrics such as collision or fire frequencies which can be used for comparisons or as a input to quantitative risk assessment. However, to optimise the use of such information for quantitative risk analysis, data have to be linked to parameters which may influence these key metrics, such as traffic, road or tunnel characteristics. These aspects are addressed in *chapter 3* (collisions) and *4* (fires). Hence, this additional data must be gathered together in addition to the incident information. For these reasons it was decided to combine these different topics in one integrated report.

1.2. BASIC DEFINITIONS

This report mainly addresses significant incidents in road tunnels. The PIARC dictionary defines the term "*incident*" in the following way:

An incident is an "*abnormal and unplanned event (including accidents) adversely affecting tunnel operations and safety*".

The definition of "*incident*" is quite broad and includes all kinds of events that may occur in a road tunnel. The report however is focussed on significant incidents only. Significant incidents are incidents which require special attention, because they are, or have the potential to develop into, events with serious consequences to the health or life of people, to property, to infrastructure or to the environment; or are valuable for further evaluation with respect to underlying basic risk factors. Significant incidents in particular include collisions and fires, which are addressed in detail in *chapters 3* and *4* respectively; but in some countries other incidents like vehicle breakdowns or incidents that cause the closure of a tunnel are also typically considered as significant.

However, the detailed definition of significant incidents differs from country to country, depending on national requirements (examples are given in *appendix 1*)

The basic understanding of these terms as used in this report are illustrated in *illustration 2*.

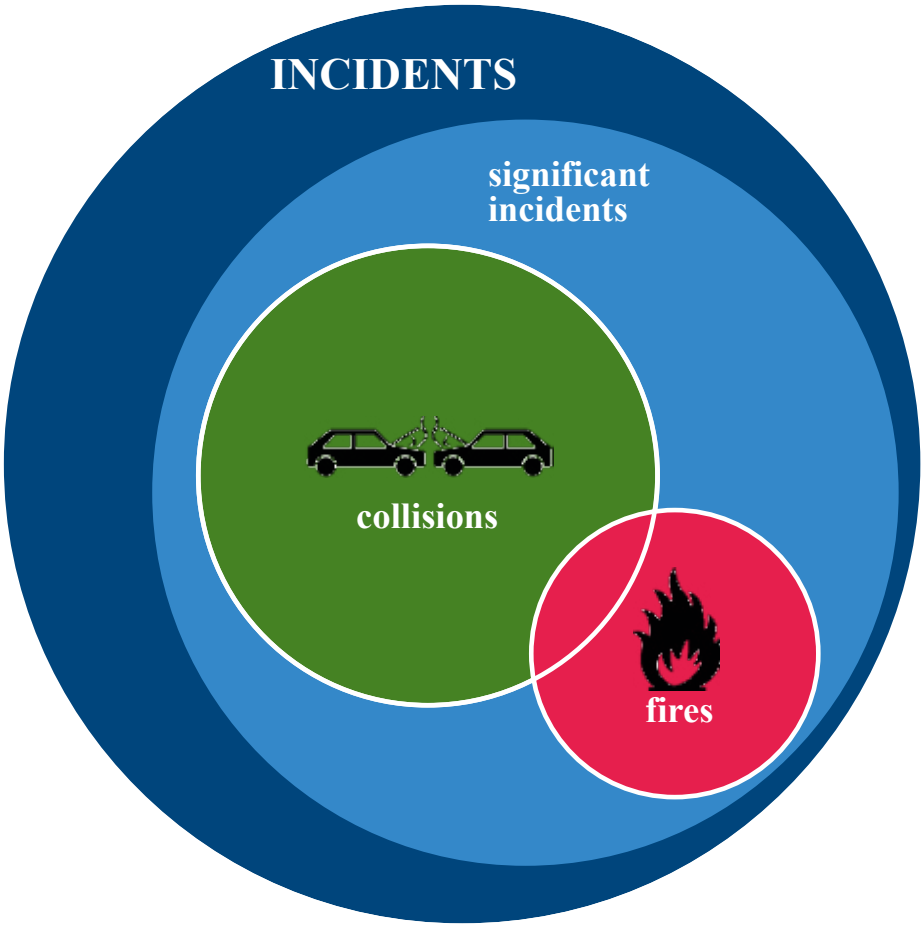

Illustration 2: illustration of the relationship between incidents, significant incidents, collisions and fires

Another definition which has to be addressed in the context of this report is the definition of the term "*fire*": A Fire may be defined as "*an unwanted or uncontrolled combustion process characterised by heat release and accompanied by smoke, flames or glowing*" (Norwegian Directorate for Civil Protection).

Smoke releases without fire (i.e. either smoke without significant combustion or smoke without heat release or negligible heat release) are not addressed as fires in this report. This definition is in particular relevant for data collection and data evaluation to ensure the comparability of fire rates.