



INTEGRATED APPROACH TO ROAD TUNNEL SAFETY

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Content

- Why an integrated approach for road tunnel safety?
- Recent initiatives on road tunnel safety
- General principles and safety practises
- Elements in an integrated approach
- Proposal for an 'holistic' approach
- Concluding remarks

Why an integrated approach for road tunnel safety?

- Need for a framework to holistically take into account:
 - regulations,
 - infrastructure and operational safety features,
 - safety assessment,
 - tunnel usage,
 - operating experiences
 - safety management

- The PIARC proposal for an integrated approach has been developed in co-operation with SafeT and UPTUN.

- It is *not* intended to present a uniform worldwide approach.

- No new research was done for the proposal.

- Target group:
 - Road Tunnel Designers
 - Road Tunnel Operators
 - Administrations/ authorities responsible for road tunnel safety.



Recent initiatives on road tunnel safety

International recommendations and legislation

- United Nations Economic Commission for Europe
 - PIARC participation in a multi-disciplinary group of experts on road tunnel safety.
- The EU Directive 2004/54/EC took into account previous PIARC work.

European research projects and thematic networks:



Sirtaki

Safe Tunnel

Virtualfire



COSUF

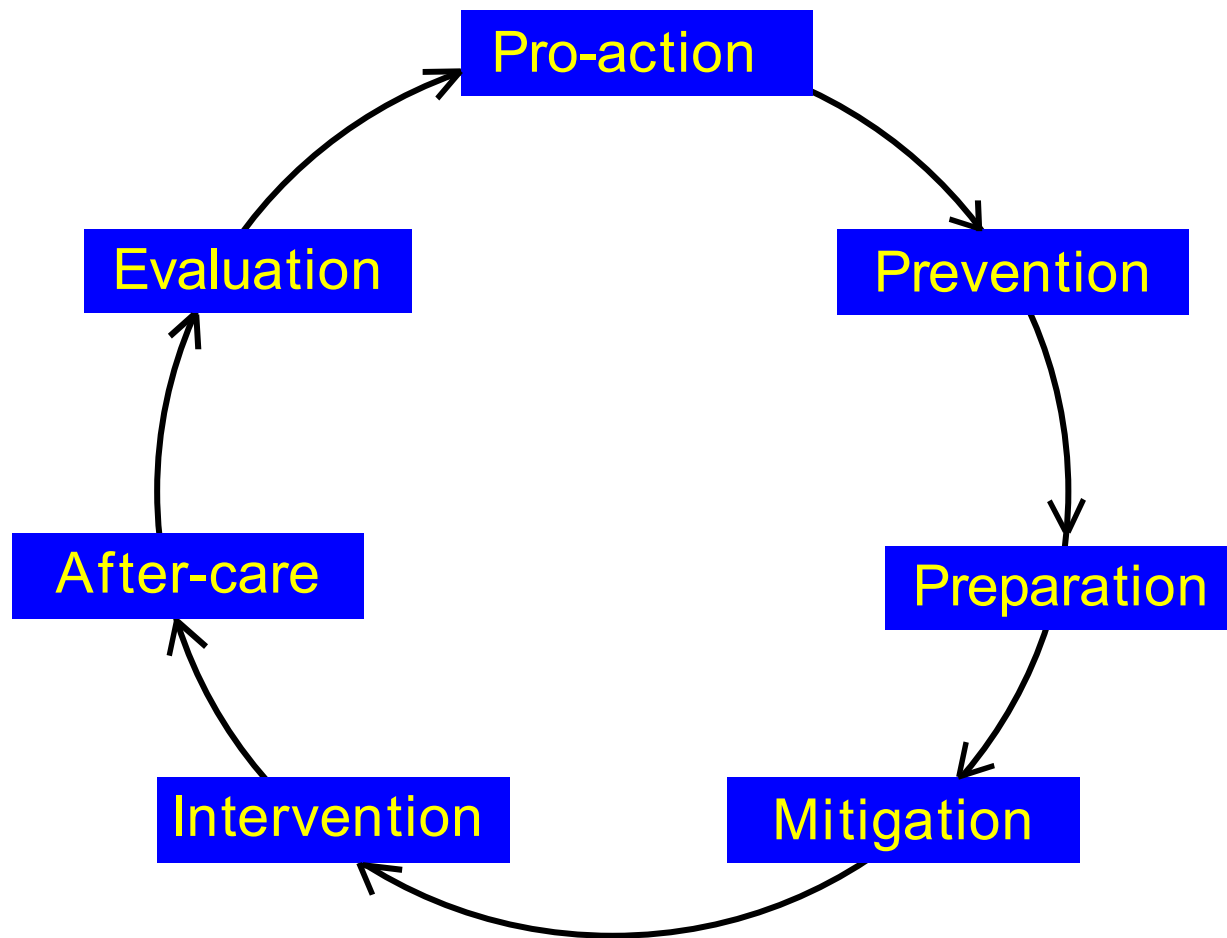
General principles: safety objectives

How safe is safe enough ?

- Prevent critical events
- Reduce the consequences of accidents (fires) by creating the prerequisites for:
 - Self rescue possibilities
 - Road user intervention
 - Ensuring efficient action by emergency services
 - Protecting the environment
 - Limiting material damage

General principles: the safety circle

Safety Circle

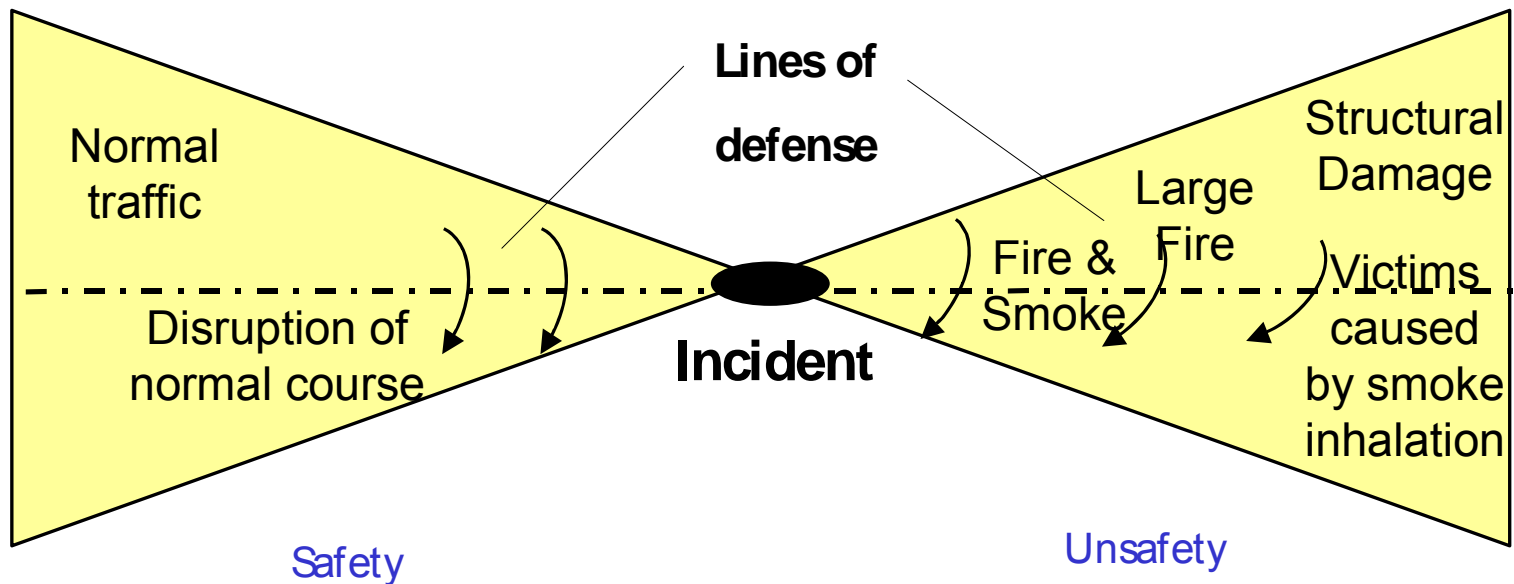


General principles (continued)

Bow Tie Model

Causes

Effects





Safety practices

PIARC member countries were investigated

- Asia (Japan)
- Australia
- Europe (Austria, Belgium, Czech Republic, Denmark, France, Greece, Norway, The Netherlands, Portugal, Sweden)
- North-America (Canada-Quebec, United States)

Safety practices: Investigation Topic 1

Safety requirements and regulations

- Most European countries and Canada-Quebec follow EU Directive 2004/54/EC.
- In North America: old tunnels have been upgraded on the basis of US NFPA 502.
- Australia, Austria and the Netherlands have been following a national tunnel law since 2006.
- 'good father' principles
- Some countries have safety levels exceeding the EU Directive.
- Denmark and Portugal: "case-by-case basis" up until now.

Safety practices: Investigation Topic 2

Infrastructure safety provisions

- Safety features are mostly based on national regulations.
- Occasionally, prescribed safety features are tested by means of a performance-based analysis.
- The completeness of set of the safety features may be dependent of the length of the tunnel and the traffic volume.

Safety practices: Investigation Topic 3

Operational safety features

- Many countries have been using plans and procedures to manage safety, even before the EU Directive 2004/54/EC addressed this.



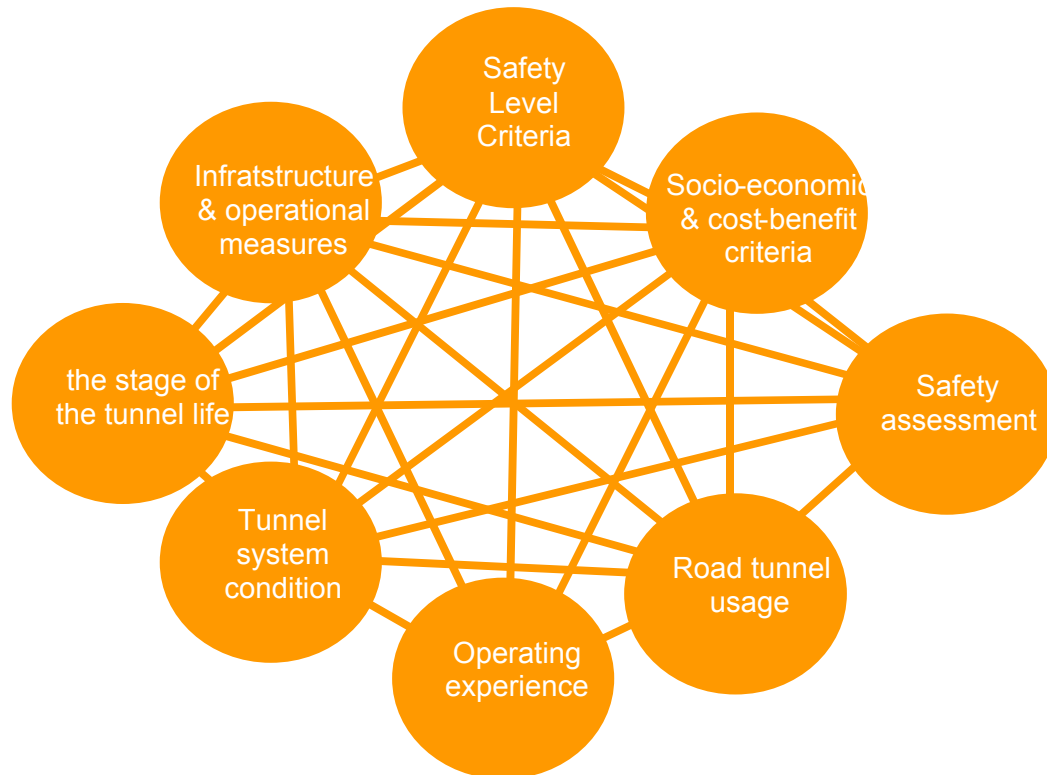
Safety practices: Investigation Topic 4

Safety Assessment

- A common tool for verification of tunnel safety.
- It may involve a probabilistic risk analysis, a scenario-based deterministic analysis or a combination of both.
- Risk analysis is explicitly requested (where necessary) by the EU Directive (see PIARC report "Risk Analysis for Road Tunnels").

Elements in an integrated approach

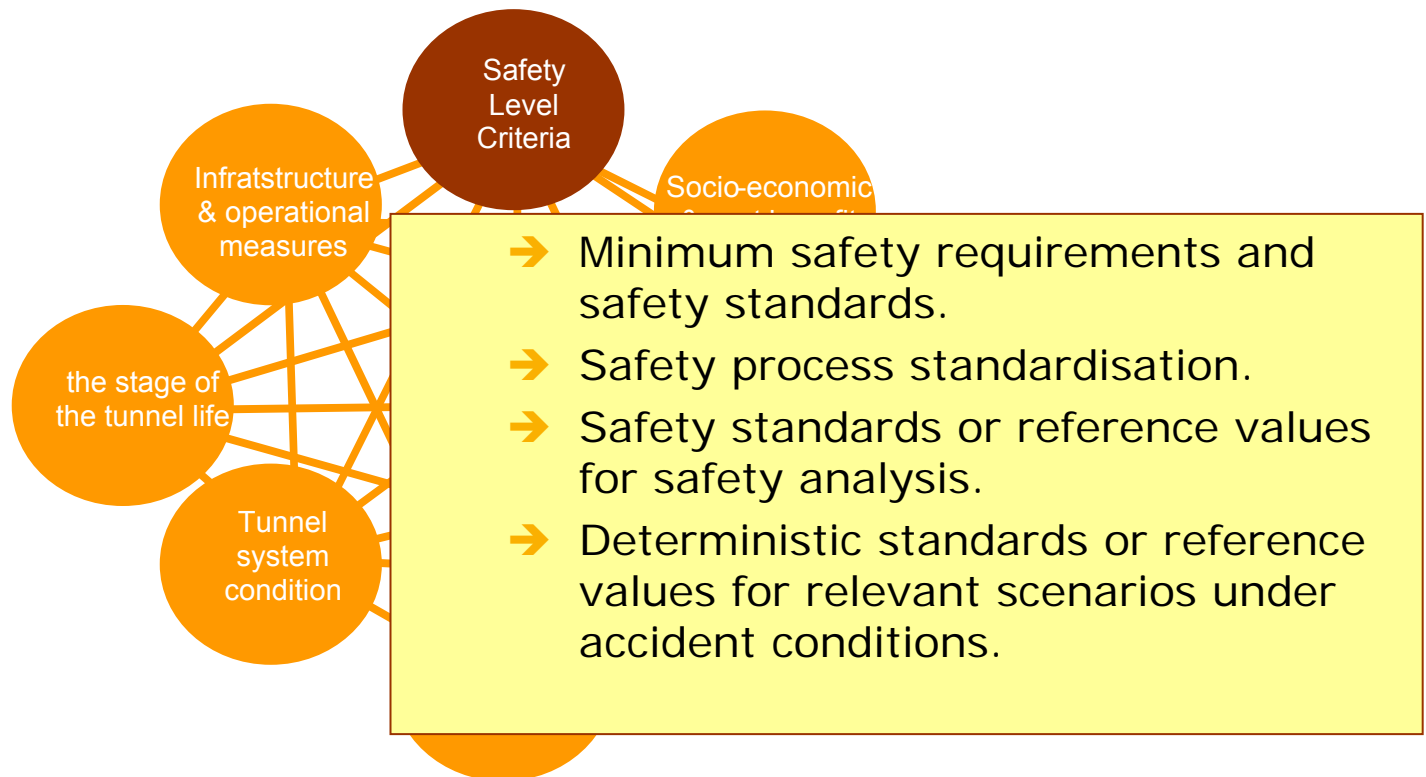
A framework to relate the elements:



The integrated approach should enable:

- ➔ the safety assessment of all types of road tunnels
- ➔ differentiation between tunnel-specific characteristics.

Elements in an integrated approach



The integrated approach should enable:

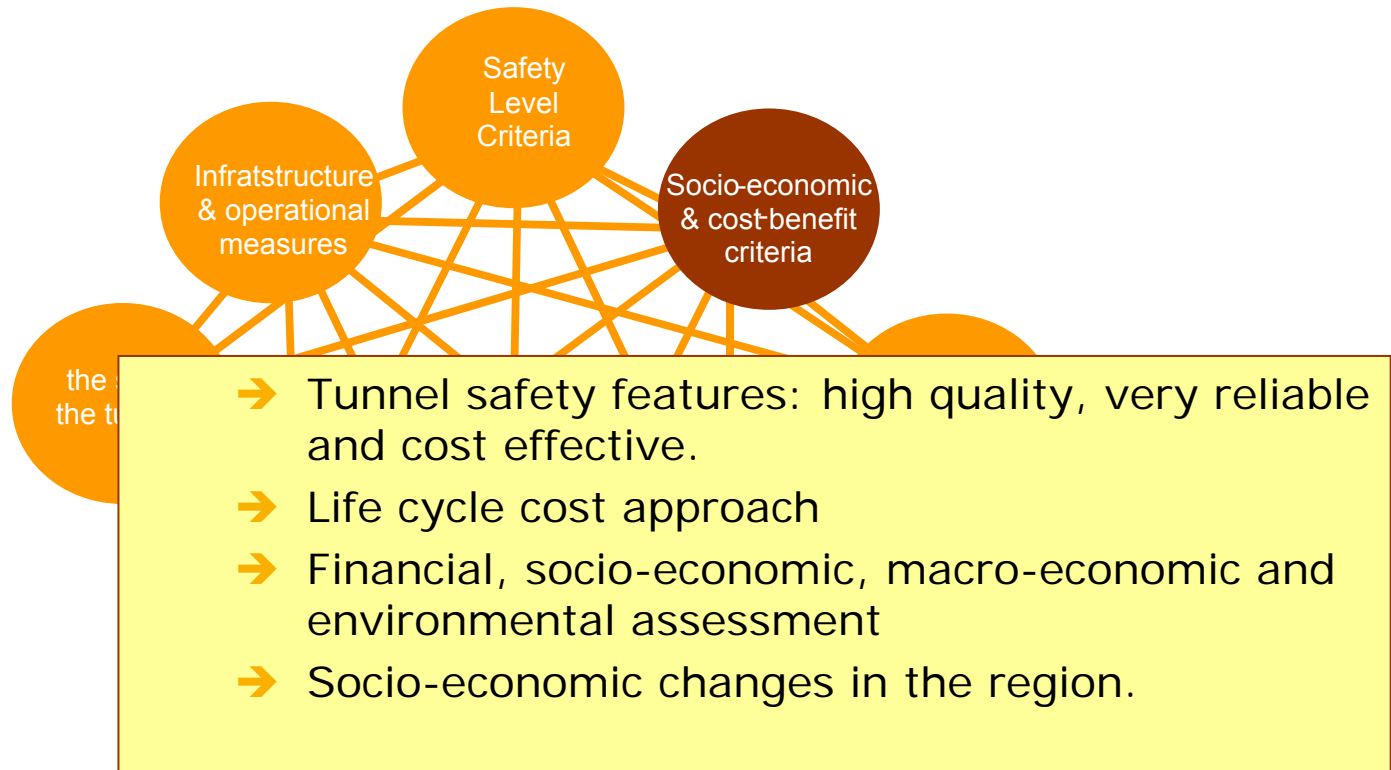
- the safety assessment of all types of road tunnels
- differentiation between tunnel-specific characteristics.

Elements in an integrated approach



- Safety performance to a tunnel system.
- Prescriptive or performance-based and should be distributed in a balanced way over the safety circle
- 'Infrastructure' safety features:
 - all technical systems and instruments,
 - geometrical and structural solutions,
 - the materials
- 'Operational' safety features are procedures for:
 - adequate tunnel safety management,
 - the distribution of safety duties, responsibilities and authorities
- The right set is the set that fulfils the safety level criteria

Elements in an integrated approach

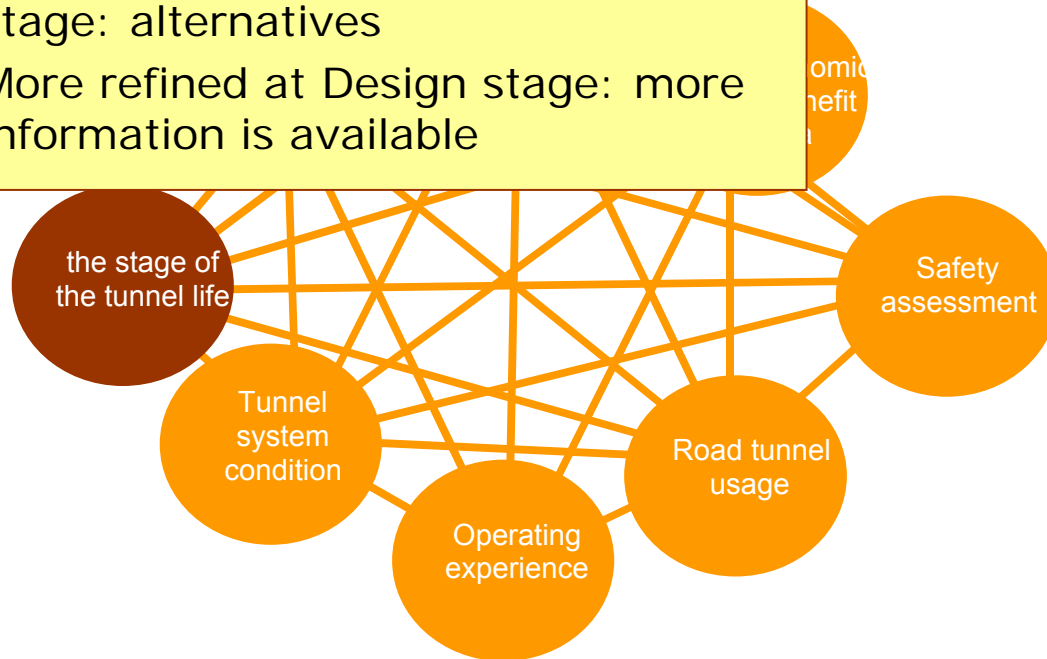


The integrated approach should enable:

- the safety assessment of all types of road tunnels
- differentiation between tunnel-specific characteristics.

Elements in an integrated approach

- Determines the level of detail for safety analysis.
 - Rough Analysis at the Planning stage: alternatives
 - More refined at Design stage: more information is available



The integrated approach should enable:

- the safety assessment of all types of road tunnels
- differentiation between tunnel-specific characteristics.

Elements in an integrated approach

Safety
Level
Criteria

- Has the desired safety level been reached ?
- How can the safety performance be tested ?
- What is Probabilistic Safety Assessment?
- What is Deterministic Safety Assessment?
- More details in PIARC report 'Risk Analysis for Road Tunnels'

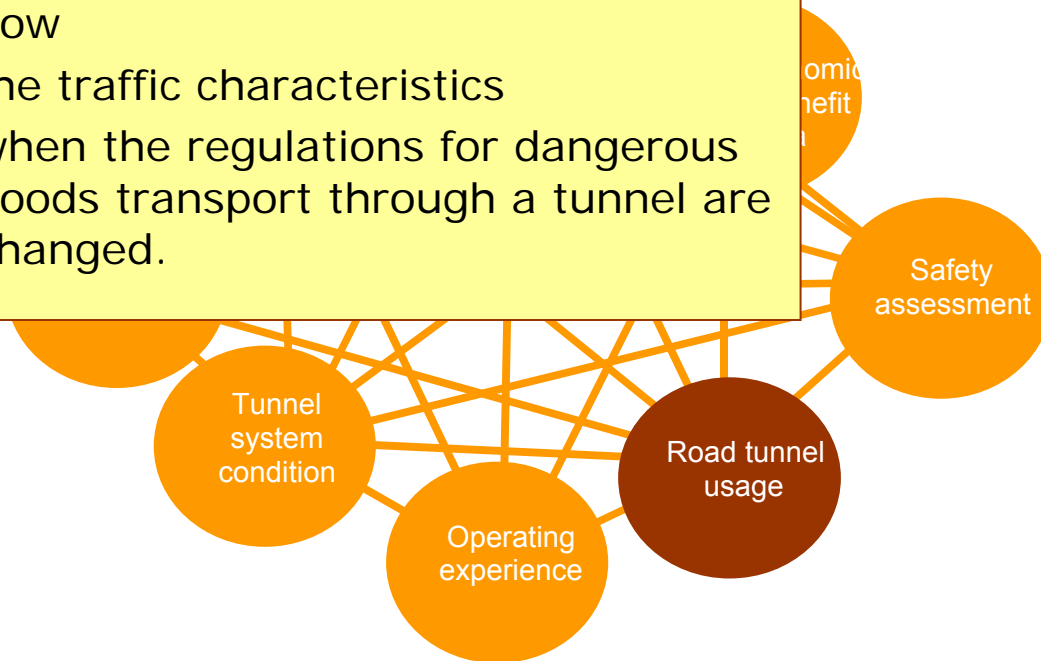
Safety
assessment

ble:

- the safety assessment of all types of road tunnels
- differentiation between tunnel-specific characteristics.

Elements in an integrated approach

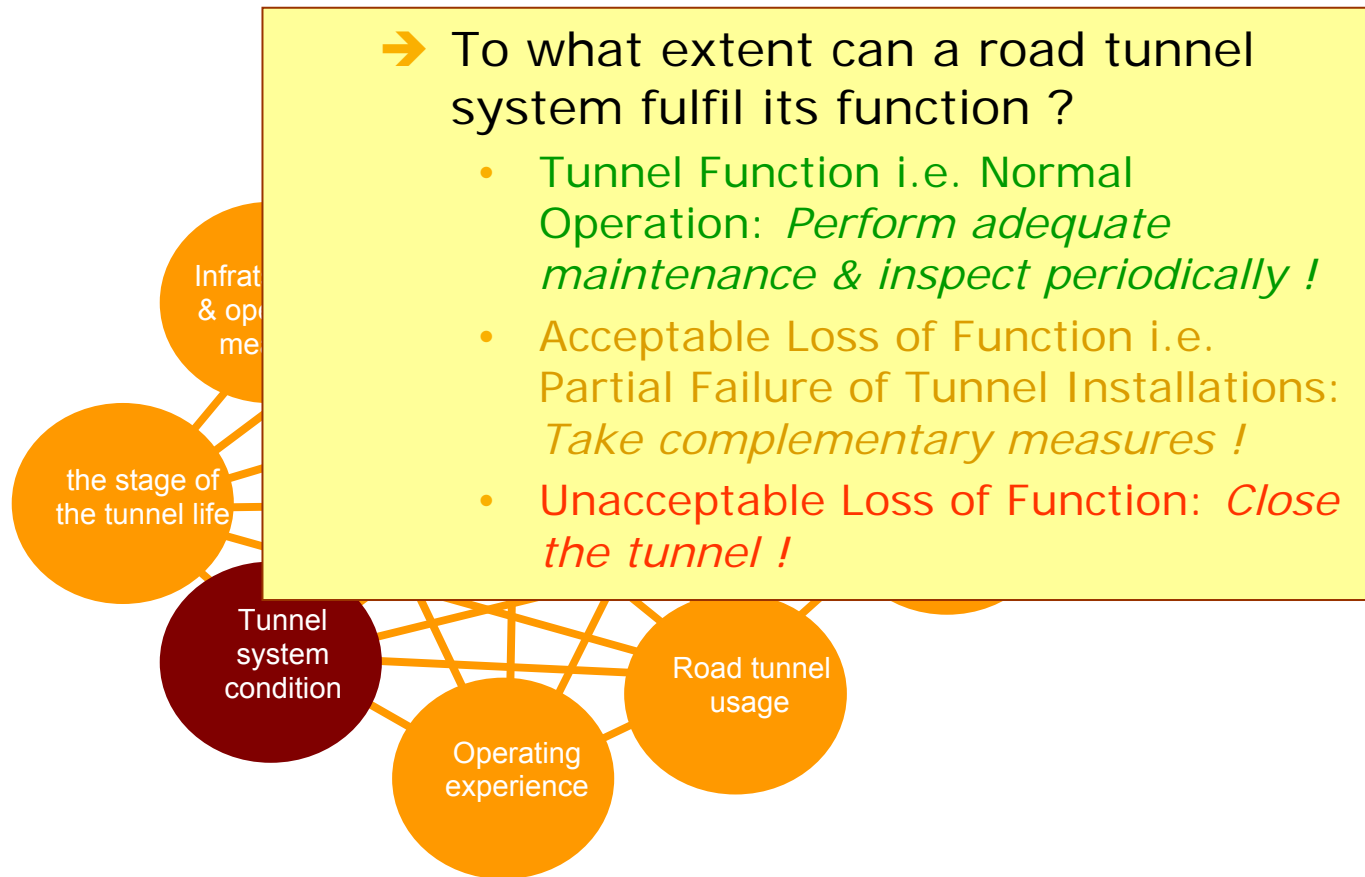
- Re-assess safety when a change has occurred or is expected, for instance:
- a substantial increase in the traffic flow
 - the traffic characteristics
 - when the regulations for dangerous goods transport through a tunnel are changed.



The integrated approach should enable:

- the safety assessment of all types of road tunnels
- differentiation between tunnel-specific characteristics.

Elements in an integrated approach

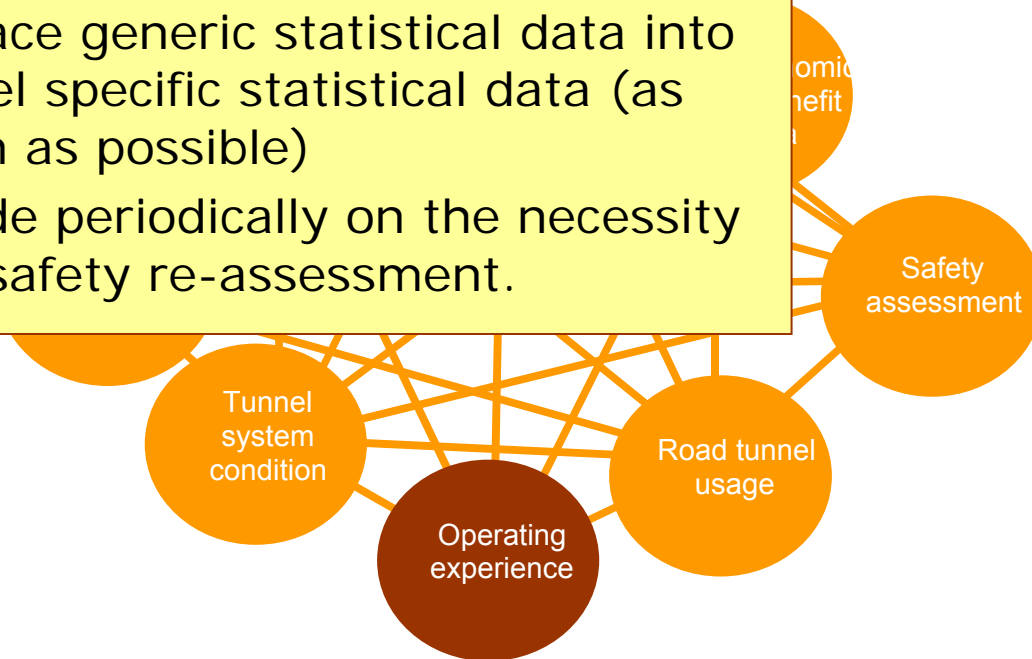


The integrated approach should enable:

- the safety assessment of all types of road tunnels
- differentiation between tunnel-specific characteristics.

Elements in an integrated approach

- For a start use generic statistical data of incidents and performance of (safety) equipment
- Replace generic statistical data into tunnel specific statistical data (as much as possible)
- Decide periodically on the necessity of a safety re-assessment.



The integrated approach should enable:

- the safety assessment of all types of road tunnels
- differentiation between tunnel-specific characteristics.

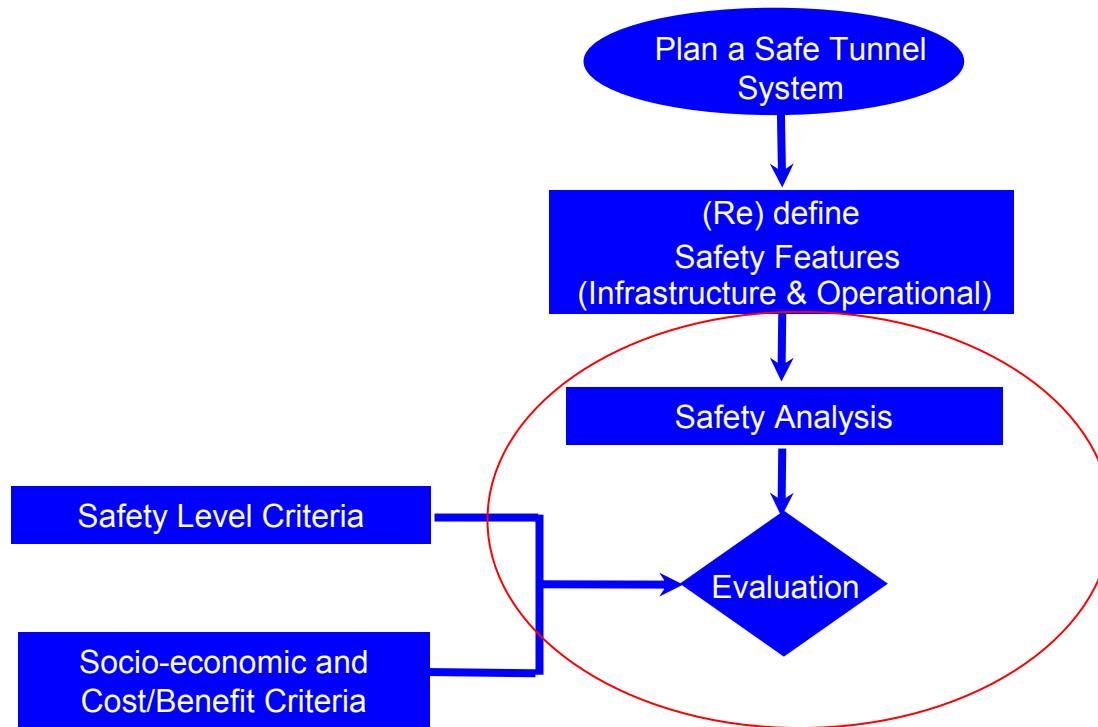
Proposal for an 'holistic' approach

Plan a Safe Tunnel
System

Safety Level Criteria

- Minimum safety (legislation)
- Extra Safety (Project or country specific)

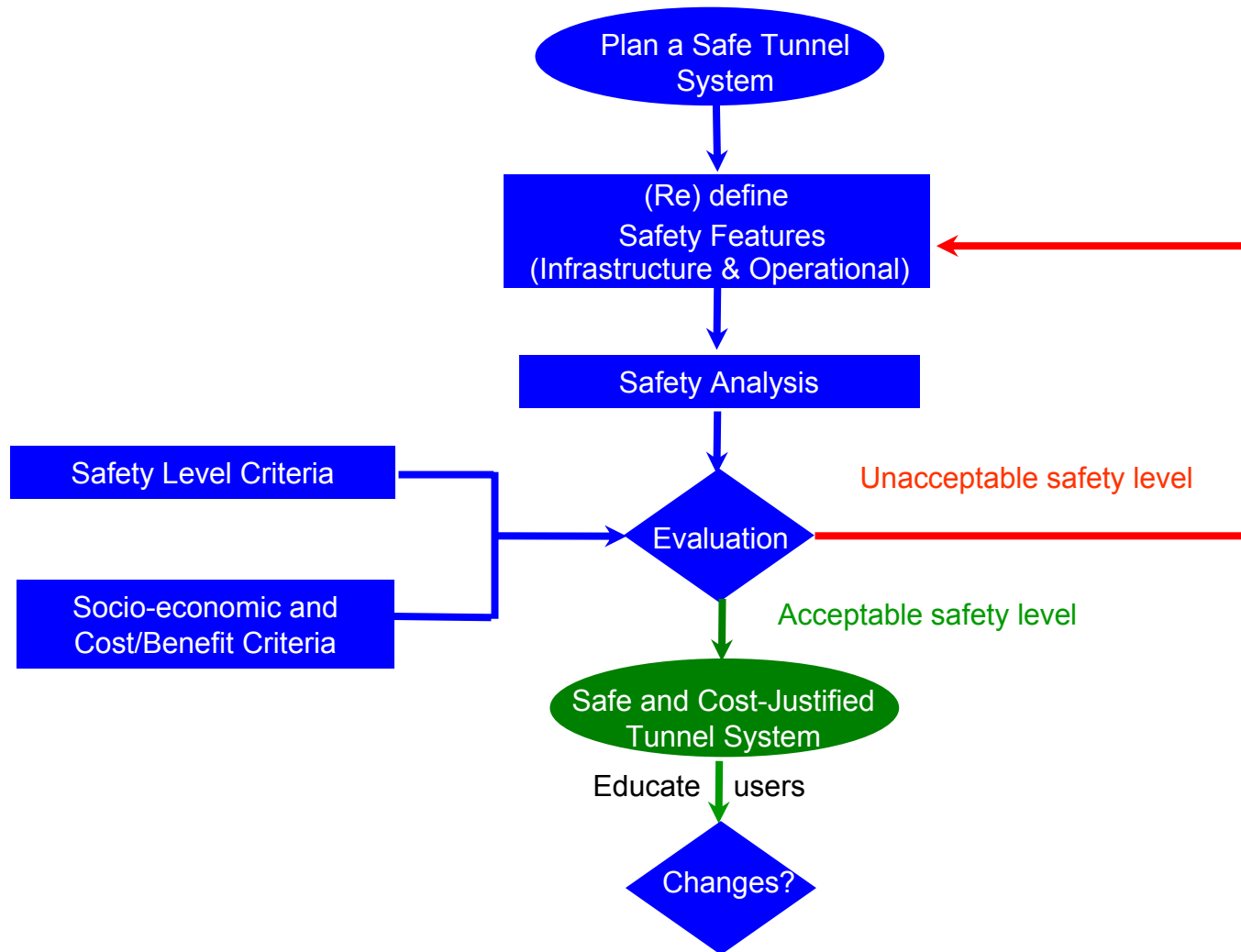
Proposal for an 'holistic' approach



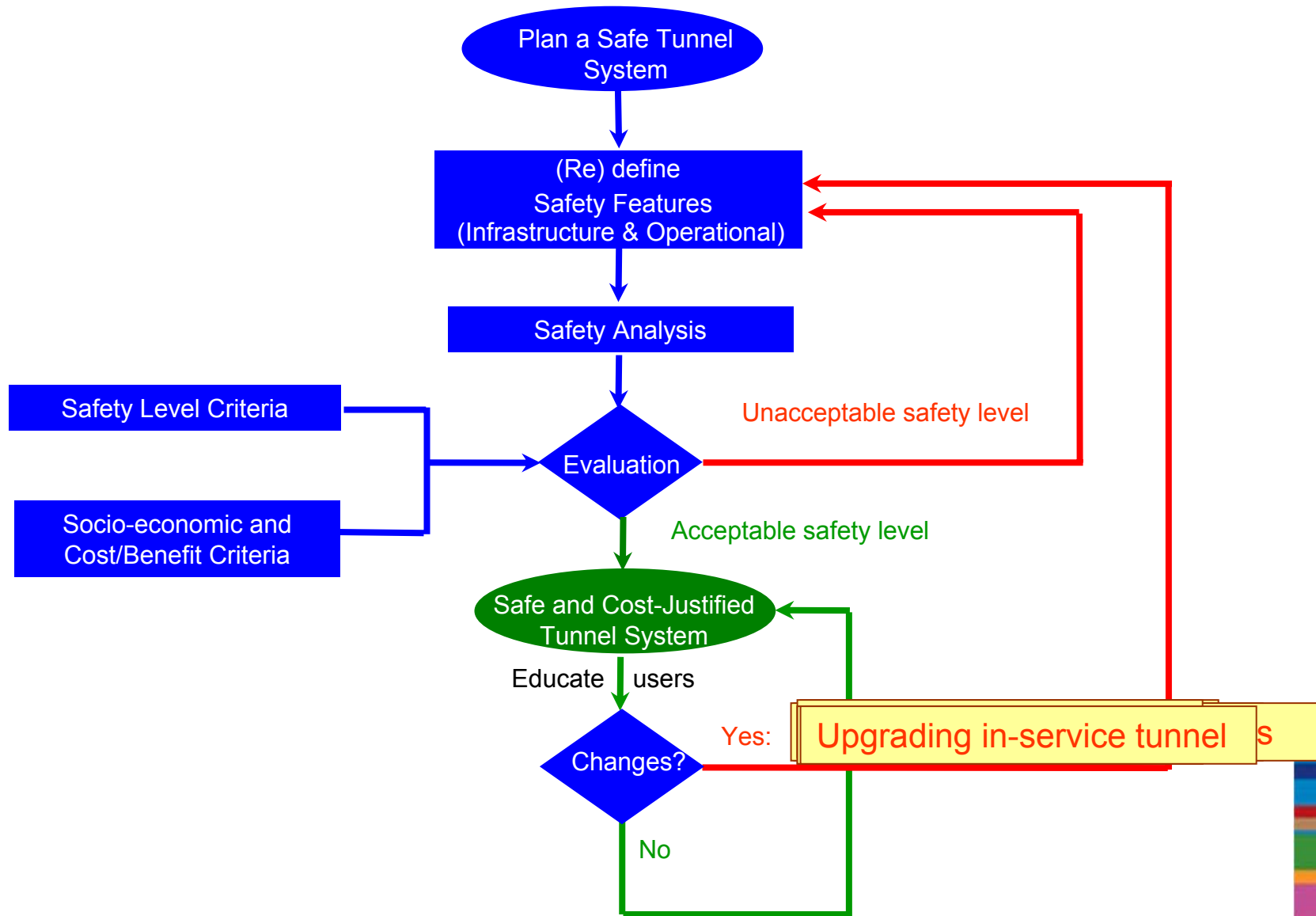
Safety Assessment = Safety Analysis and Safety Evaluation

- Probabilistic (Scenario-Based) Analysis
- Deterministic (Scenario-Based) Analysis
- Combination of both

Proposal for an 'holistic' approach



Proposal for an 'holistic' approach



Concluding remarks

What is an integrated ('holistic') approach to tunnel safety ?

It is a common framework to

- Plan a new tunnel
- Design a new tunnel
- Construct a new tunnel
- Operate a new tunnel
- Upgrade or refurbish an in-service tunnel

At each stage of the tunnel life the required safety levels are fulfilled.

All of this should take place according to a plan following the right safety procedures and filed in safety documentation.

Concluding remarks

With an 'holistic' approach the tunnel safety around the world will be increased:

- lives are saved,
- societies save money by a reduction of:
 - Accidents, injuries and fatalities;
 - Damage to the tunnel structure; and
 - Macro-economic losses

An integrated approach facilitates tunnel design optimisation.

- Best practices in each country can smoothly fit in
- Fit for all purposes:
 - prescriptive safety features,
 - performance-based safety features
 - a combination of both.

Acknowledgements

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Questions ???