

Risk analysis of very long italian railway tunnels

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Why a Risk Analysis?

- **We need to build a new tunnel**
- **We need to make some changes on existing tunnel**
- **We need to be sure that our tunnel is safe enough**

Risk Analysis key issues

- Risk based approach (risk based safety objectives)
- Hazard identification
- Scenarios identification and description
- Hazard factors and consequences prediction
- Cost Benefit evaluation
- Uncertainty evaluation and treatment

Very Long Tunnels Characteristics

- According to the european standards tunnel characterized by $L > 5$ km can be regarded as LONG TUNNELS
 - TSI - SRT: Rolling stocks safety performance classification ($A < 5$ km, $B > 5$ km)
 - Italian Decree 28.10.2005: additional safety measures for $L > 5$ km
- TSI – SRT: Tunnels of more than 20 km in length require a special safety investigation

Very Long Tunnels Characteristics

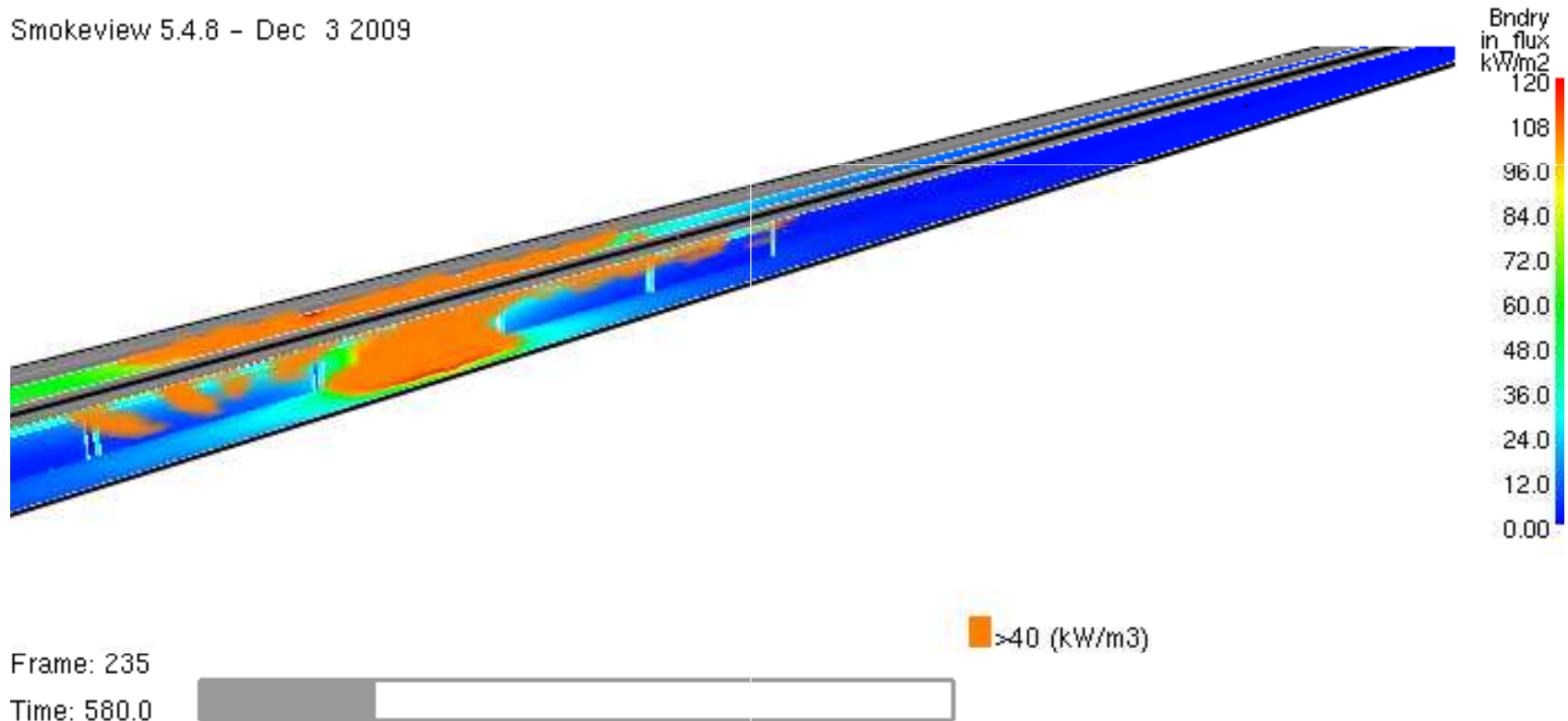
- **Frequency of the initiator events**
- **Number of trains potentially involved in a tunnel fire**
- **Length of the egress path**
- **Time available for a fire to**
 - **reach significant HRR values**
 - **break fire barriers**
- **Aleatoriness of the boundary conditions**
- **Complexity of rescue intervention**
- **Complexity of fire brigade intervention**

All these parameters are roughly proportional to the TUNNEL LENGTH

Dangerous goods in very long tunnels

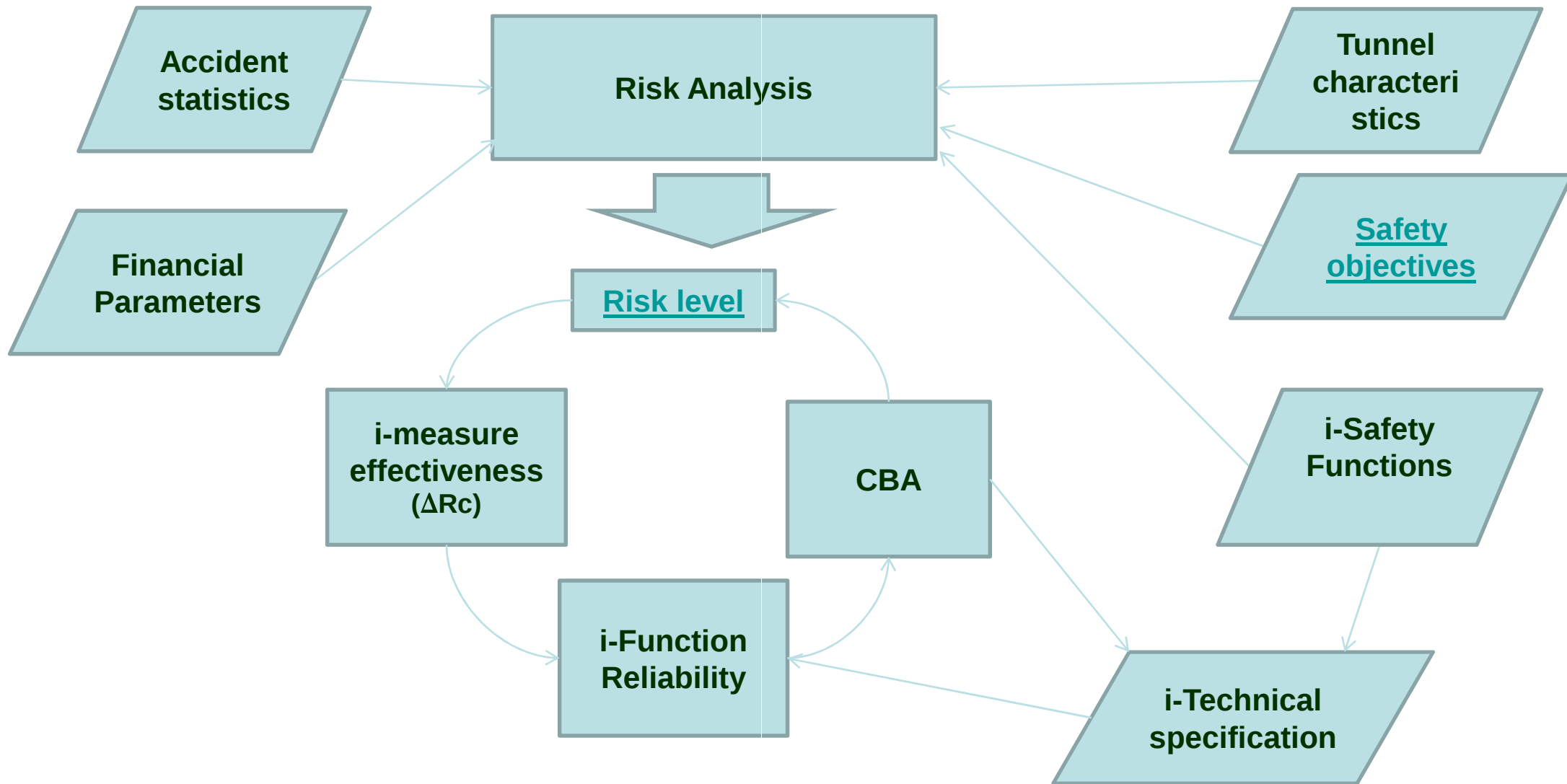
- **A Pool fire (150 MW) determined after a derailment of a tank**

Smokeview 5.4.8 - Dec 3 2009



- **Heat flux untenable in a range of 100 m from the fire source**
- **Hazard factors can spread km far from the fire source**

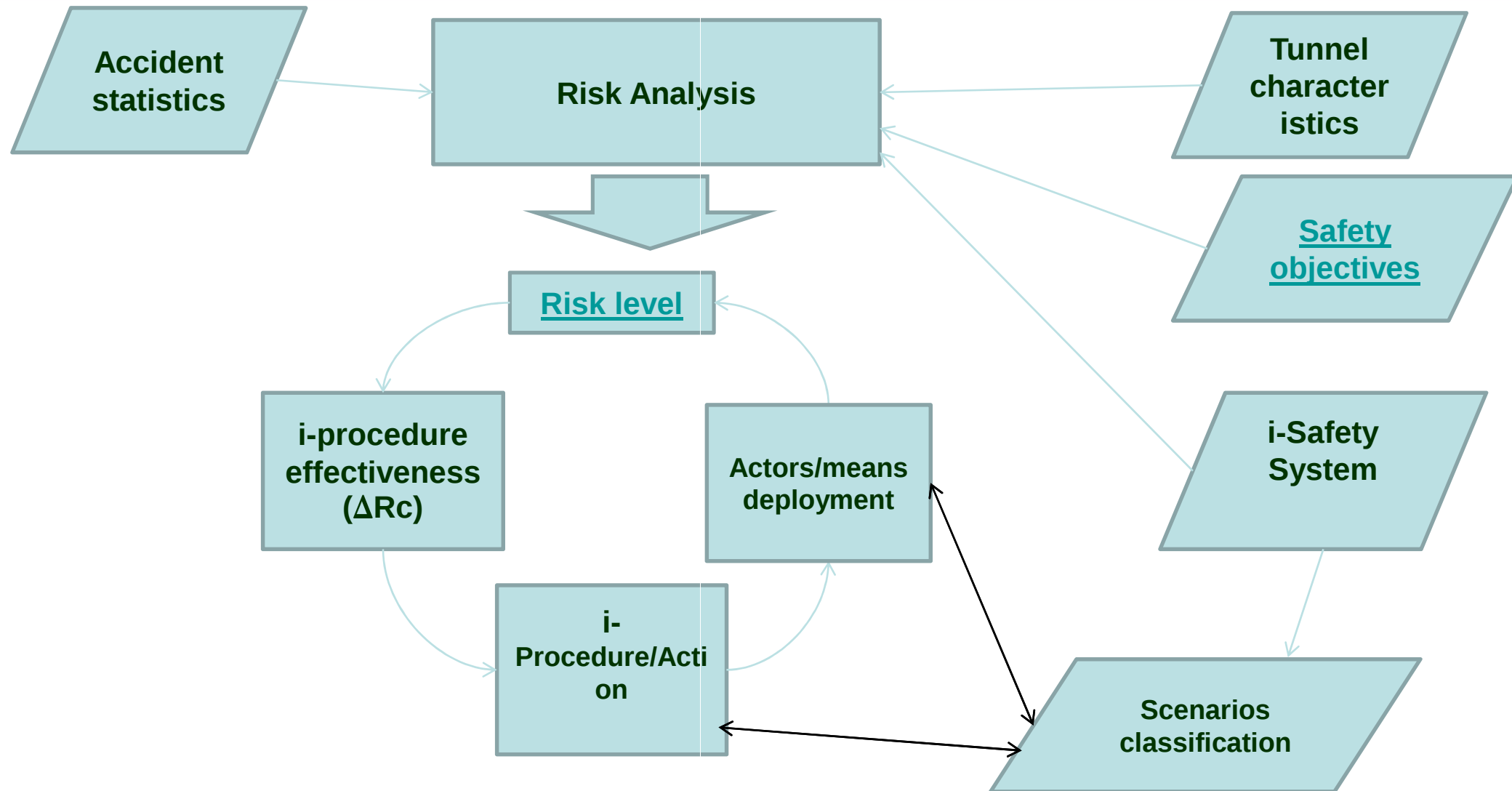
Risk Assessment – SIL apportionment



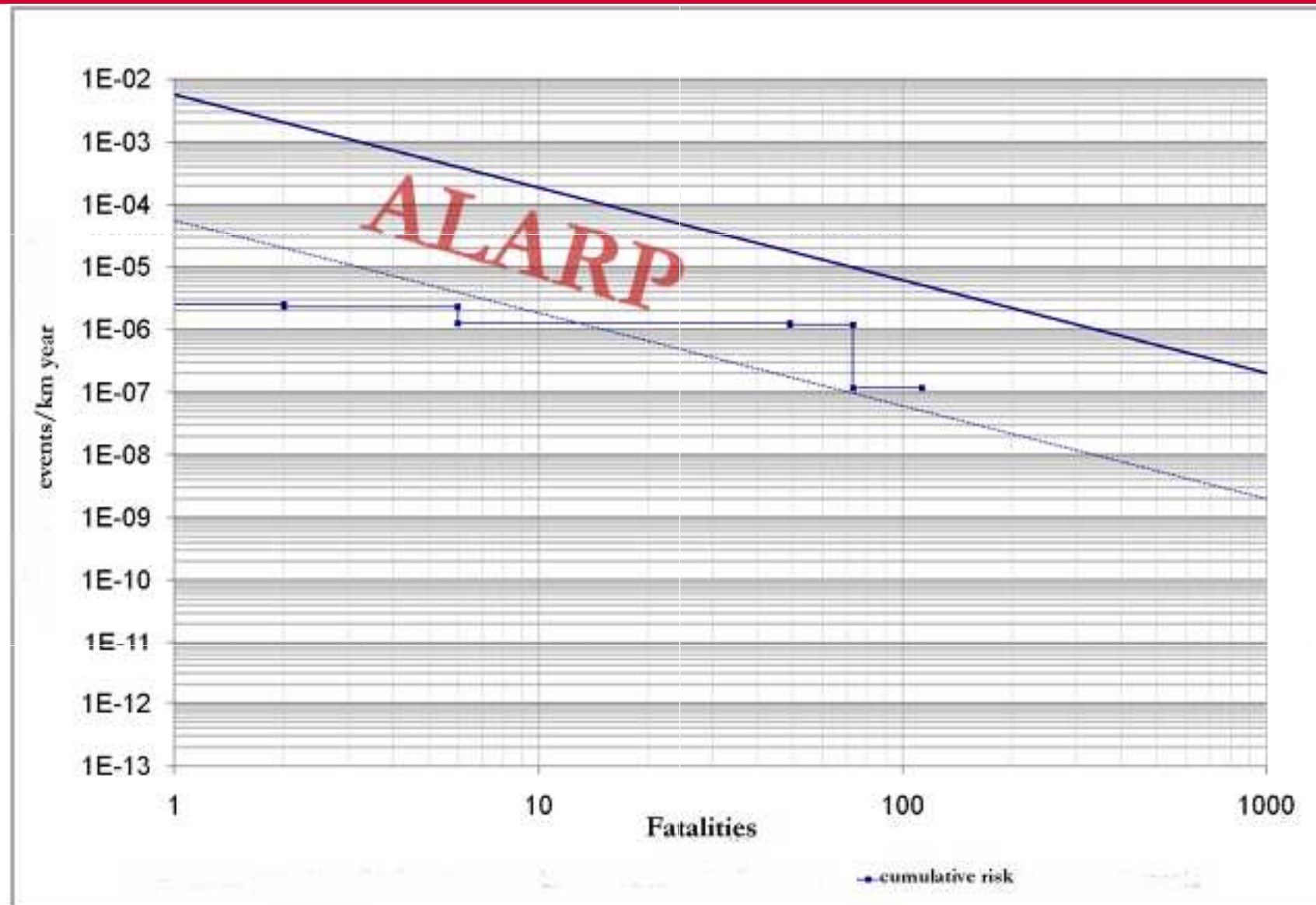
Emergency Plan

- **Emergency call/notification reception**
- **Emergency classification**
- **Procedure assignment based on the incident classification**
- **Internal and external resources assignment**
- **Coordination with external agencies**
- **Corresponding response procedure monitoring**
- **Incident closure registration**

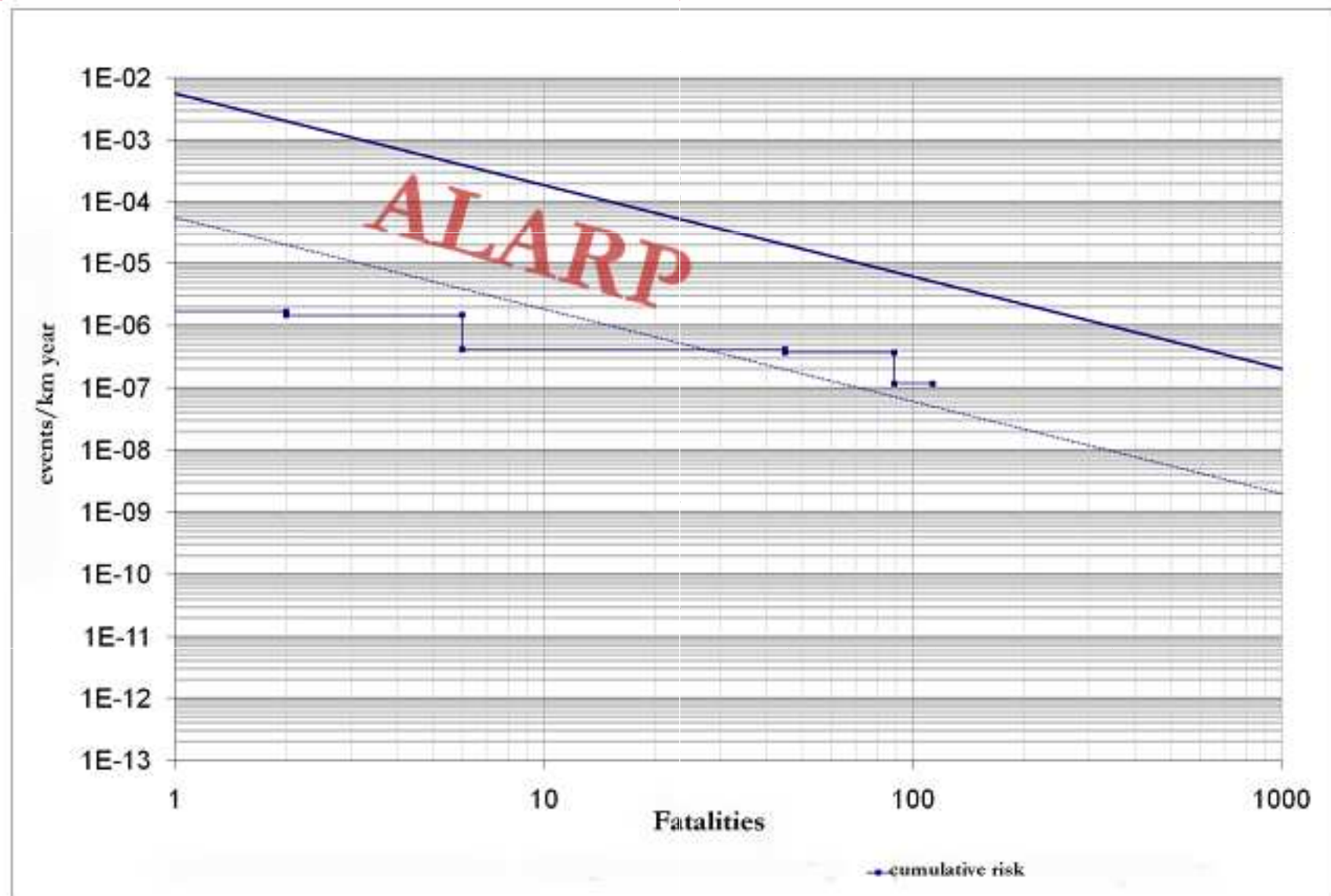
Risk Assessment – Emergency Plan



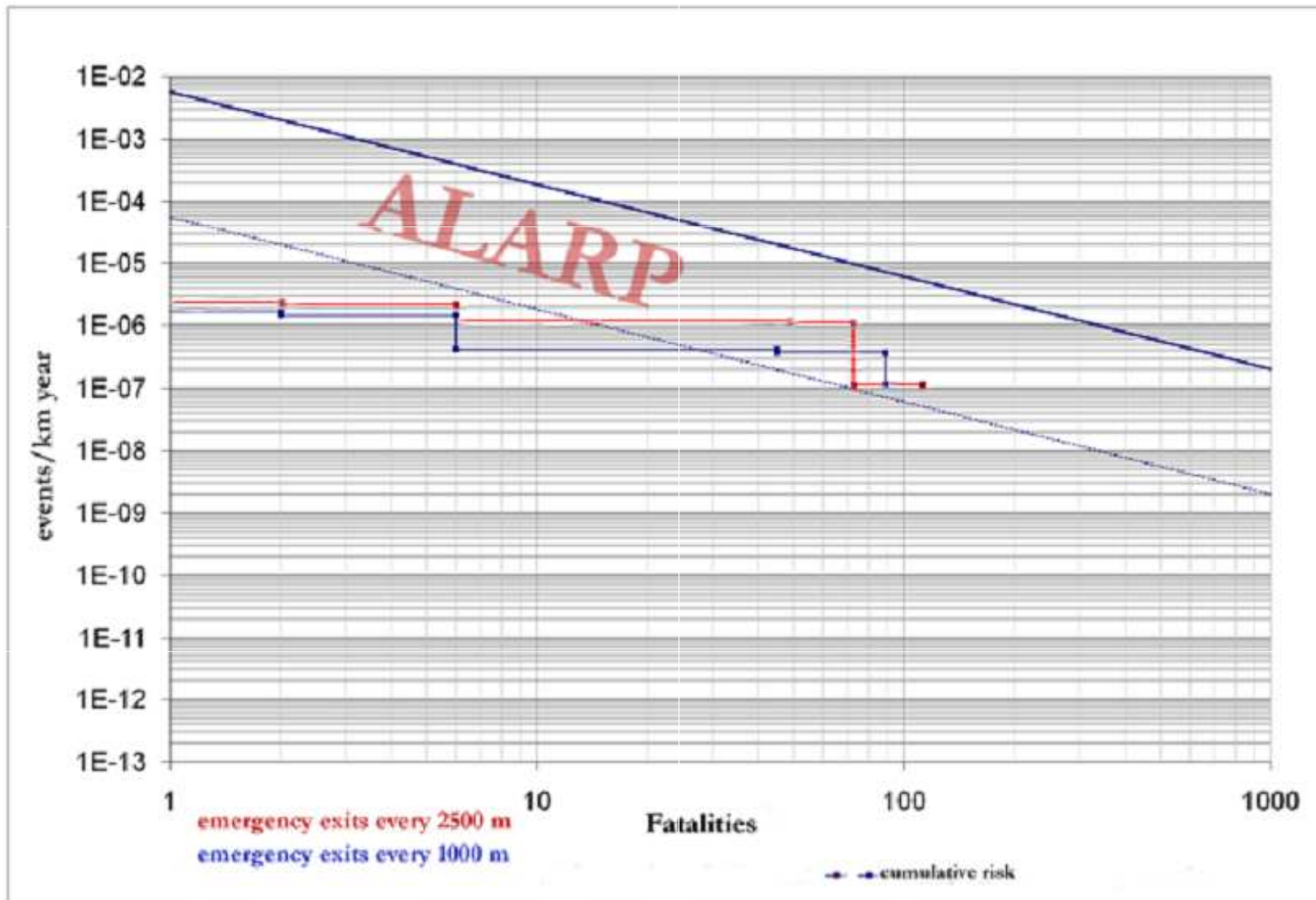
Case Study - Results



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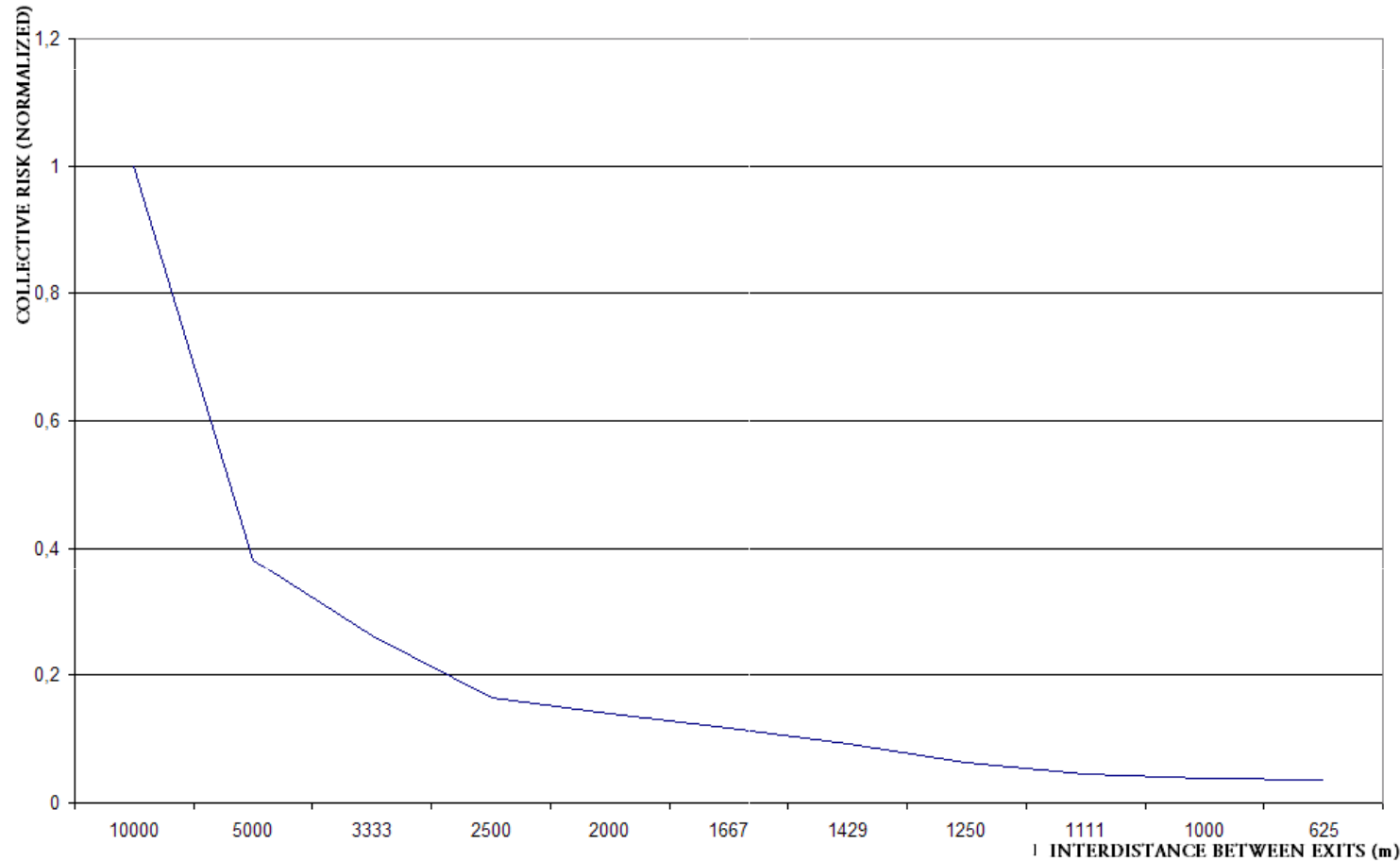


Case Study - Comparison



Case Study - Results

- A sensitivity analysis has been performed varying the number of intermediate exits along the tunnel



Conclusions

- Tunnel safety design carried out through a risk based decision making process (PROs)
 - Optimized SIL apportionment for safety functions
 - Appropriate criteria can be determined to manage degraded operational state (availability / safety)
 - Scenarios classification according to the expected risk addressing the emergency plan design

Conclusions

- Tunnel safety design carried out through a risk based decision making process (CONs)
 - Large amount of data and appropriate performance criteria are needed
 - Several time consuming activities to be carried out
 - Multi-skilled engineering team needed

Thank you!

