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# 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**

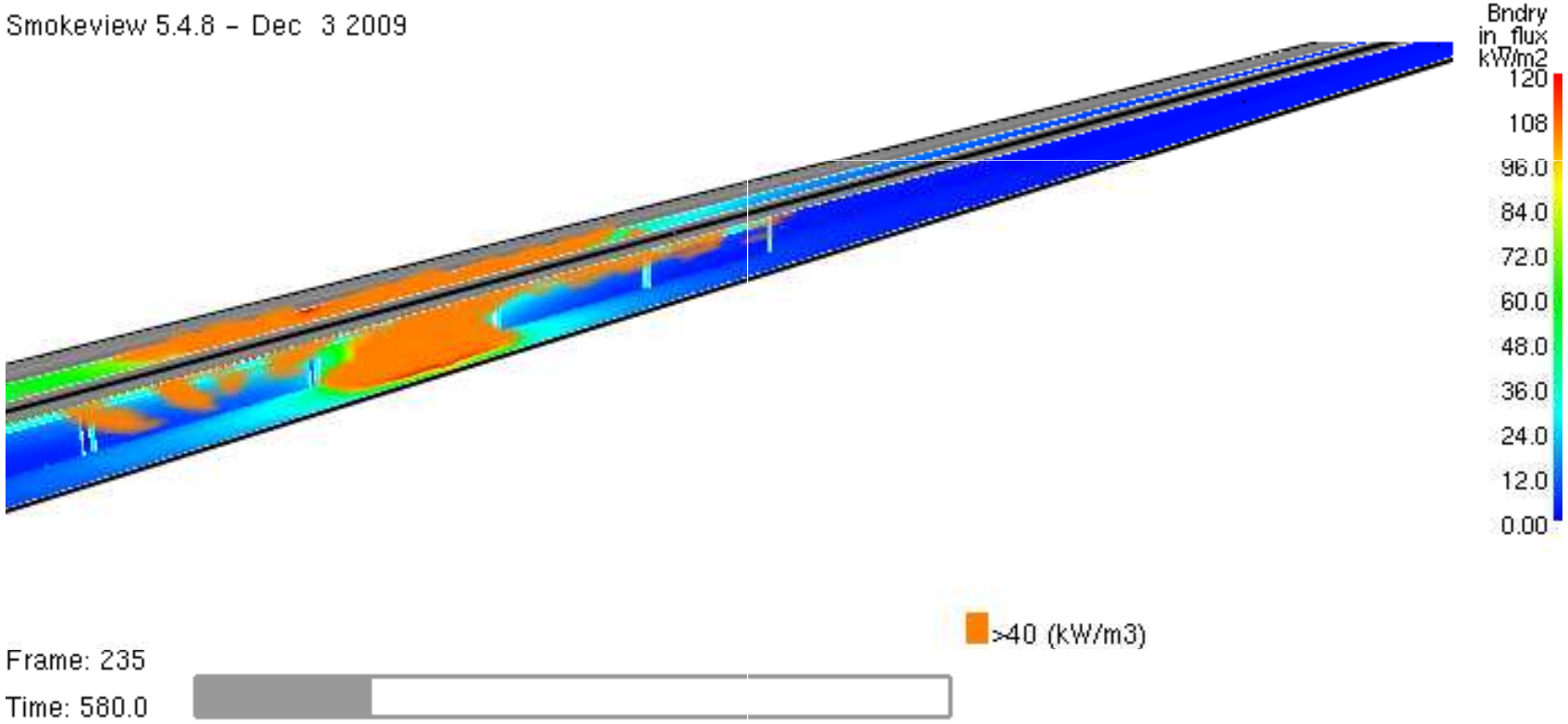
# Very Long Tunnels Characteristics

- 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
- Aleatoriety of the boundary conditions
- Complexity of rescue intervention
- Complexity of fire brigade intervention

**All these parameters are roughly proportional to the TUNNEL LENGHT**

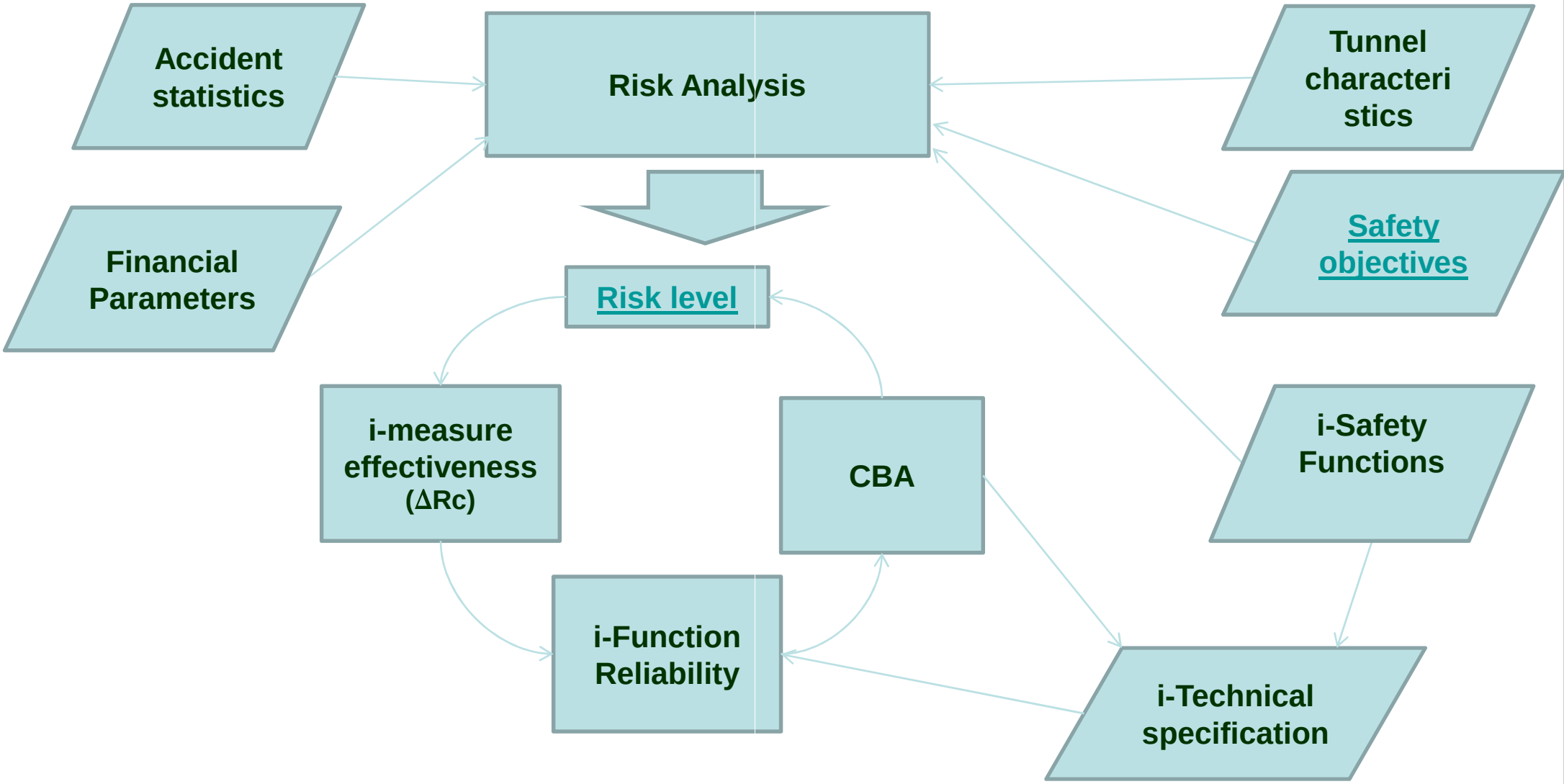
# Dangerous goods in very long tunnels

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




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

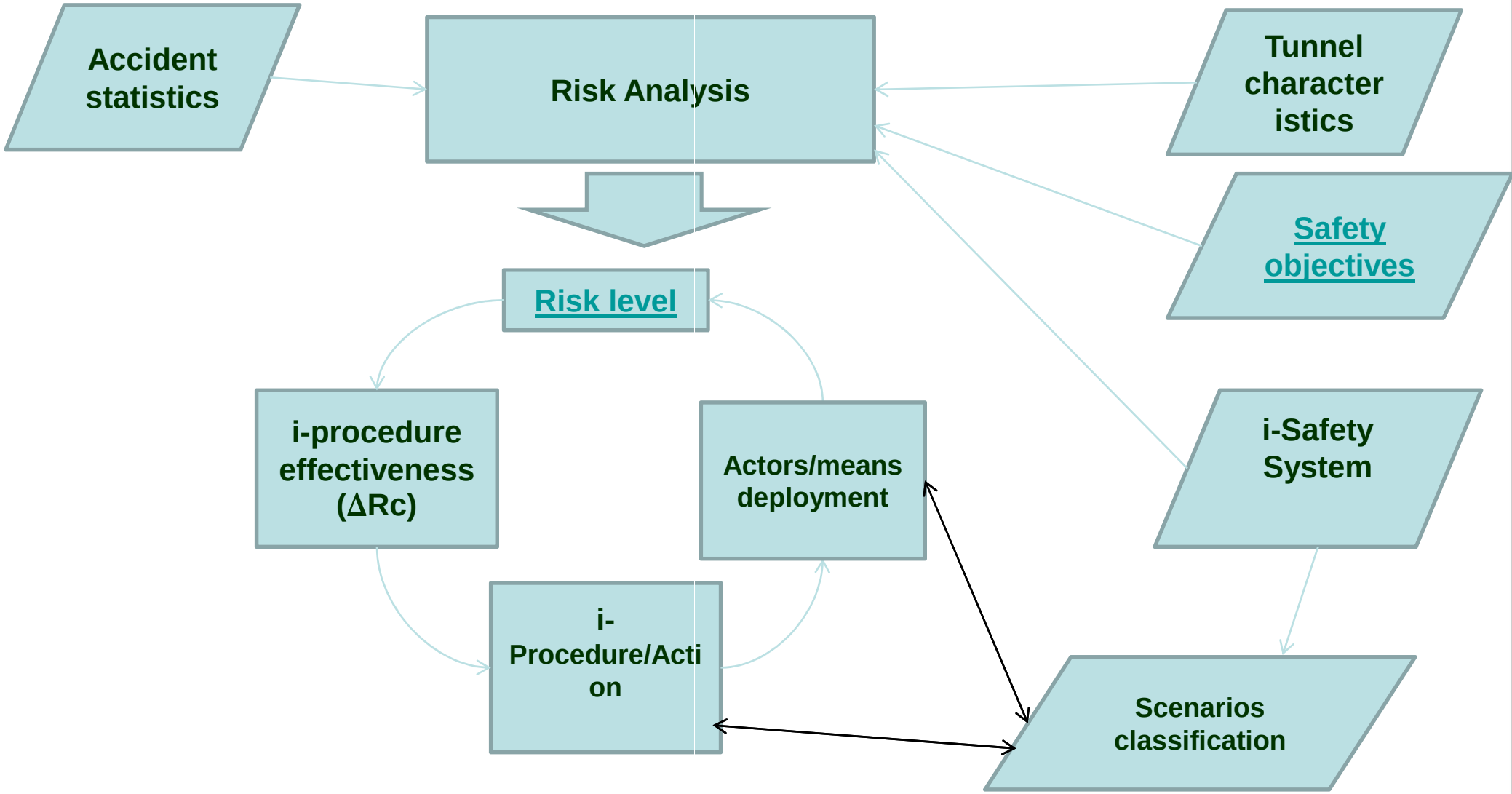
# Risk Assessment – SIL apportionment



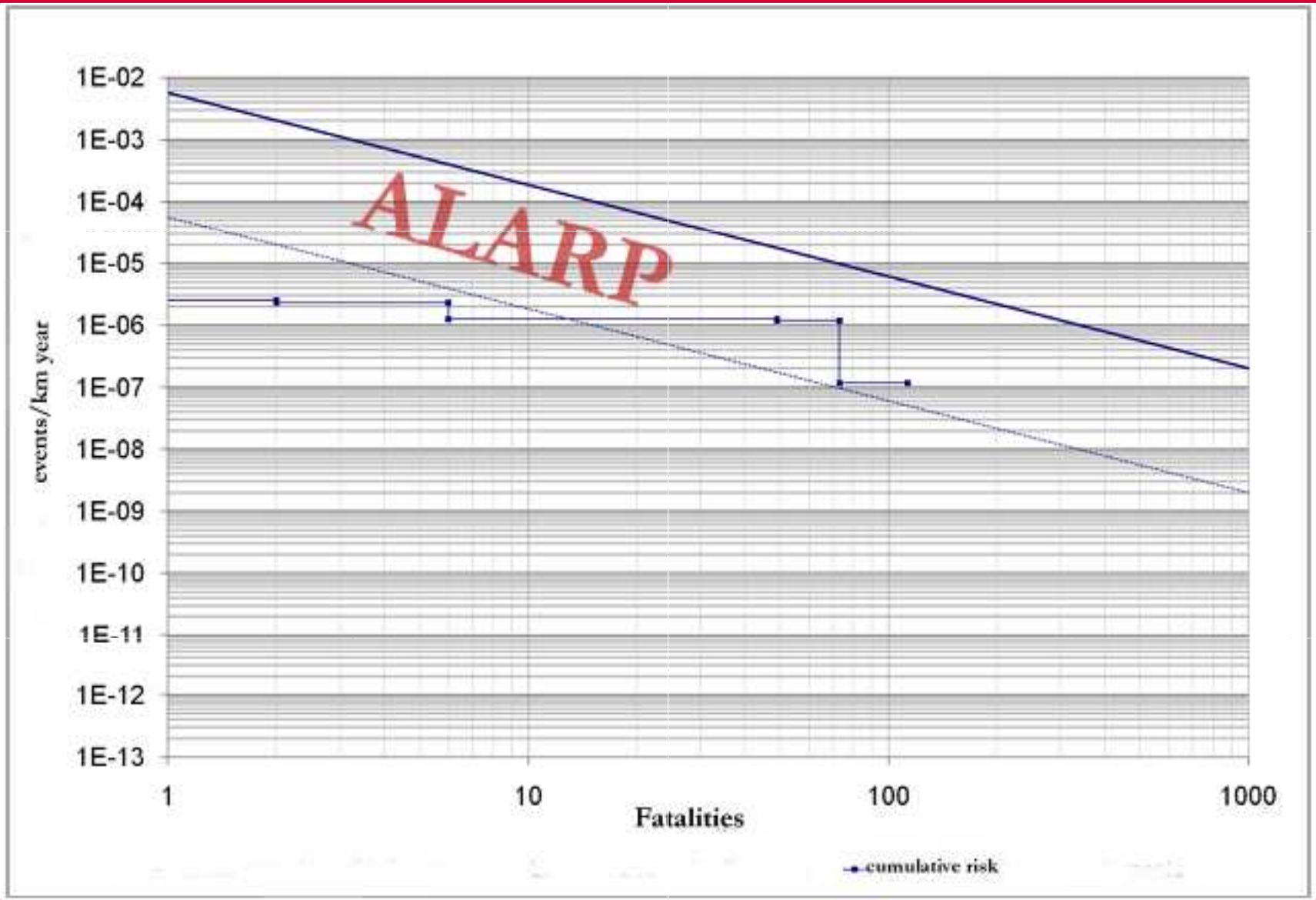
# Emergency Plan

- 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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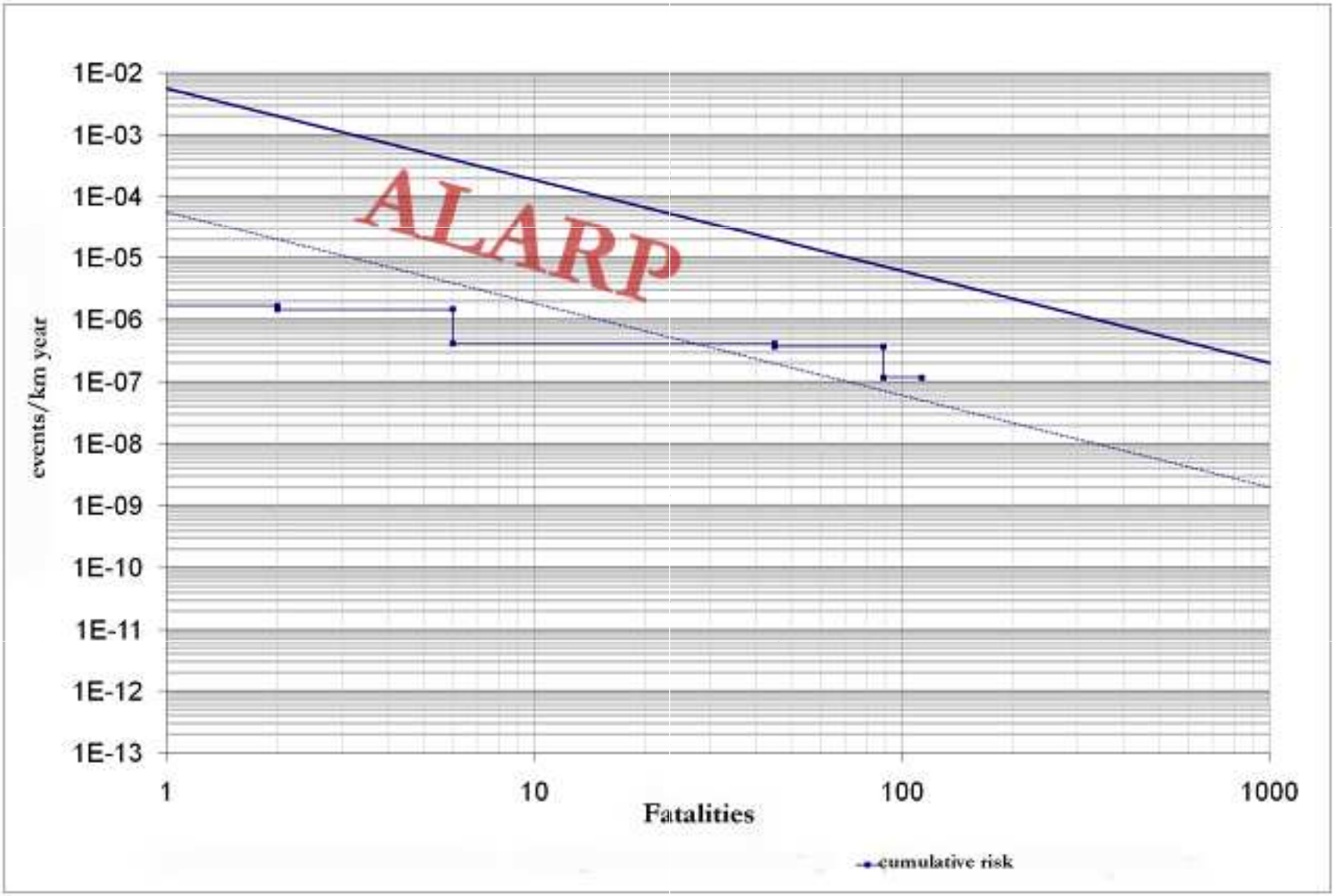


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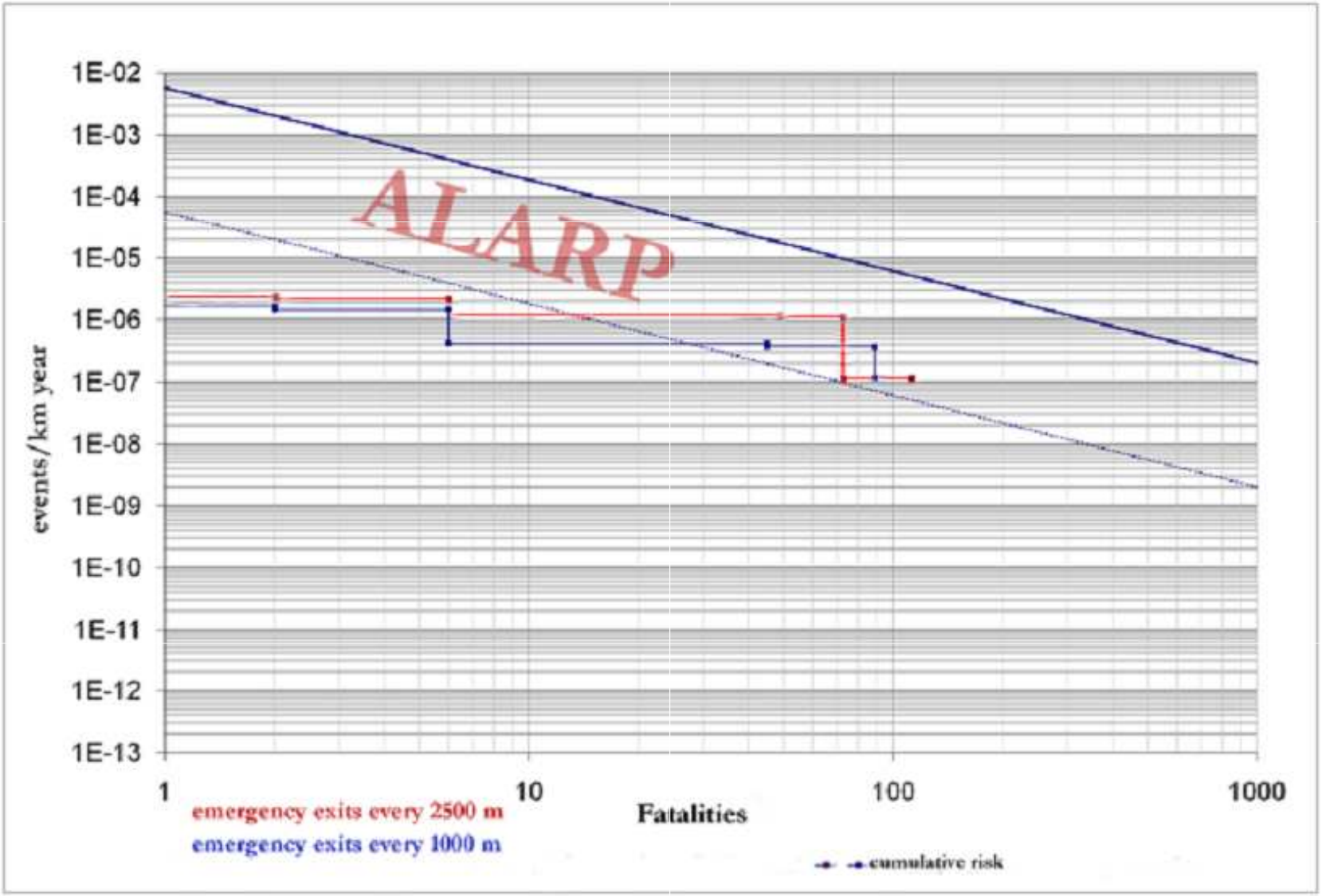
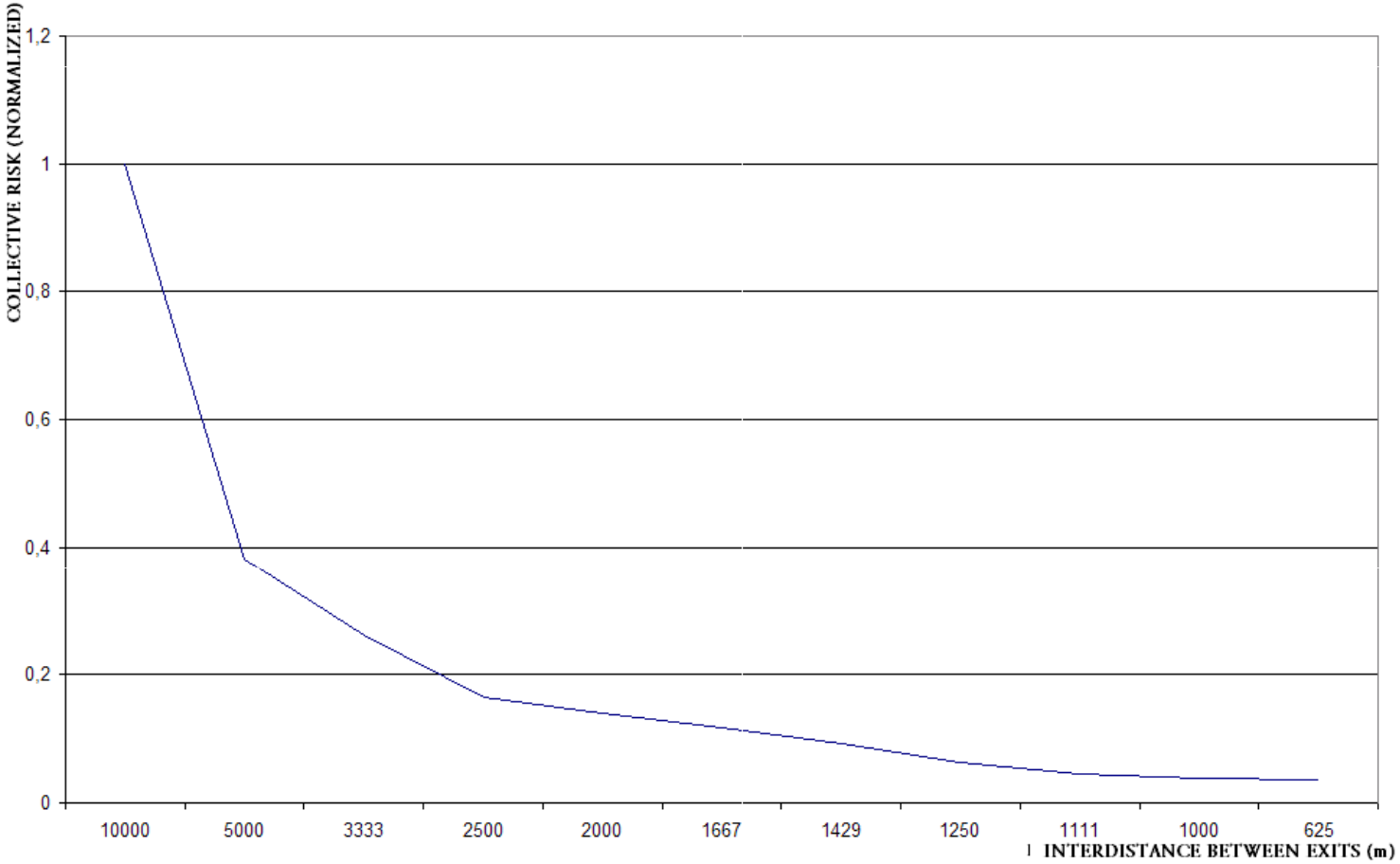
# Case Study - Comparison



# 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!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