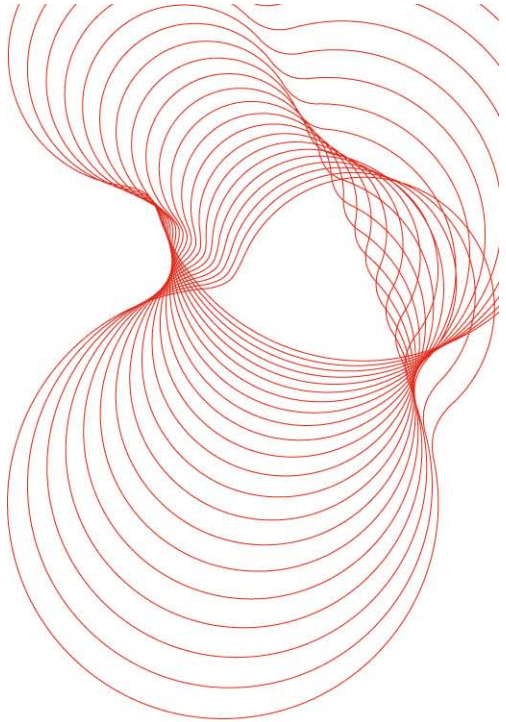


# Opportunities for materials' selection and railcar fire safety

Prof David Charters, PhD, CEng, FIFireE, MIMechE

Director of Fire Engineering

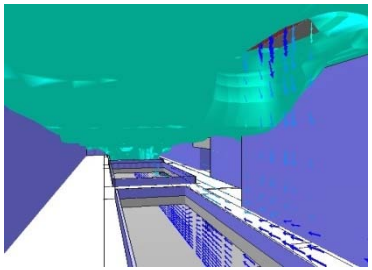
Visiting Professor of Fire Risk Analysis at the University of Ulster

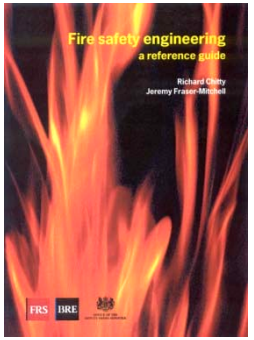
# Overview

1. Introduction
2. Fire safety in tunnels
3. Fire engineering of tunnels
4. New opportunities in railcar design
5. Summary

| EU RTD Project | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|
| FIT | Consultable databases & guidelines | | | | | |
| DARTS | Cost-optimal & durable new design | | | | | |
| Safe Tunnel | | Preventive safety measures | | | | |
| Sirtaki | | Advanced tunnel management | | | | |
| Virtual Fires | | Tunnel fire simulator | | | | |
| UPTUN | | | Upgrading of existing tunnels - Innovation | | | |
| SafeT | | | Harmonised European Guidelines | | | |

# A unique perspective






# Recent tunnel fires include

| Date | Tunnel | Type | Dead |
|---|---|---|---|
| 18/02/03 | Taegu, S. Korea | M | 197+ |
| 25/01/03 | Chancery Lane, London Underground, England | M | |
| 03/11/02 | Homer Tunnel, New Zealand [5] | R | |
| 24/10/01 | St Gotthard, Switzerland | R | 11 |
| 18/07/01 | Baltimore (Howard Street), USA | T | |
| 27/11/00 | Laerdal, Norway | R | |
| 11/11/00 | Kaprun, Austria | T | 158 |
| 29/05/00 | Cross Harbour Tunnel, Hong Kong [6] | R | |
| 29/05/99 | Tauern, Austria [7] | R | 12 |
| 24/03/99 | Mt Blanc, France/Italy [8] | R | 39 |
| 18/11/96 | Channel Tunnel, England/France [9] | T | |
| 28/10/95 | Baku, Azerbaijan | M | 289 |
| 15/10/94 | Kingsway (Mersey) Tunnel, England [10] | R | |
| 01/03/94 | Huguenot Tunnel, South Africa [11] | R | 1 |
| 19/02/91 | Bethnal Green, London Underground, England [12] | M | |
| 16/01/91 | Zurich, Switzerland [13] | T | |
| 18/11/87 | Kings Cross, London Underground, England [14,15] | M | 31 |
| 17/01/79 | San Francisco BART, USA [16] | M | 1 |

**Key:**

M = Metro

R = Road

T = Train

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# Variations in tunnel fire safety challenge

| Item | Metro | Rail | Road |
|---|---|---|---|
| Length | 5 to 600 meters mean between 2 stations | 30 m to about 50km | 200 m to about 20 km |
| Location | city | city, country | city, country |
| Exits | stations | tunnel ends | tunnel ends, shelters with access to other tunnels |
| Possibilities to move from accident place to safe exit | very narrow pathways | narrow pathways | wider pathways |
| Intervention time of firemen | 5 to 10minutes | 10 to 60 minutes | 5 to 10 (firemen at the end) to 60minutes |
| Fire heat release rate | 7 to 20 MW fire load under control | 10 to 200 MW(TMD) fire load depends on vehicles (their load) | 2 to 200 MW(TMD) fire load depends on vehicles (their load) |
| People | 100 to 250 per wagon | 150 per wagon | 1 to 100( bus) |
| Traffic control | strict control | strict control | no control to individual drivers |
| Communica-tion for alarm | driver or interphone | driver of the train | each driver of each vehicle |
| Materials | fire resistance standard | fire resistance standard | no standard |
| Firemen intervention | stations cannot use cars | ends of tunnel cannot use cars | ends of tunnel, special accesses |

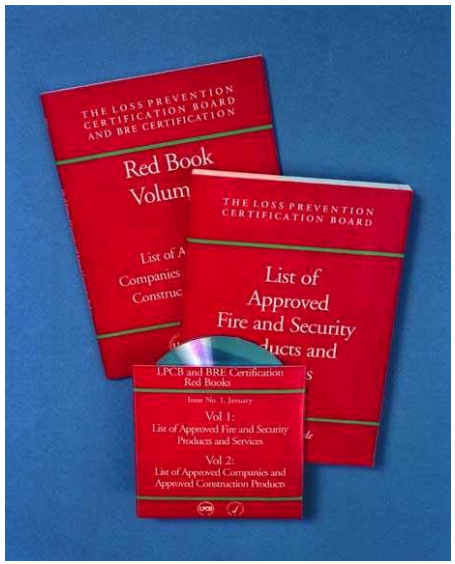
# Standard small-scale tests

- Checks conformity to regulator requirements
- Spread of flame
- Limited data

# ‘Always built and managed as intended?’

“There is hardly anything  in the world today that some man can’t make just a little bit worse and sell just a little bit cheaper, and the people who buy on price alone are this man’s lawful prey.”

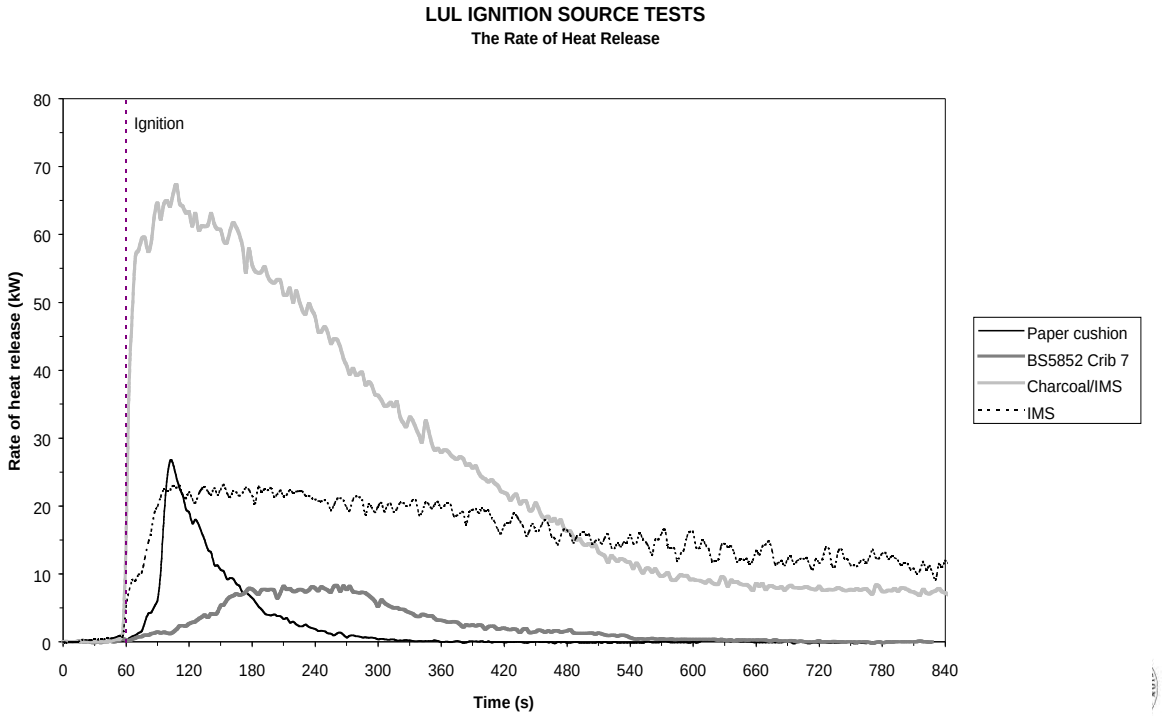
*John Ruskin (1819 – 1900)*


Independent 3rd Party approval

*www.redbooklive.com*

# London Underground metro car used for the test

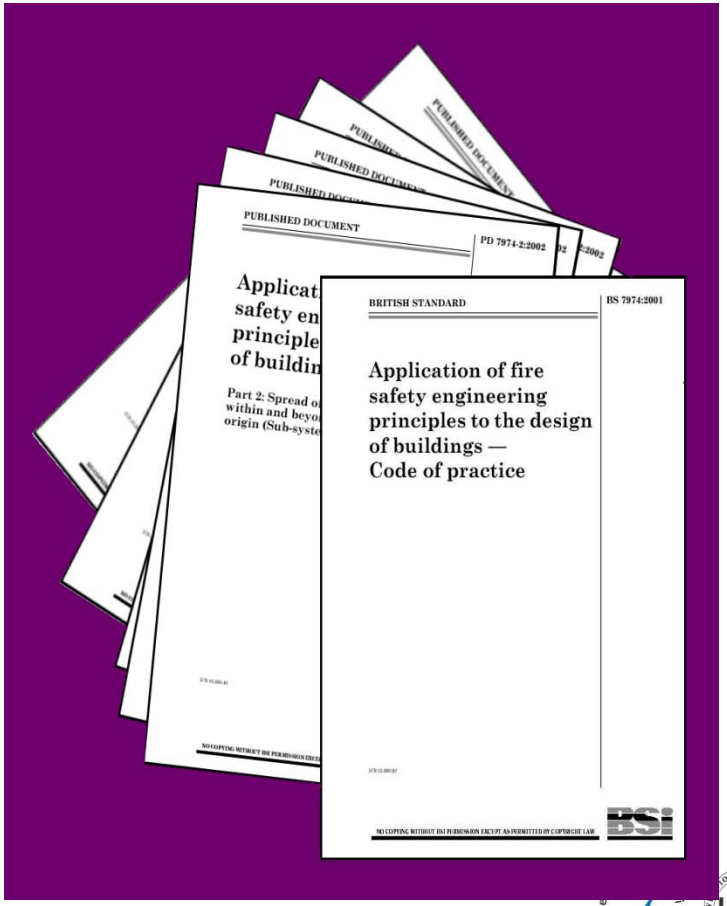


# BS 7974

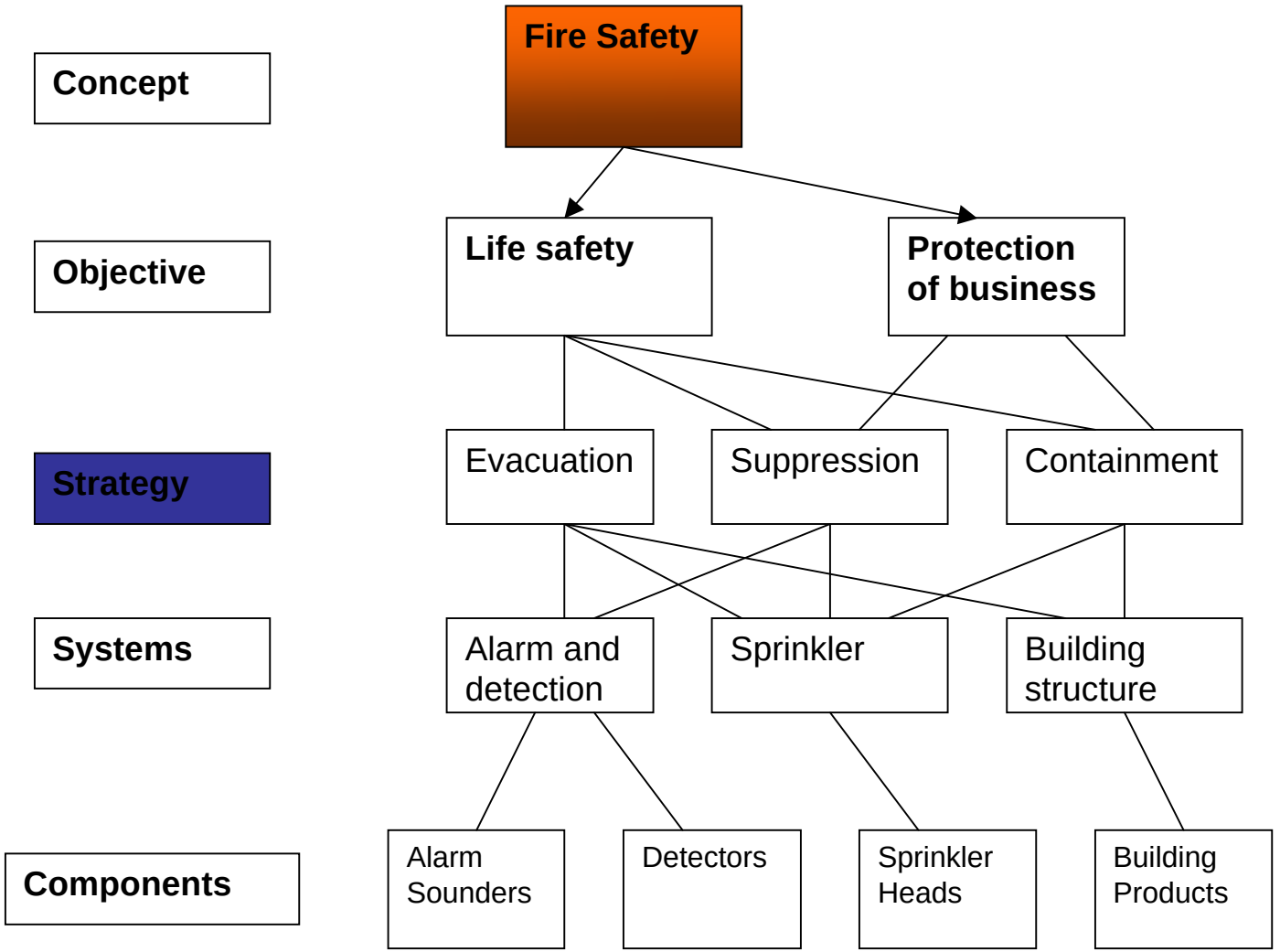
British Standard  BS 7974 - Code of Practice on the Application of fire safety engineering principles to the design of buildings

Published Documents PD 7974:

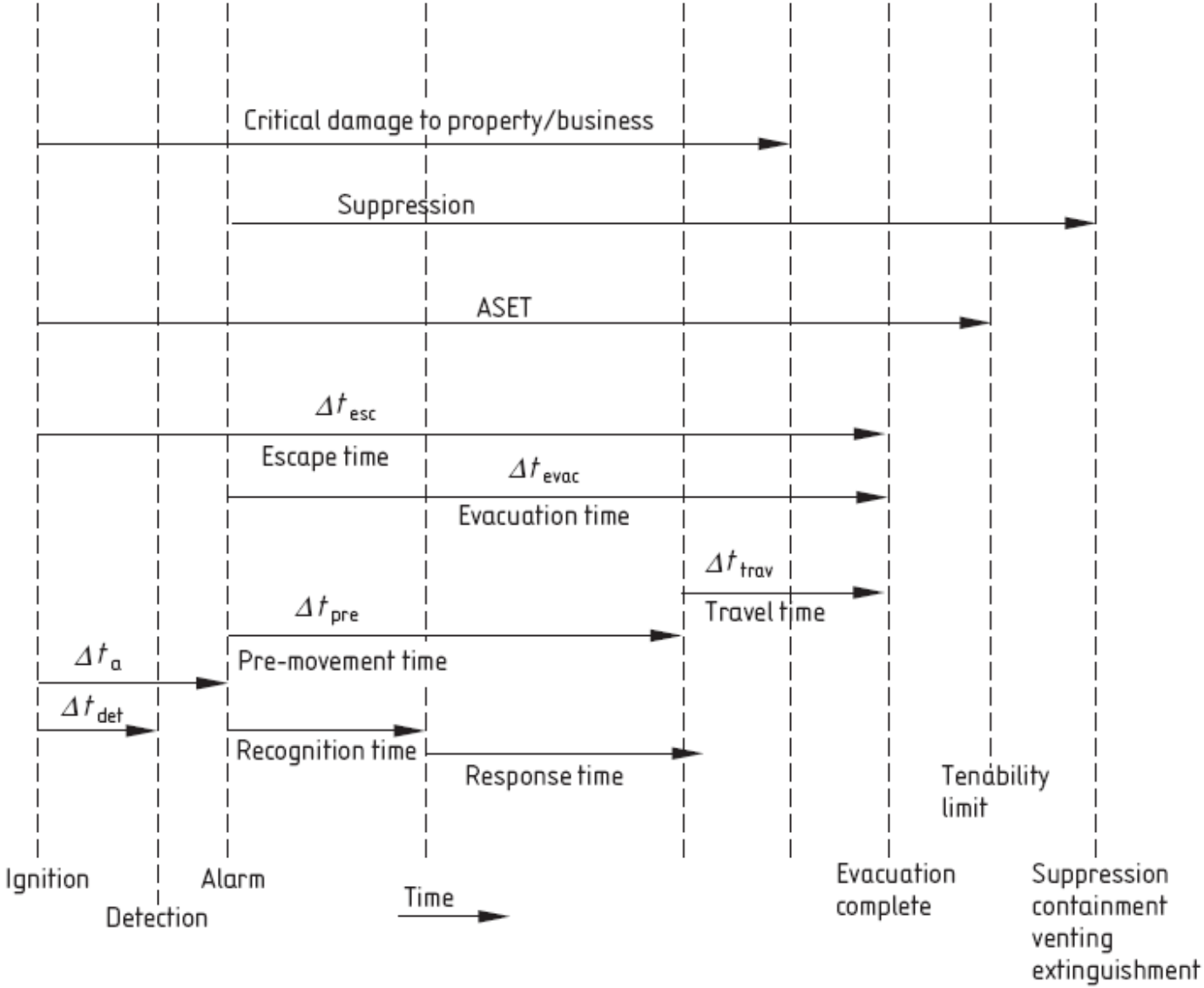
- Part 0 Introduction
- Part 1 Initiation and development of fire
- Part 2 Smoke movement beyond the room of origin
- Part 3 Response of structure to fire
- Part 4 Activation of detection and suppression systems
- Part 5 Fire service intervention
- Part 6 Evacuation
- Part 7 Fire risk assessment



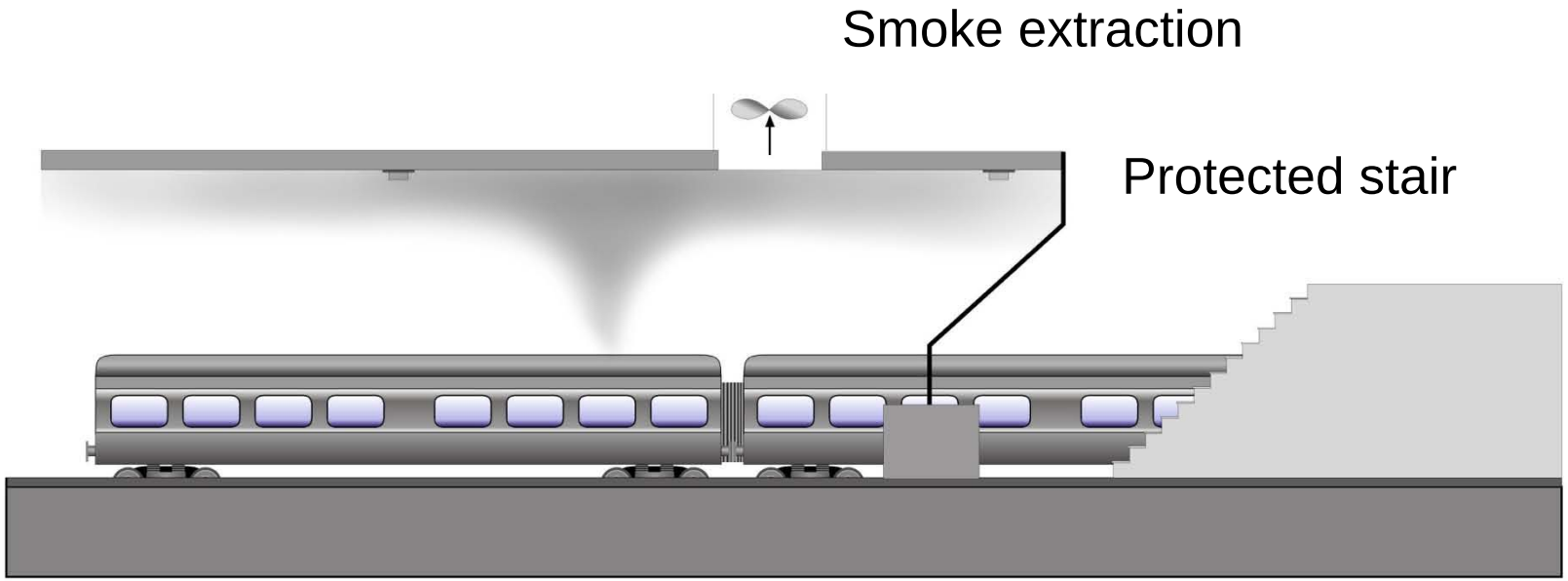
# Fire safety – hierarchical approach (Shields et al)



# Time line analysis



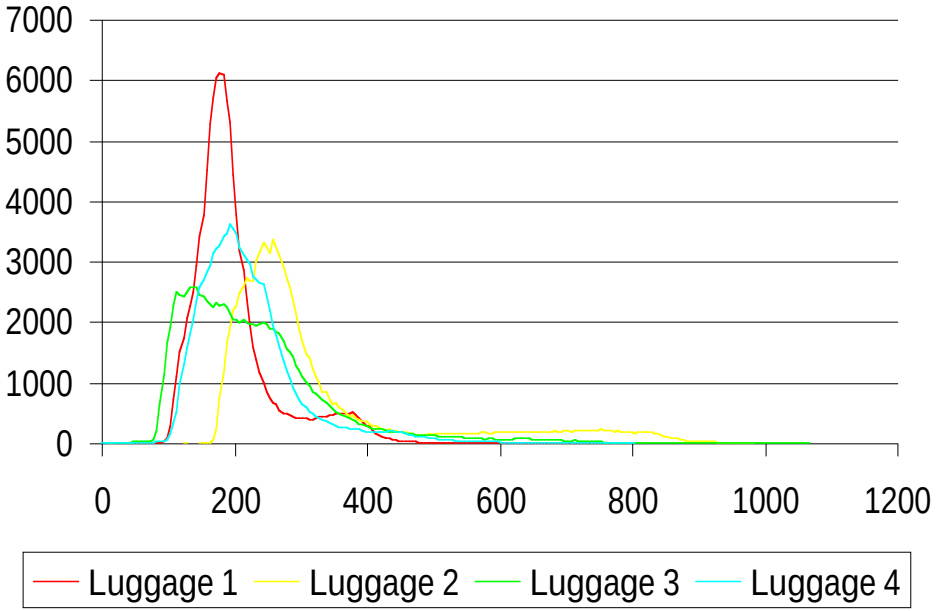
# Station/tunnel fire strategy



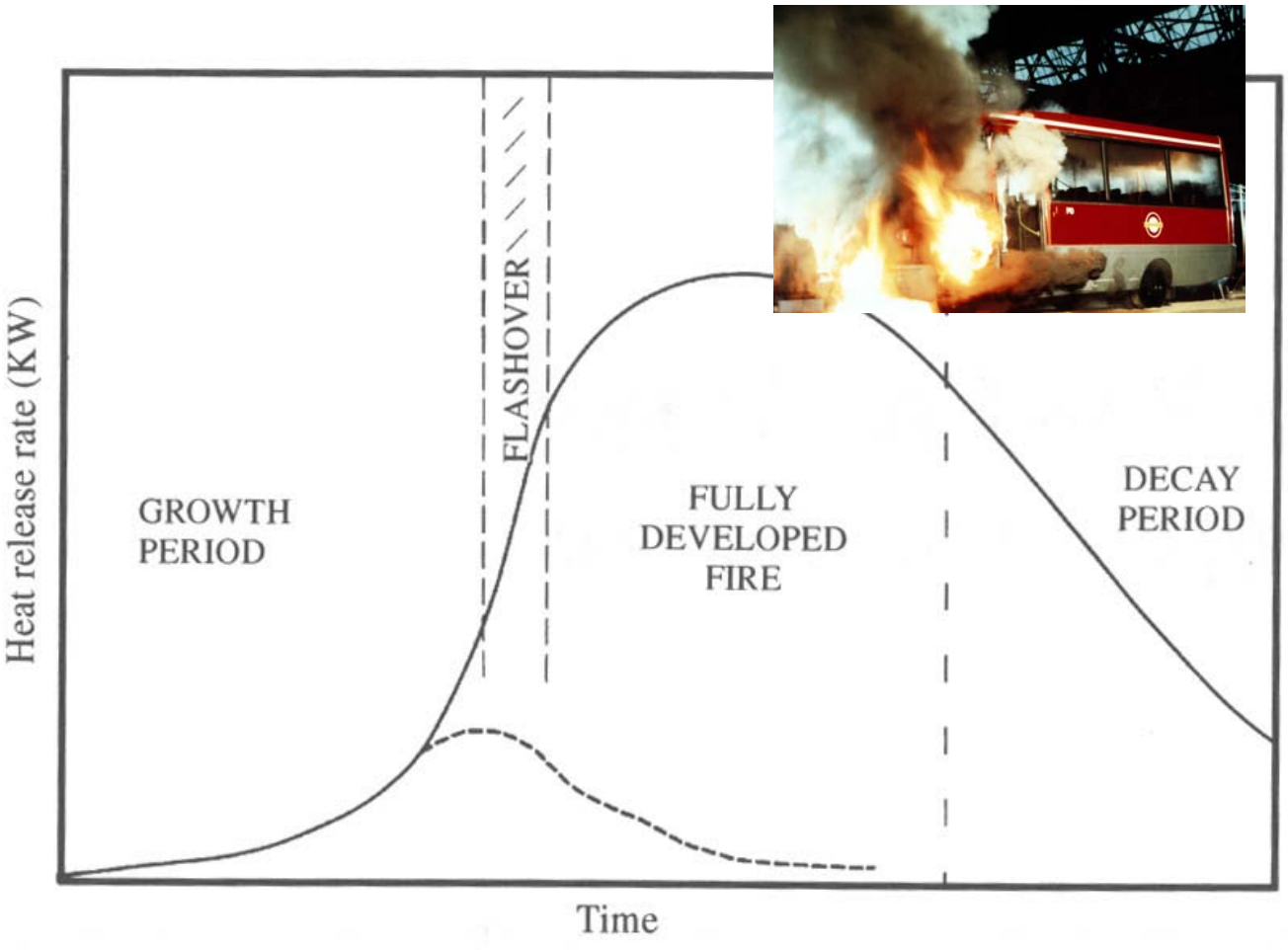
# Ignition and fire growth

Building design fire scenarios:

- Ignition – where and when?
- Fire growth rate?
- Peak rate of heat release?
- Duration?

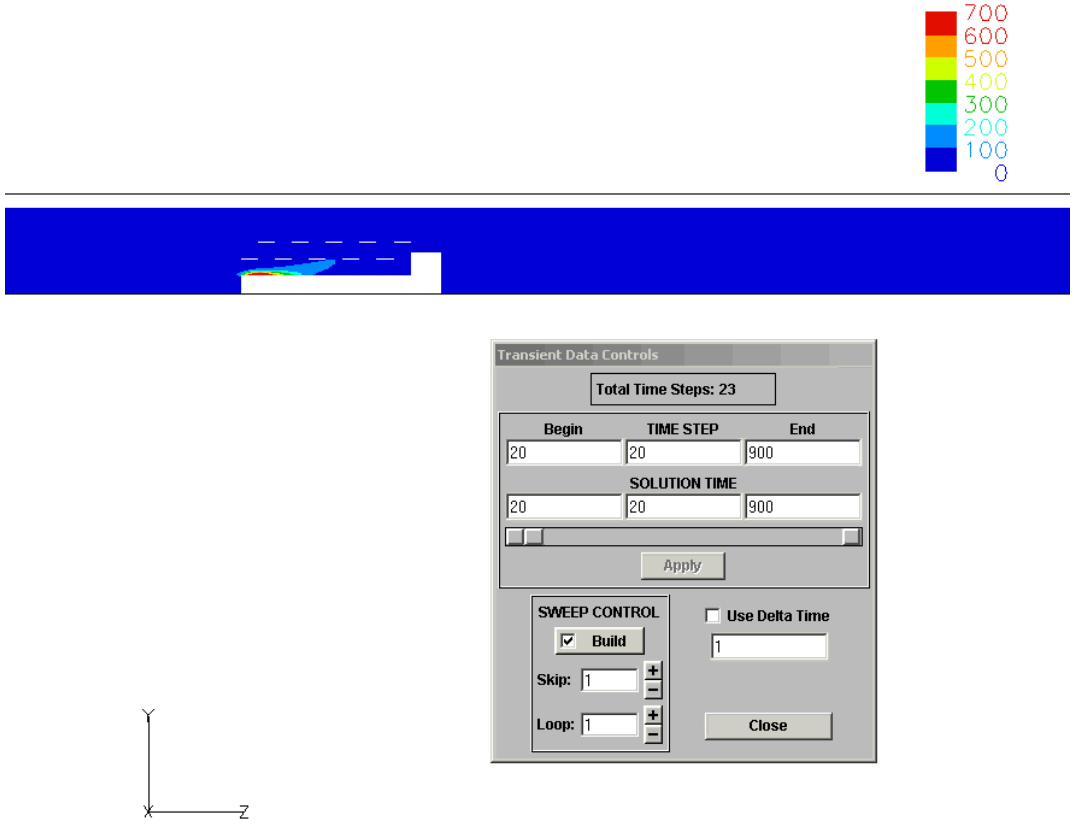


# Typical phases of fire development

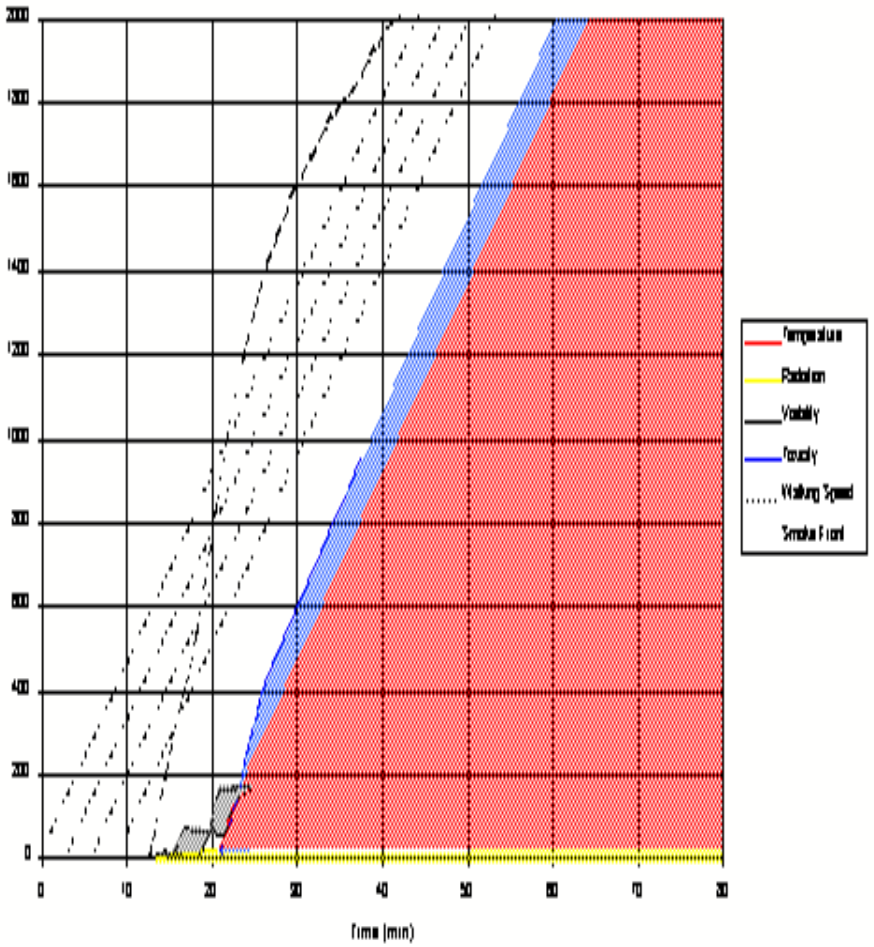


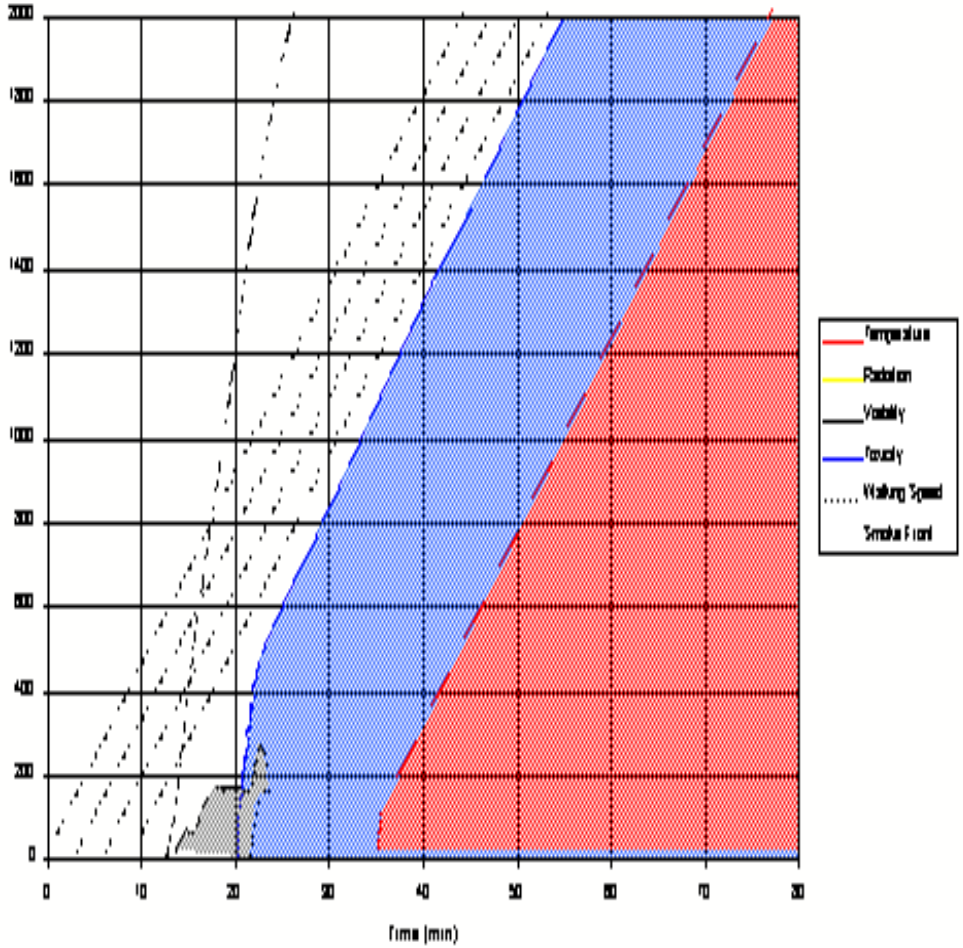
# Smoke movement

- Temperature?
- Depth?
- Toxicity?
- Visibility?
- Radiation?



# Tunnel fires - what if we have more ventilation?



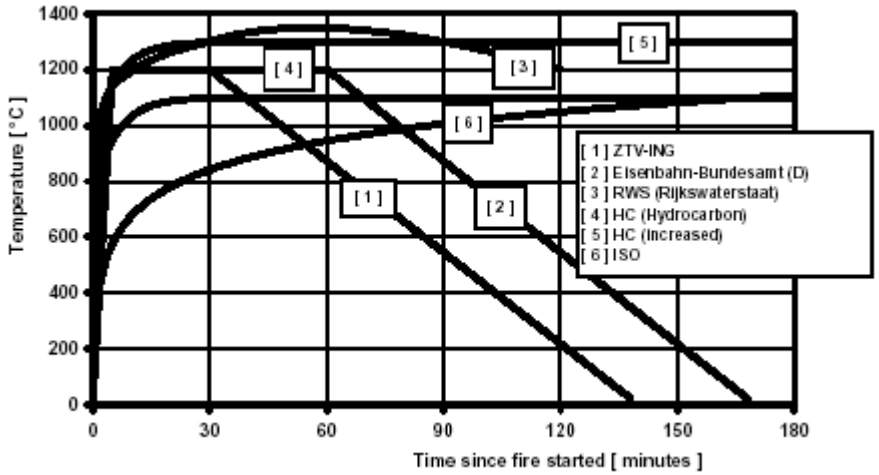




Charters and Salisbury 2001

# Structural response

Fire resistance:

- Fire severity
  - Temperature
  - Duration
- Failure:
  - Time
  - mode
  - extent



# Some examples of peak rate of heat release

| Rail System | Vehicle | Peak Heat Output (MW) |
|---|---|---|
| 1. British Rail | 415 | 16 |
| 2. British Rail | Sprinter | 7 |
| 3. MTRC Hong Kong | Commuter vehicle | 1.4 |
| 4. MTRC Hong Kong | Commuter vehicle | 2.0 |

**Key:**

1 Old passenger carriage with upholstered seating and combustible linings

2 Modern carriage with fire retardant upholstered seating

3 Carriage with metal seating, etc

4 Under-carriage fire scenario

# Design fire

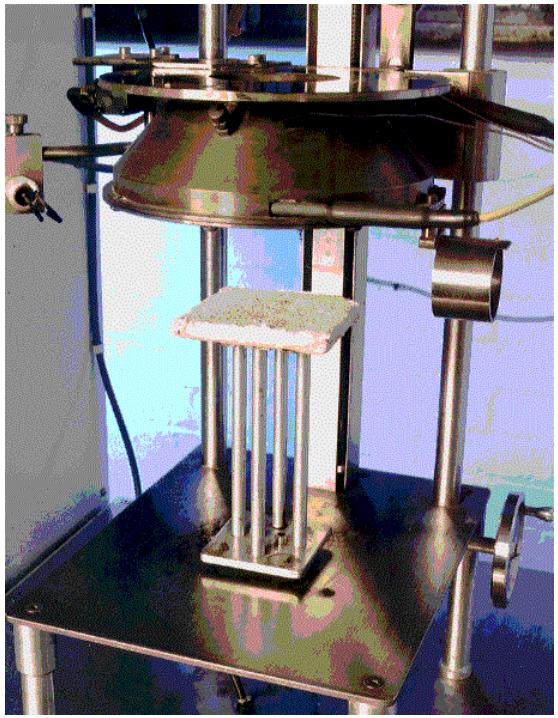
Sources of information:

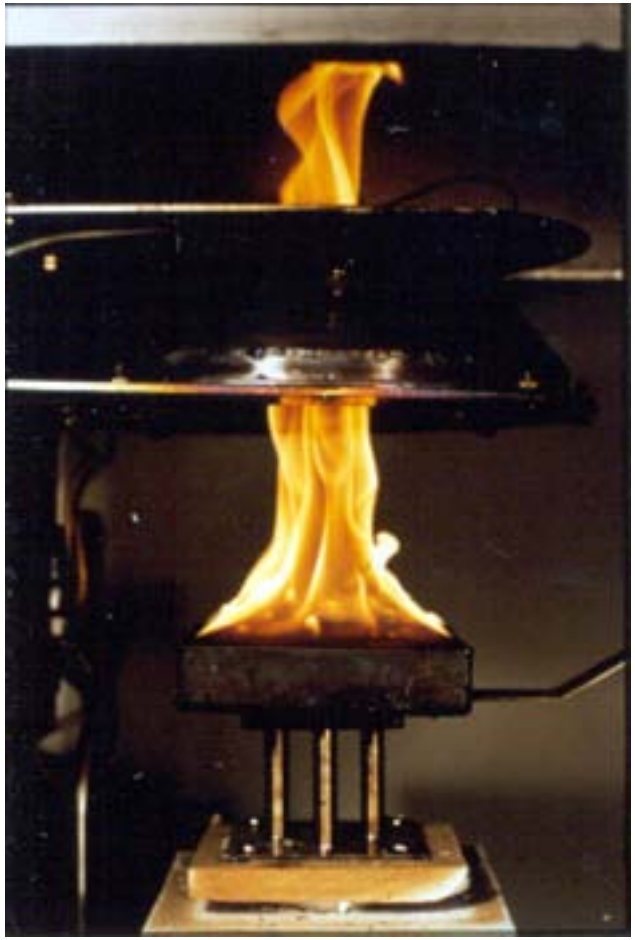
- Literature review
- Historical data
- Small scale testing
- Furniture calorimetry
- Full scale experiment
- Computer modelling
- ‘Expert judgement’

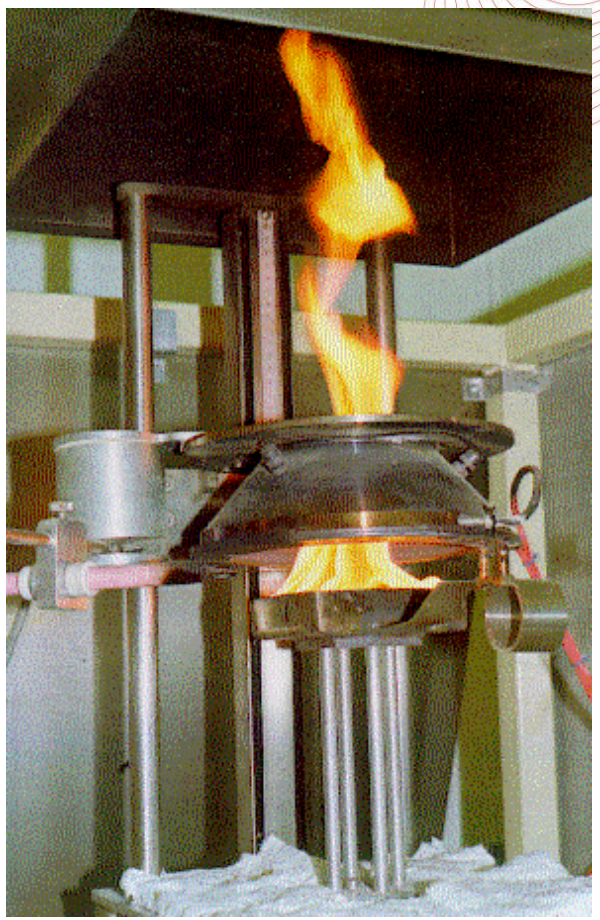
# Small-scale tests - Cone

ISO 5660:

Fully developed fires only





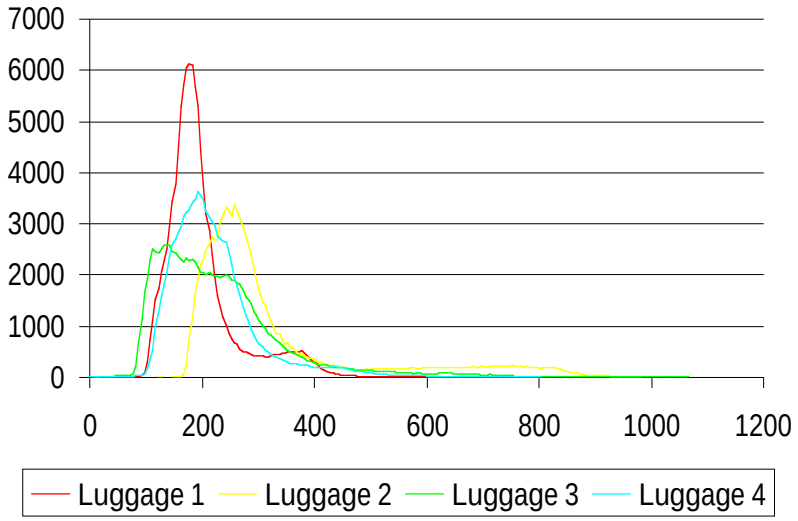


# ISO 5660 Method

ISO 5660 can give valuable insight into peak rate of heat release, though it assumes that:

- There is a fully developed fire
- Radiant heat flux throughout the whole space at the same time
- The radiant heat flux is high compared to that for the onset of flash-over (50kW/m2 vs 20kW/m2)
- All material surfaces along the carriage are involved at the same time
- There is a large ignition source
- Flame spread and fire growth are very rapid
- There is no burn-out of materials
- There is no ventilation control of the fire
- There is no asymmetry in fire development

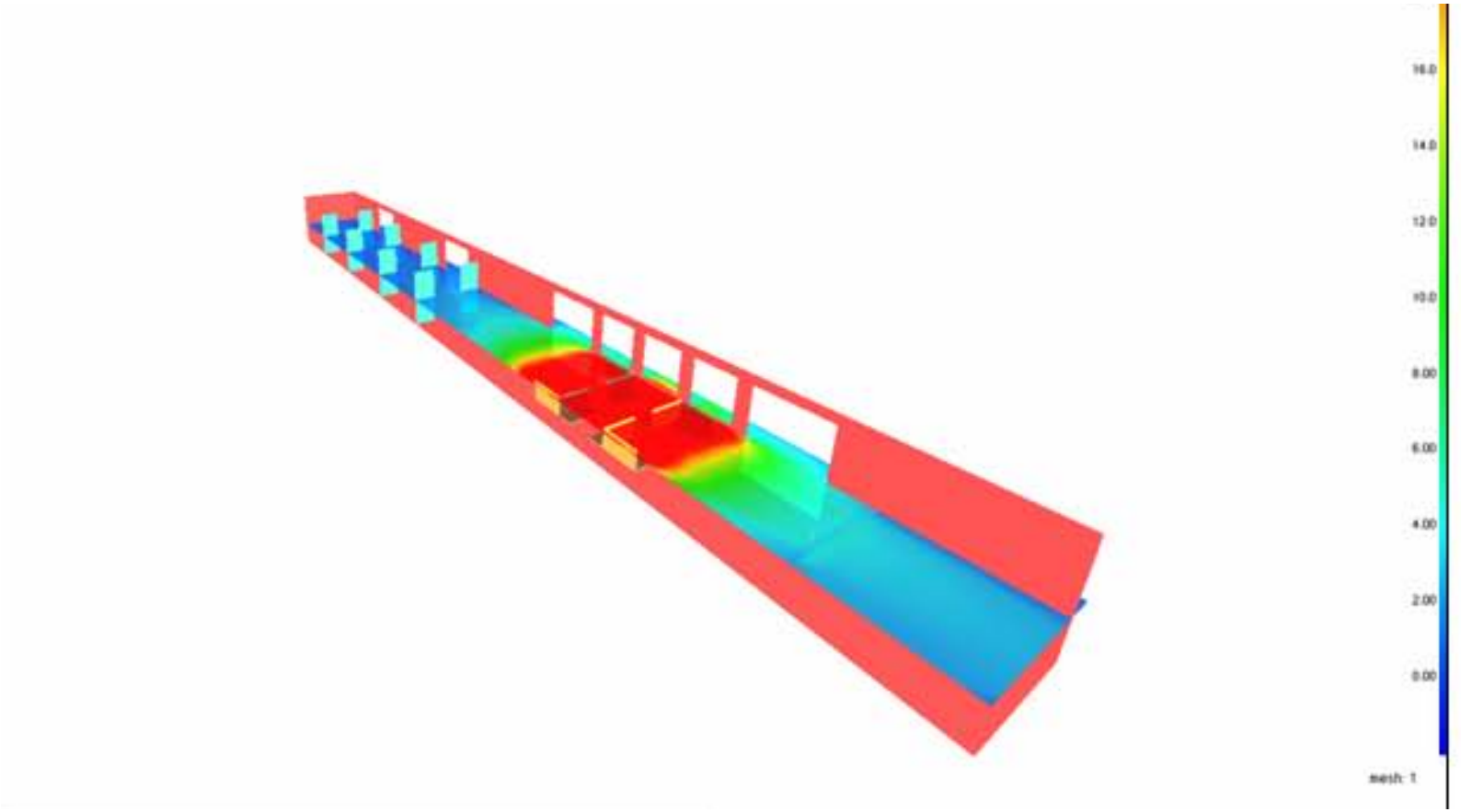
# Furniture calorimetry



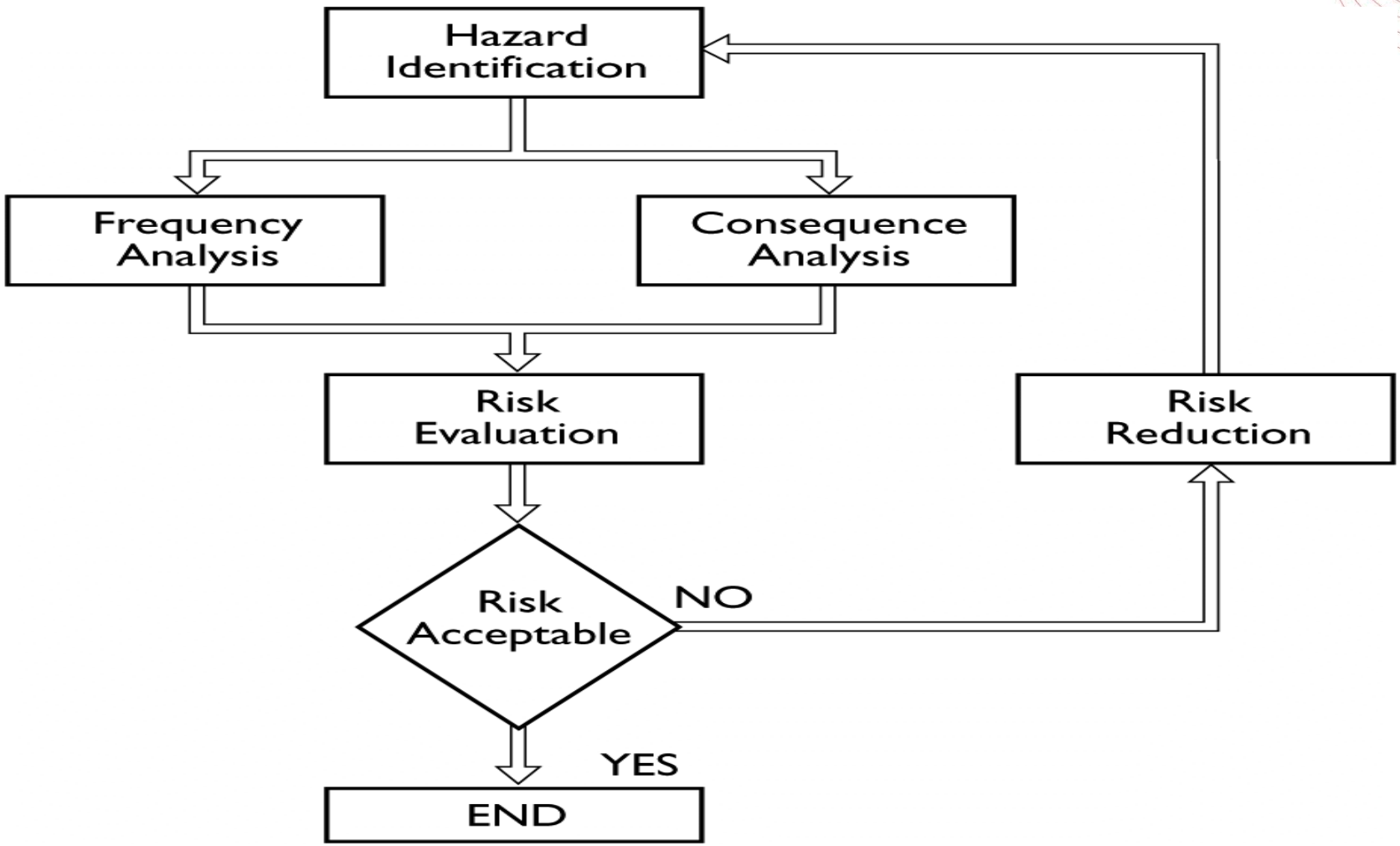
# Design fires

1. Design fires are key to the adequacy of tunnel fire strategies
2. Many factors affect the selection of appropriate design fires
3. Projects using a similar design fire approach include:
   - Dublin Metro West
   - Dublin Metro North
   - DLR Reassessment for fire safety standards
   - Channel Tunnel Rail Link
   - …etc

# Computer modelling



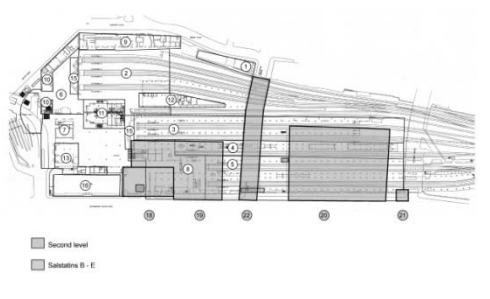
# Quantitative fire risk assessment



# Network Rail fire risk management

Risk-informed fire safety management:

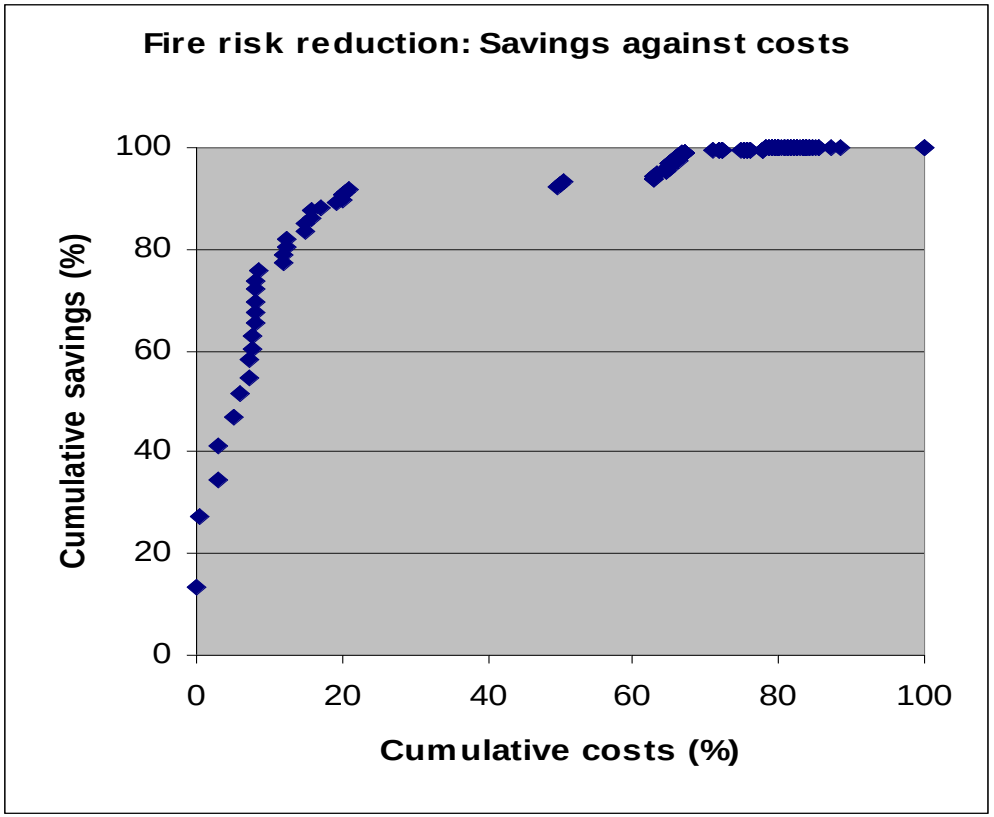
- QRA 90 assets:
  - Life safety
  - Asset protection
  - Business continuity



- 80% of benefit from 15% of investment
- £3m investment
- Savings:
  - £22m cost (poor investment)
  - £14m every year

**Improved punctuality!**

Charters and Wu 2002



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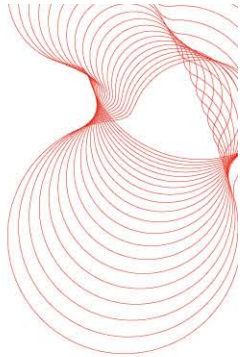

- The number, size and complexity of tunnels and underground spaces is increasing globally
- Fire safety design is key to the safe future operation of tunnels
- Railcar design and materials' selection is crucial to fire safety engineering in the design and operation of tunnels
- Exciting new opportunities for the design of railcars to be holistically integrated into the system within which they will operate

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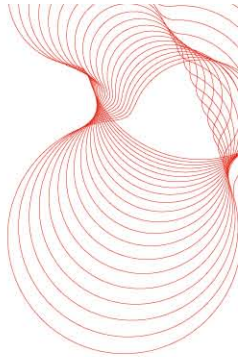

# Thank you for your attention

# Any Questions?

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