Underground fires in metro systems – failures, accidents and terrorism

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Issues

- Higher threat of fire & explosions in congested underground metro stations?
- What do recent incidents tell us about the way forward?

TST Station Fire, Hong Kong

Agenda

- Historical underground metro fires
- Firebomb attack on TST Station, Hong Kong
- Reaction-to-fire properties of rolling stock
- Cross-passage spacing
- Future fire safety measures

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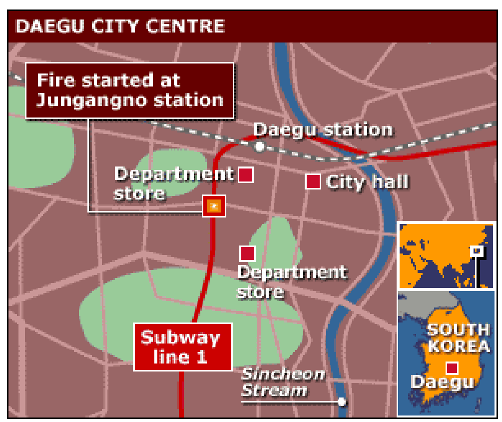
Historical underground metro fires

Jungangno Station, Daegu Subway, South Korea

- 18 Feb 2003
- Arson attack
- 192 deaths, 151 injuries
- Two subway trains destroyed
- Doors locked on second train



King's Cross Fire, London, UK

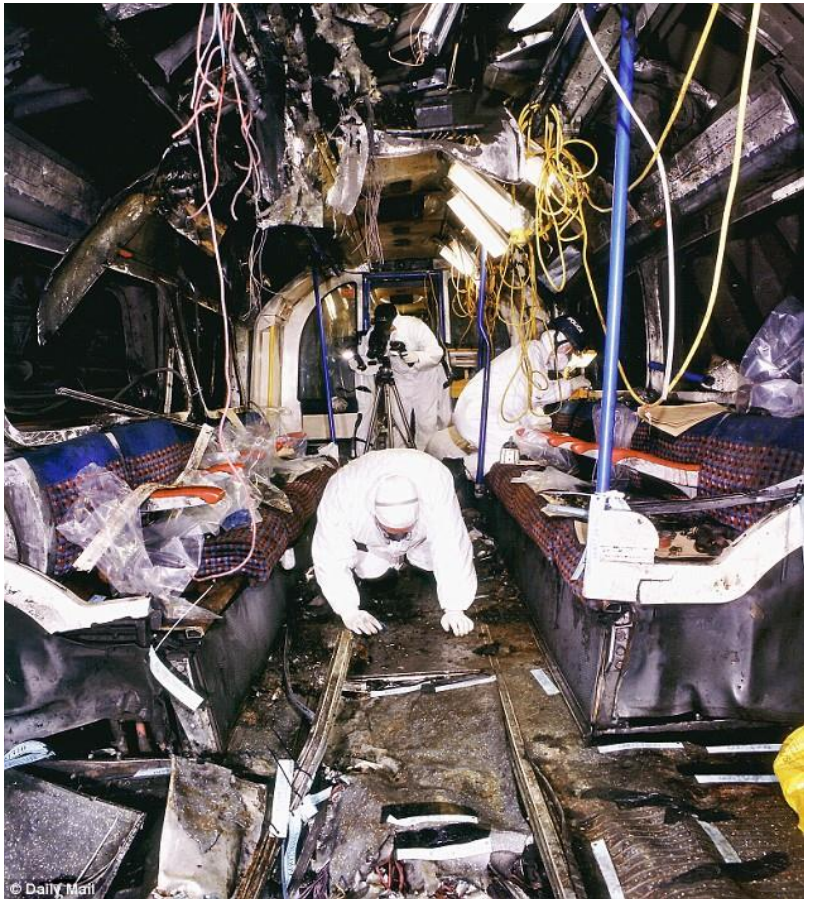
- 18 November 1987
- 31 deaths, 100 injuries
- Match ignited rubbish underneath escalator?

Baku Metro Fire

- 28th October 1995
- Electrical fault
- Train stopped between stations
- Ventilation drew smoke over evacuees
- 289 fatalities, 270 injuries

London Underground Bombings

- 7th July 2005
- Three trains underground trains bombed
- Homemade organic peroxide-based devices in backpacks
- 37 fatalities
- Incident trains smouldered, but did not burn



Firebomb attack on TST Station, Hong Kong

Background to TST Station Firebomb Attack

- 10th February 2017
- 19 injured, including 3 critically hurt
- Arson attack with liquid accelerant
- Similar attack occurred in 2004

Lessons learnt from TST Station Incident

- Human factors – reaction of passengers (standing around, taking pictures)
- Lack of CCTV cameras on the platforms
- Good reaction-to-fire properties of train materials
- Smoke escape to platform: close doors after evacuation?
- Delay in station operator response
- Conditions would be far worse in tunnel

Reaction-to-fire properties of rolling stock

Superseded Standard

- BS 6853:1999 “Code of practice for fire precautions in the design and construction of passenger carrying trains”
- 3 vehicle categories:
  - Category I: underground
    - Category Ia - single track tunnel with no side exits to a walkway
    - Category Ib - multi-track tunnel or a tunnel with side exits to a walkway
  - Category II: surface
- A lot of rolling stock to this or to older standards still in operation

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Current Standards

- BS EN 45545:2013 "Railway applications - Fire protection on railway vehicles" (in seven parts)
- BS EN 50553:2012 "Railway applications - Requirements for running capability in case of fire on board of rolling stock"
- New rolling stock normally specified to these standards in Europe

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BS EN 45545:2013

- Minimise the probability of a fire starting
- Control the rate and extent of fire development
- Minimise the impact of the products of fire on passengers and staff
- 4-minute running capability at an average speed of 80km/h

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BS EN 50553:2012

- Considers luggage fires, vandalised seat fires, some diesel fires and significant arson events
- Minimum running capability of 15 minutes for individual on-board systems including cables, technical cabinets, pneumatic and hydraulic equipment

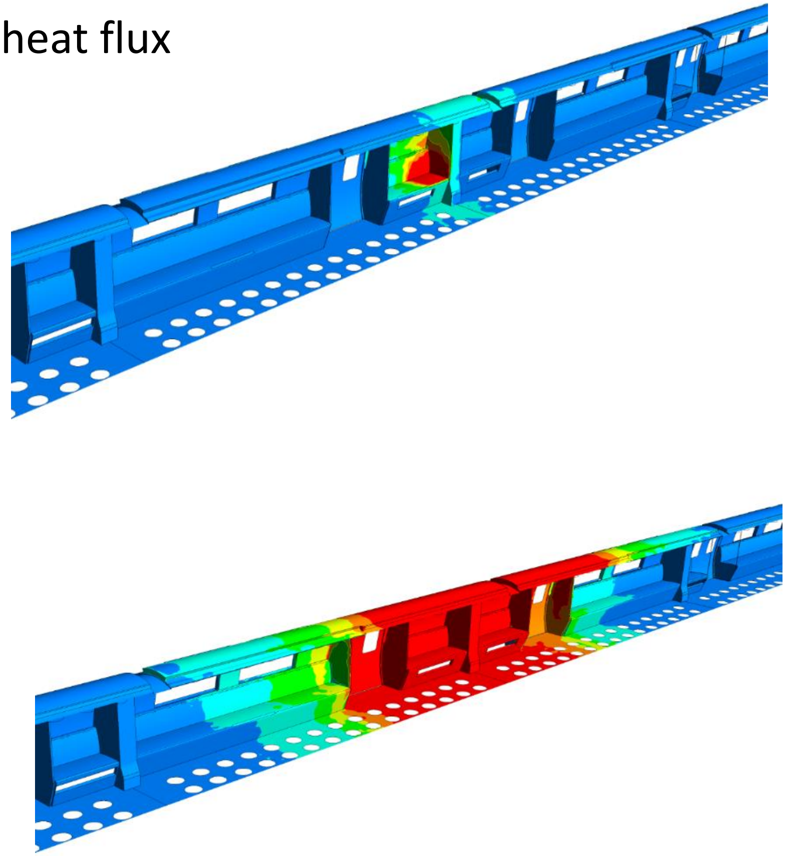
METRO project

- Mälardalen University, Sweden
- Maximum fire heat release rate of 77 MW for carriage fire including luggage
- Difficult to start the fires!
- 10 litres of diesel fuel required for ignition
- Minimum heat release rate for ignition was 2 to 3 MW
- Combustible linings carriage did not comply with current European rolling stock standards

CFD Simulation of Fire Growth in Train

- Ignition heat release rises to 150 kW after two minutes
- Conditions within carriage untenable after 3 minutes (heat release rate 540 kW), even with in-car ventilation switched on to dilute smoke

Contours of surface heat flux



Cross-passage spacing

Cross-Passage Spacing Standards

Standard	Cross-Passage Spacing
NFPA-130	244m
Australian AS 4825	240m
European TSI	500m
Singapore SFSRTS	250m

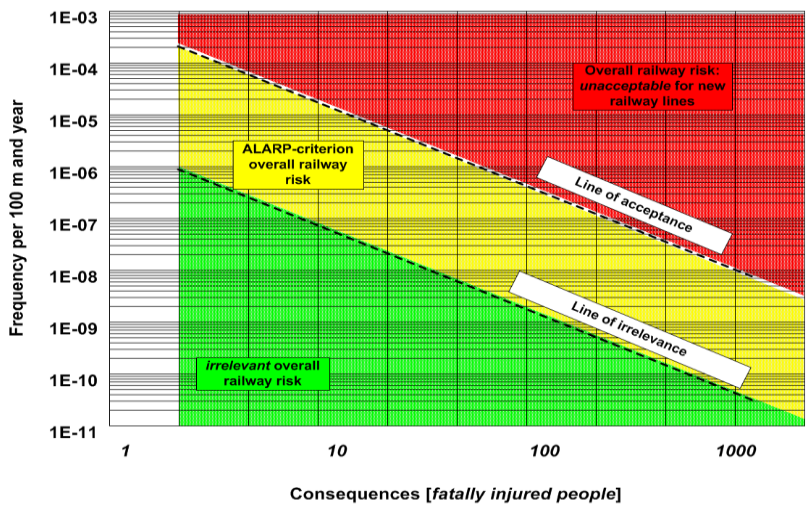
Significant difference between European TSI and other standards

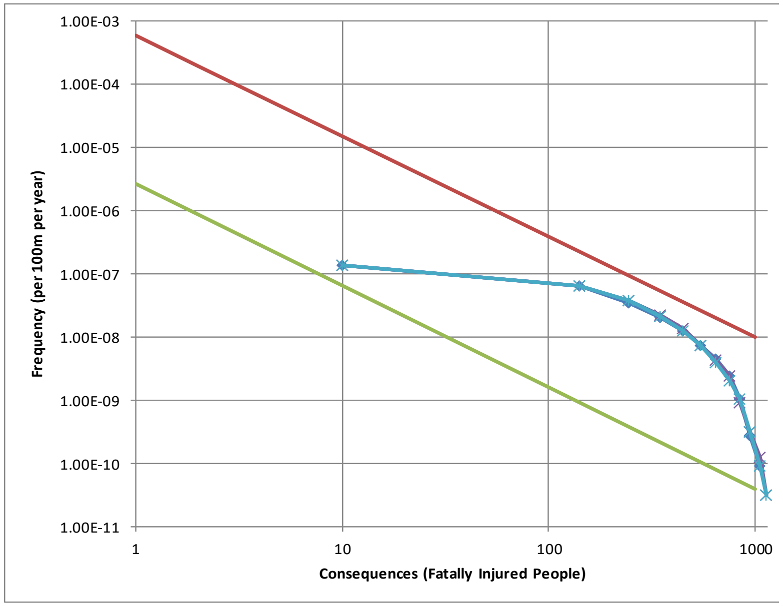
Cross-Passages in Practice

- London Crossrail scheme: has cross-passages at approximately 500m spacings, with a maximum spacing of up to 693m
- Risk assessment undertaken
- Negotiation with the London Fire Brigade

Quantitative Risk Assessment

- Estimate societal risk for compliant and non-compliant cross-passage spacings
- Investigate additional mitigation measures such as dynamic signage to aid evacuation
- Significant cost-savings can be obtained whilst maintaining acceptable risk levels (performance-based design)





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Future fire safety measures

Future Fire Safety Measures

- Tracking and communication with passengers via mobiles, including underground areas
- Dynamic evacuation signage
- Further improvements in reducing combustibility of rolling stock materials
- Innovative ventilation systems for confined spaces (e.g. MoJet®)

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Overview

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