Are we using the wrong design fires for tall building fire strategies, in light of recent full height fires?

Tall Building Fire Safety Network meeting & seminar
FIREX, London, 22nd June 2016

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Objective:

- Look at the bigger picture
- Encourage critical review
- Stimulate discussion

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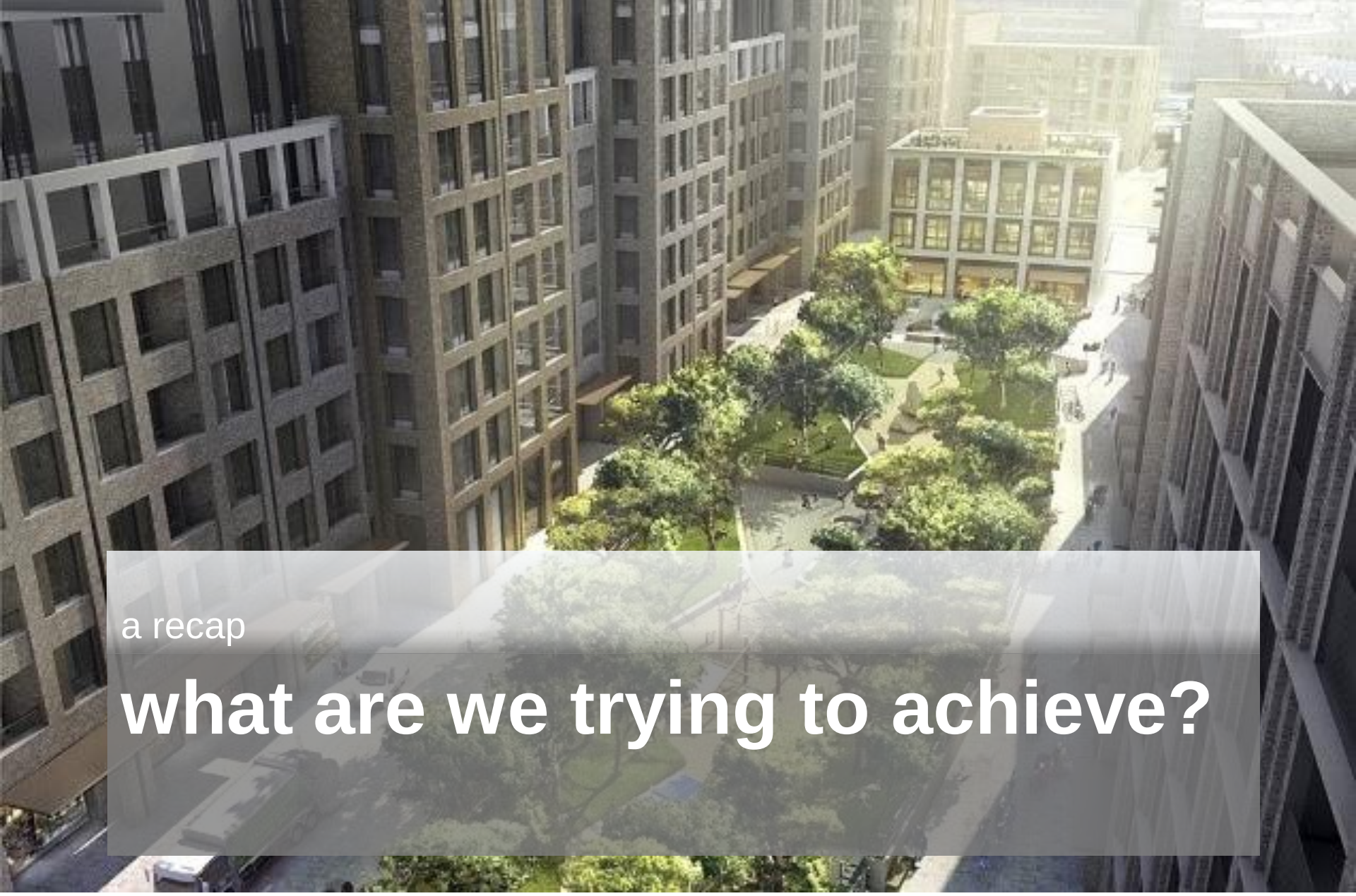
- Encourage critical review
- Stimulate discussion

Not looking to:

- Review cladding panels
- Discuss individual incidents
- Point fingers
- Get overly technical

Overview

- A recap: What are we trying to achieve?
- Tall buildings
  - How are we faring?
  - Are we ready for the future?
- Tall buildings fire safety strategies
  - Key principles
  - The impact of multi-level fires
- Multi-level fires: a warning sign?



a recap

what are we trying to achieve?

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Institution of Fire Engineers (IFE):

"…protect people, property and the environment from the destructive effects of fire"

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Building Regulations:

"…securing reasonable standards of health and safety for persons in and about buildings…"

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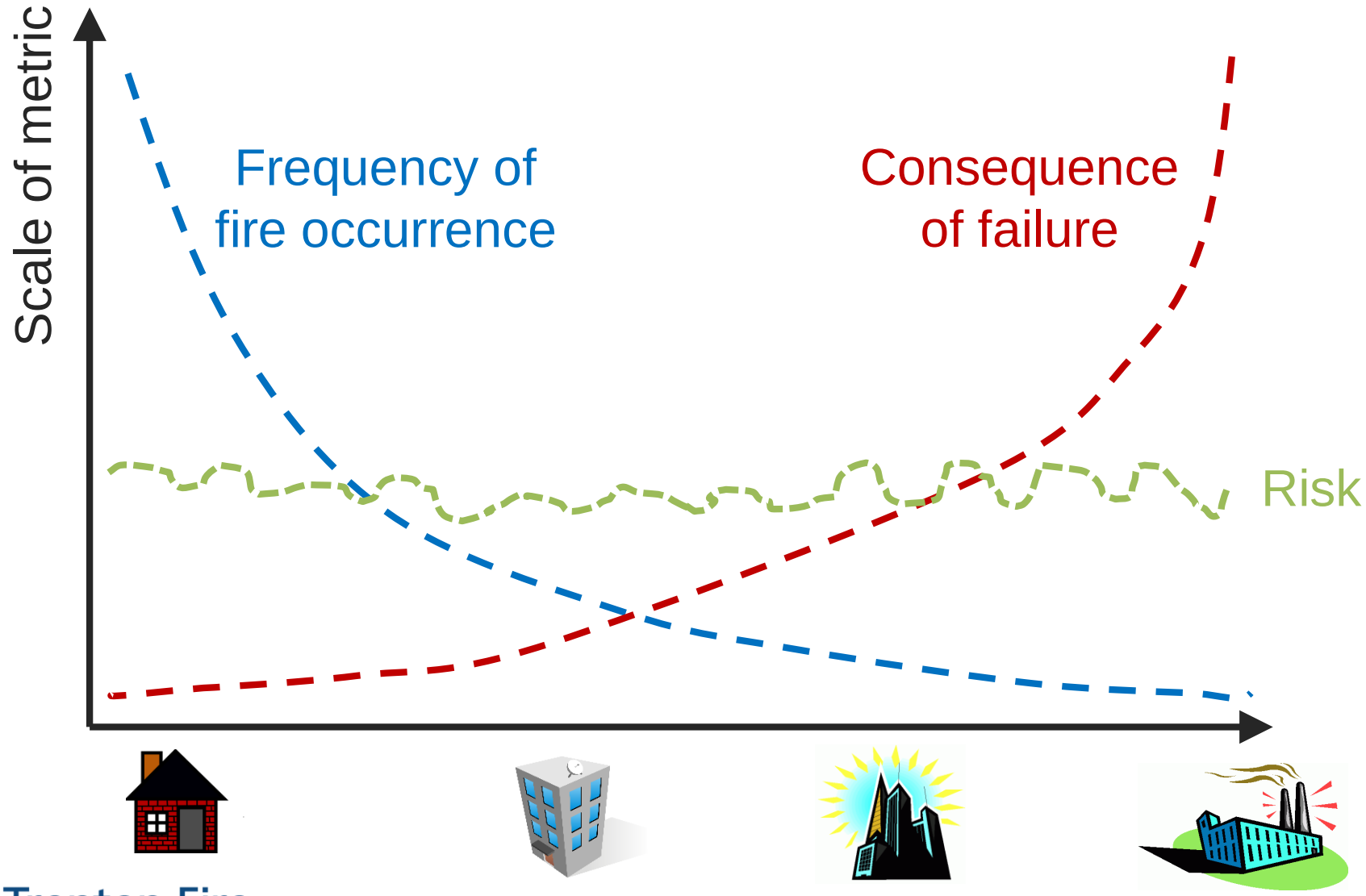

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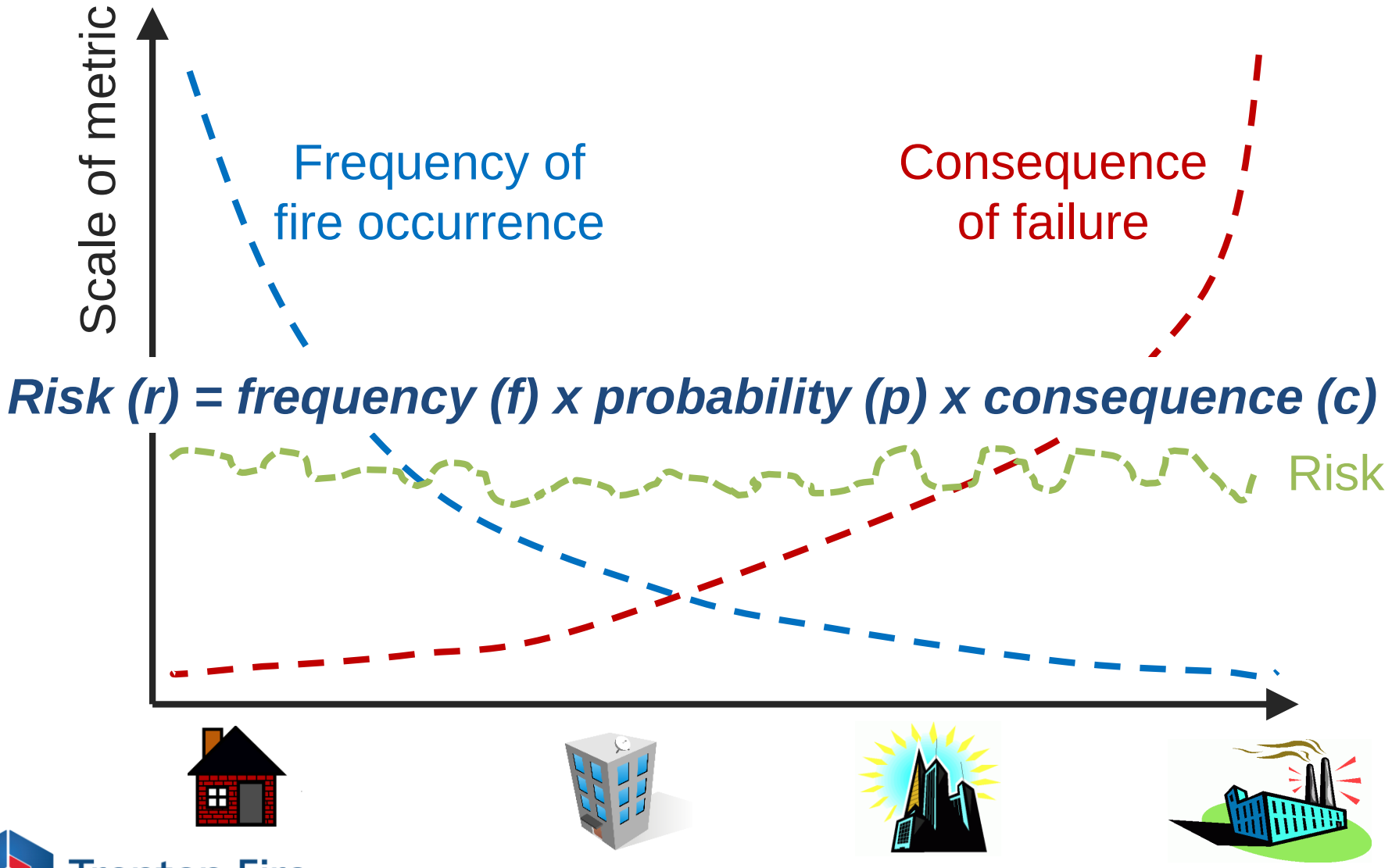
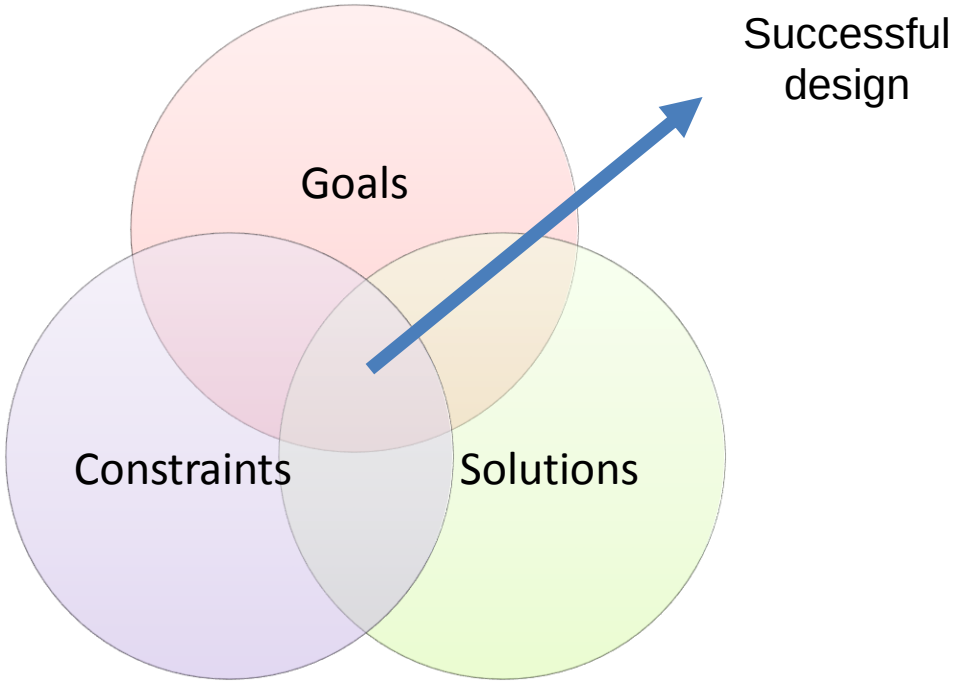


In practice…

Deliver a solution that meets goals (and obligations) within the relevant constraints



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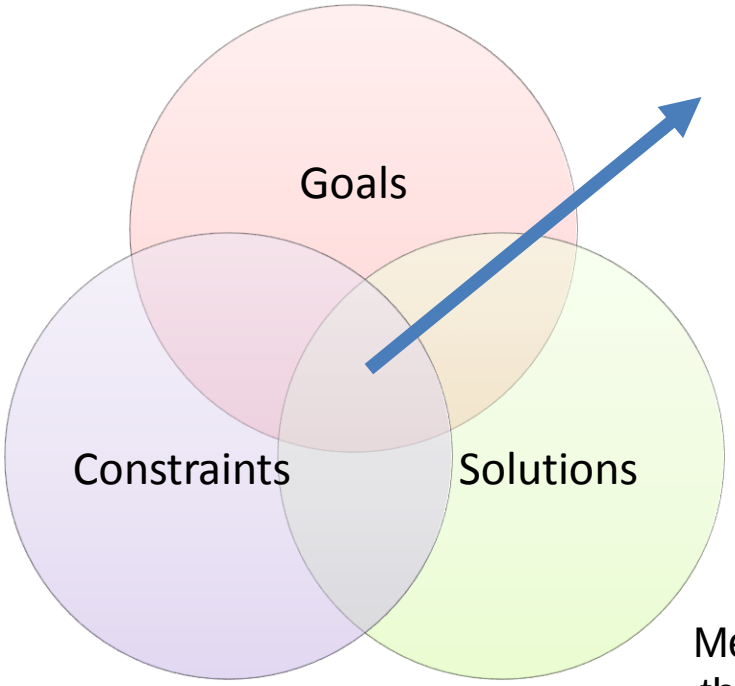
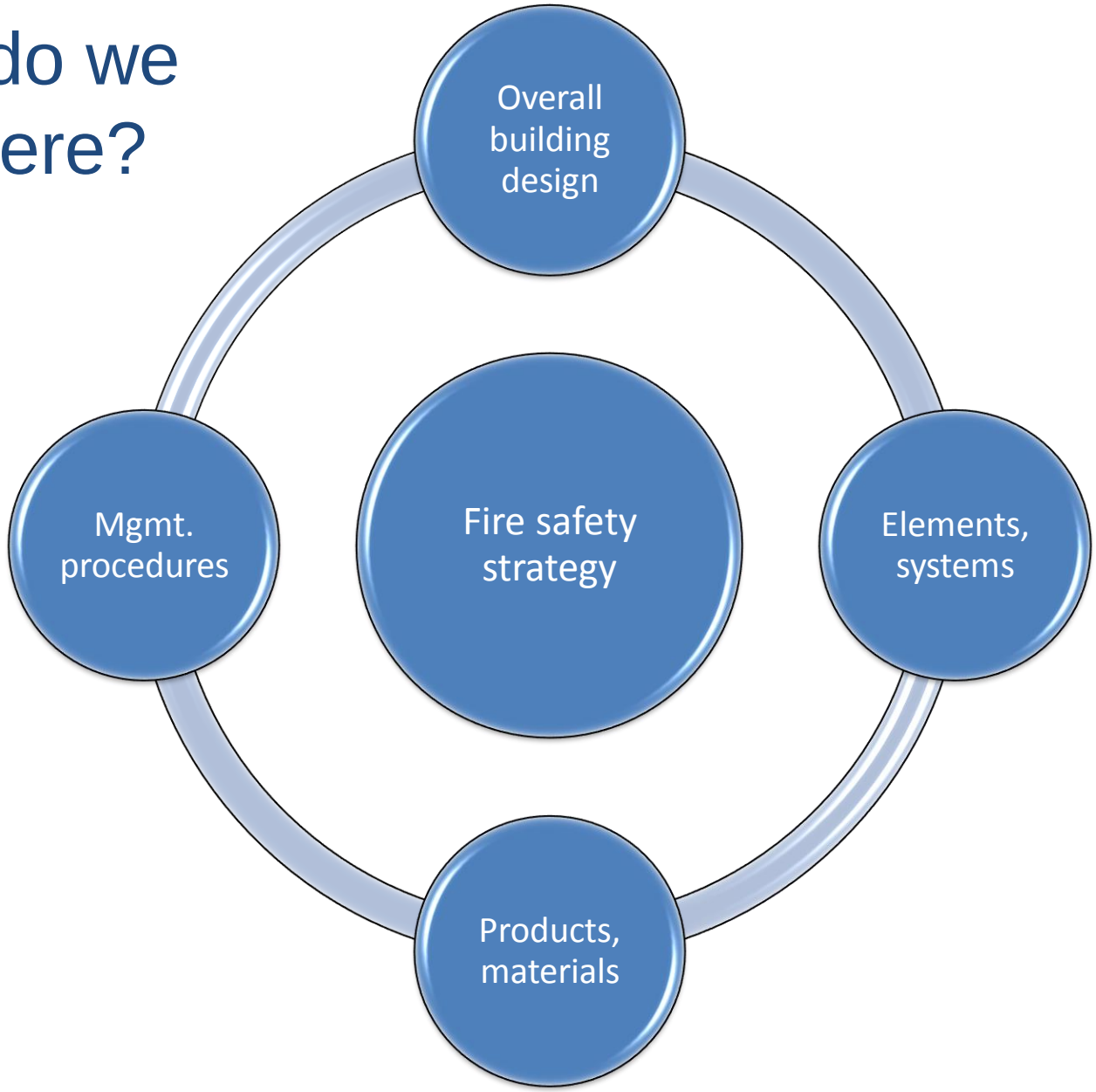


How do we get there?



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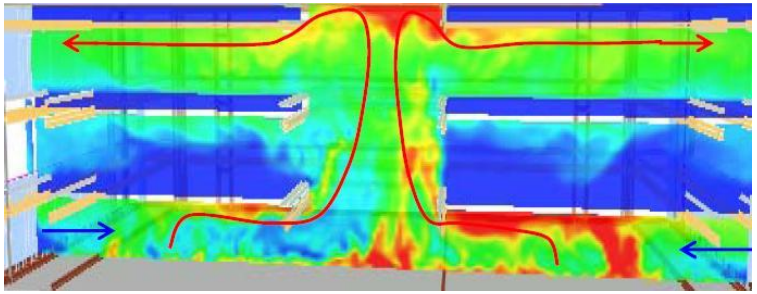
Acceptability of overall design

Fire engineering

Prescriptive design

Performance-based design



"…intended to provide guidance for some of the more common building situations"

otherwise...

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Acceptability of elements, systems

Designed, installed and maintained in accordance with…

- Industry standards (e.g. BS, EN, LPC)
- Manufacturer's guidelines
- Requirements of the fire safety strategy

Acceptability of products, materials

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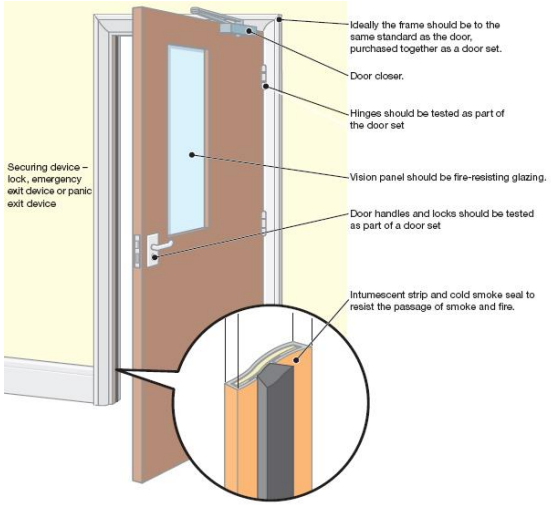

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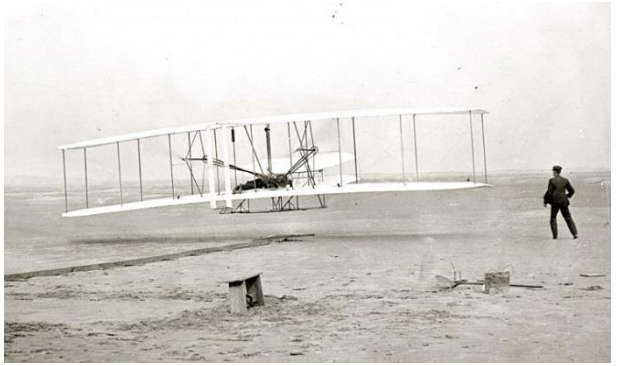
Acceptability of management

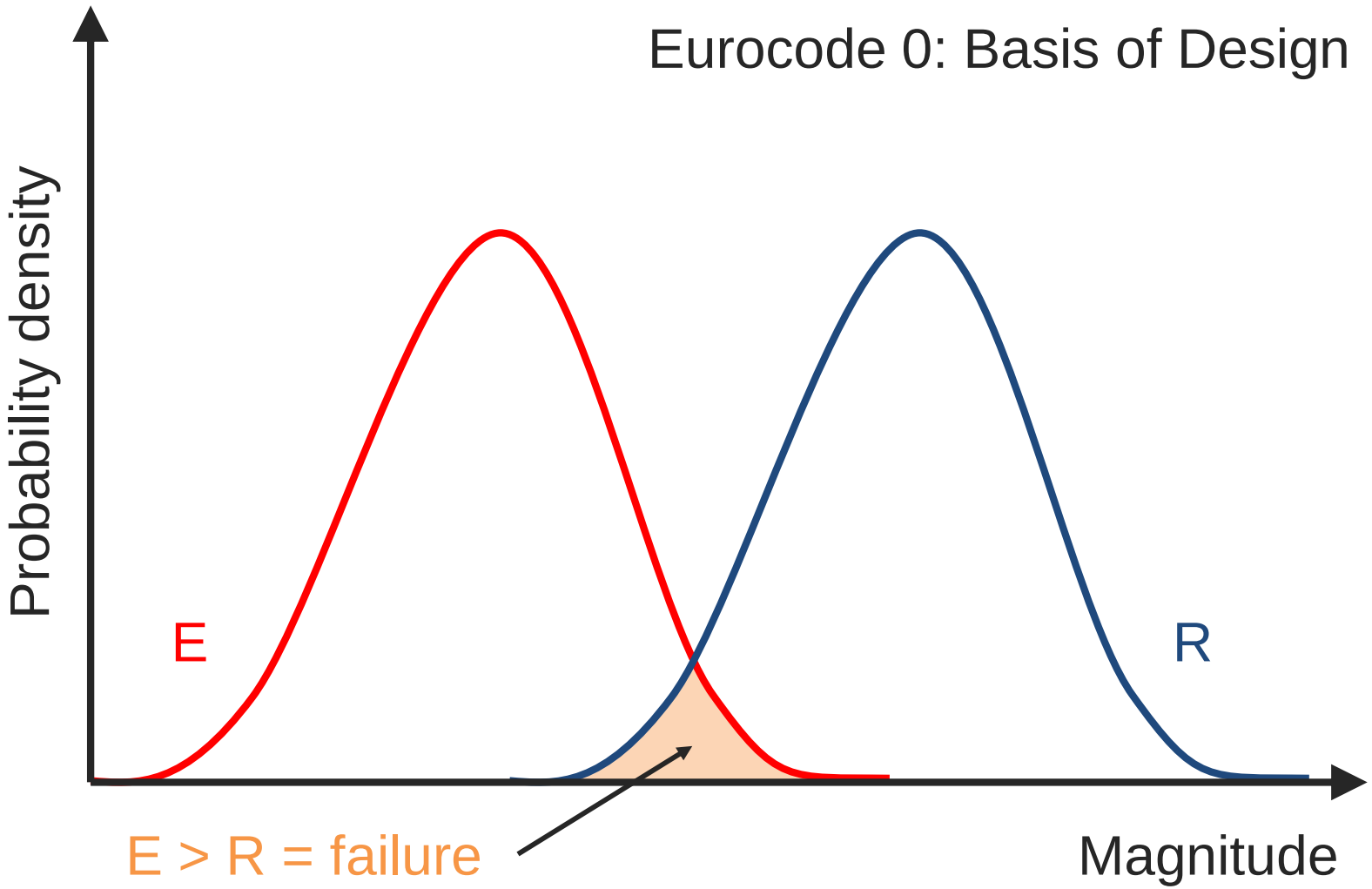
- Experience
  - Individual
  - Collective
- Risk assessment
- Feedback loop

How have these methods evolved?

- Build what we want or need
- Weaknesses highlighted by failures, and commonly tragedies
- Revisit and improve the process when risk is not longer tolerable
- Over time, acceptable concepts emerge



What is tolerable risk?



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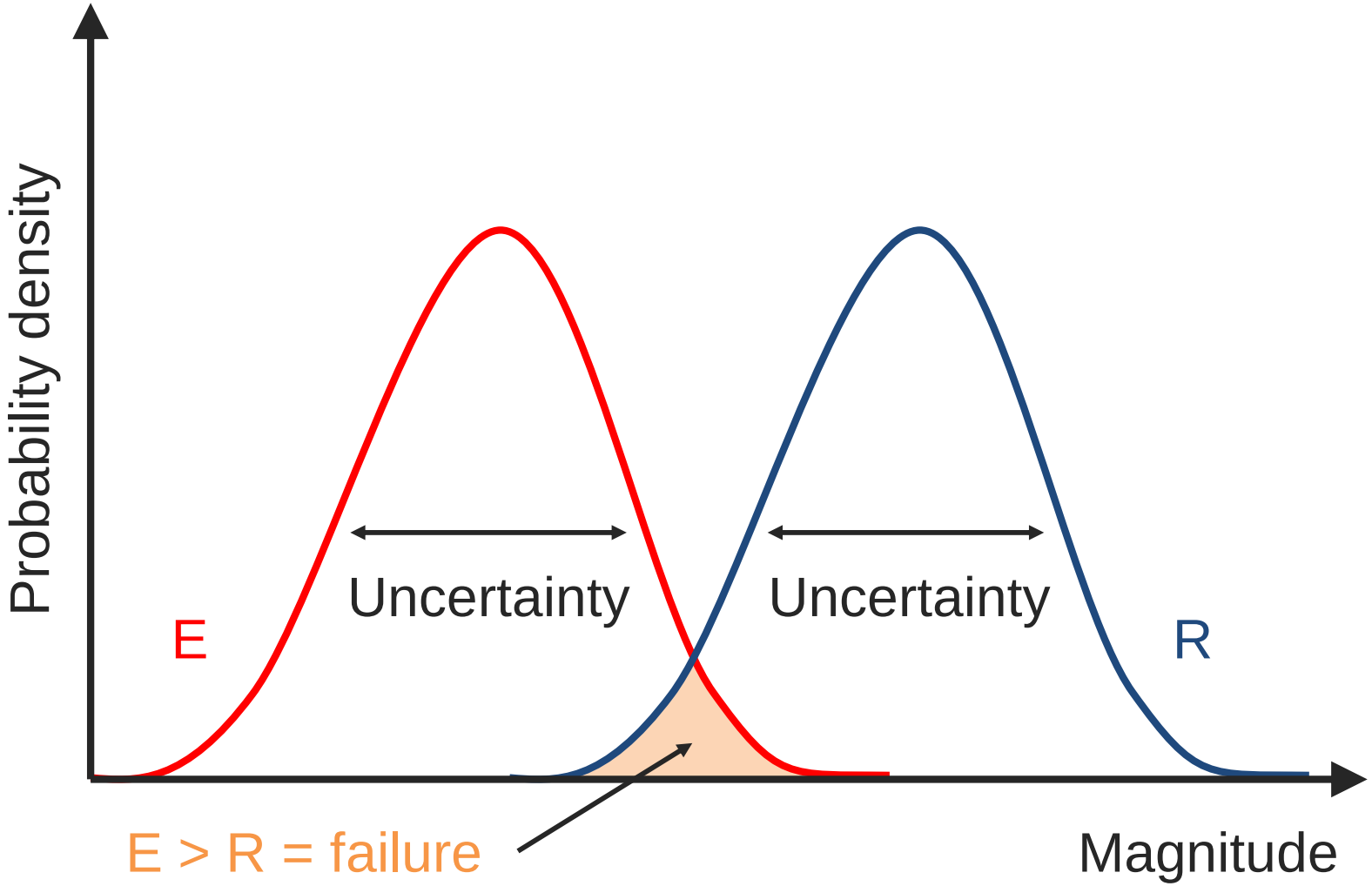

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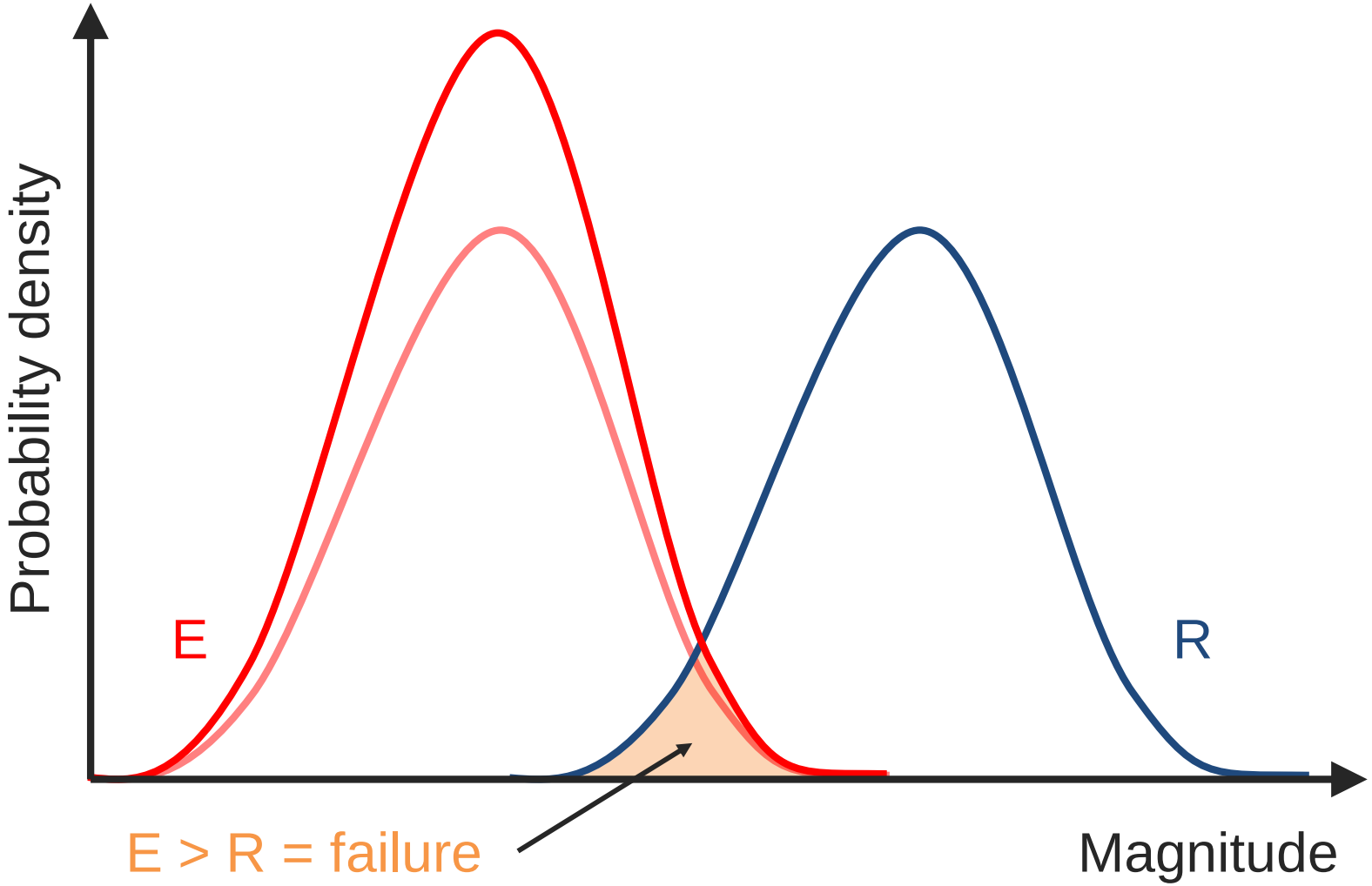

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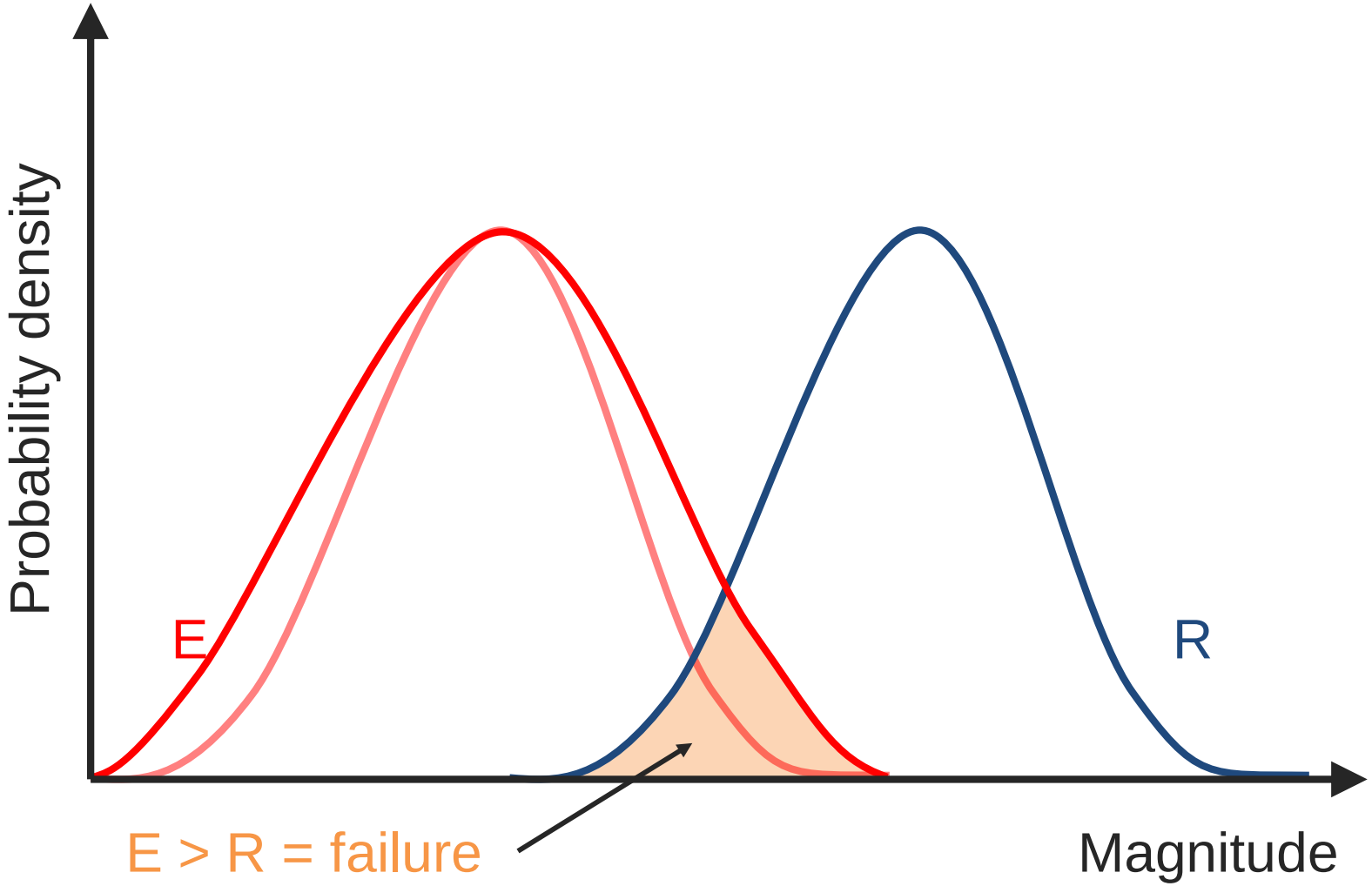

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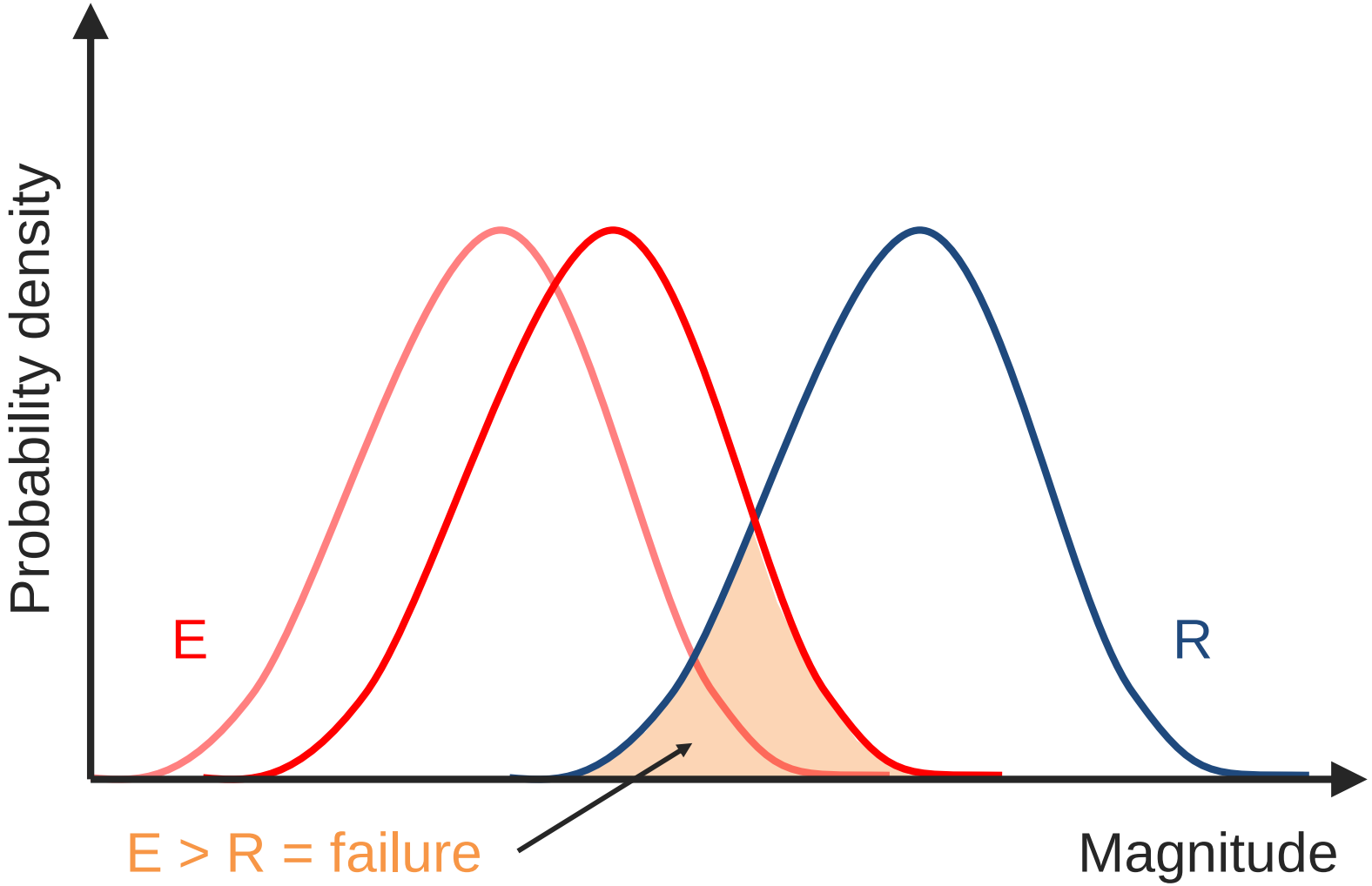

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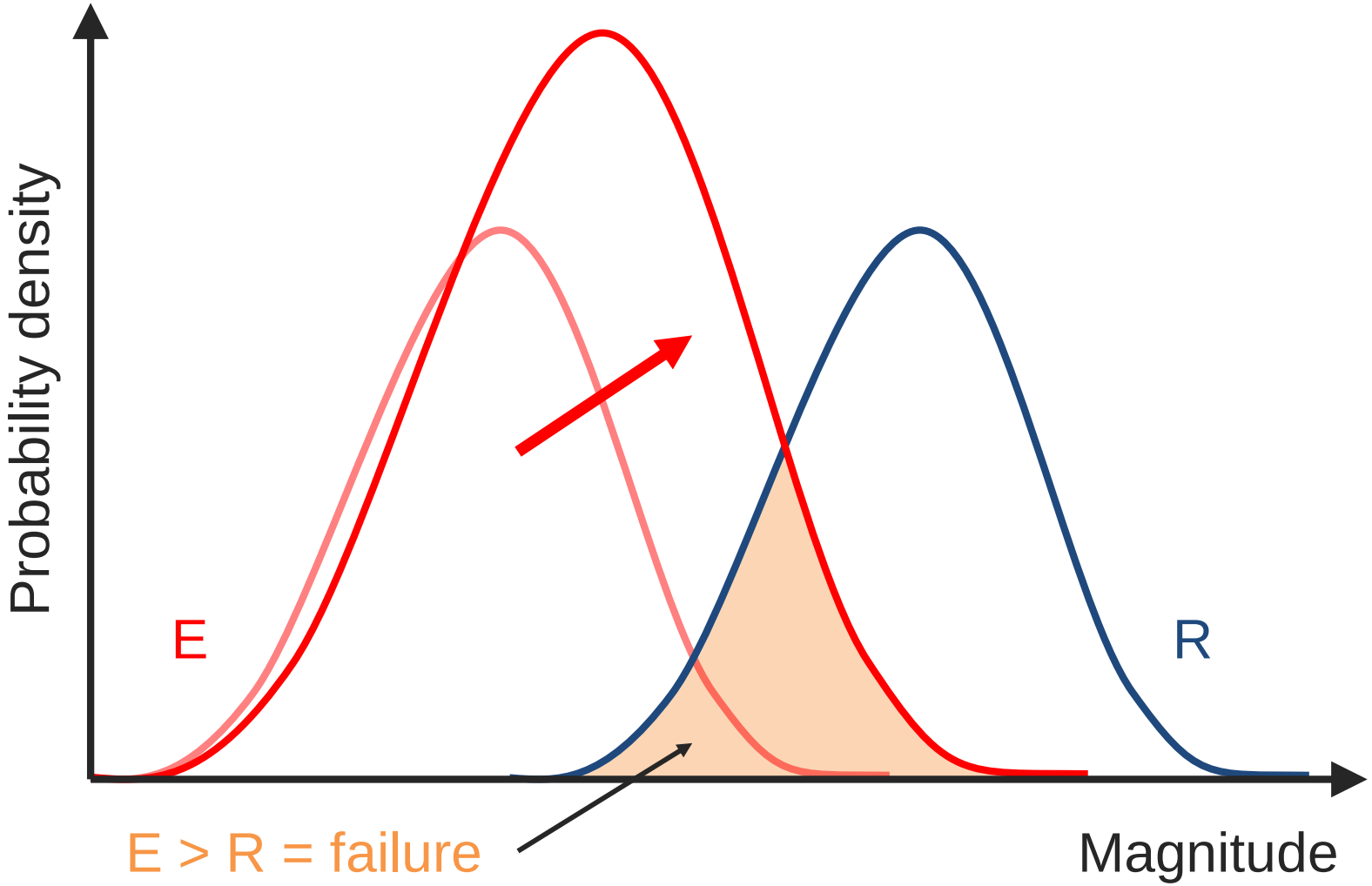

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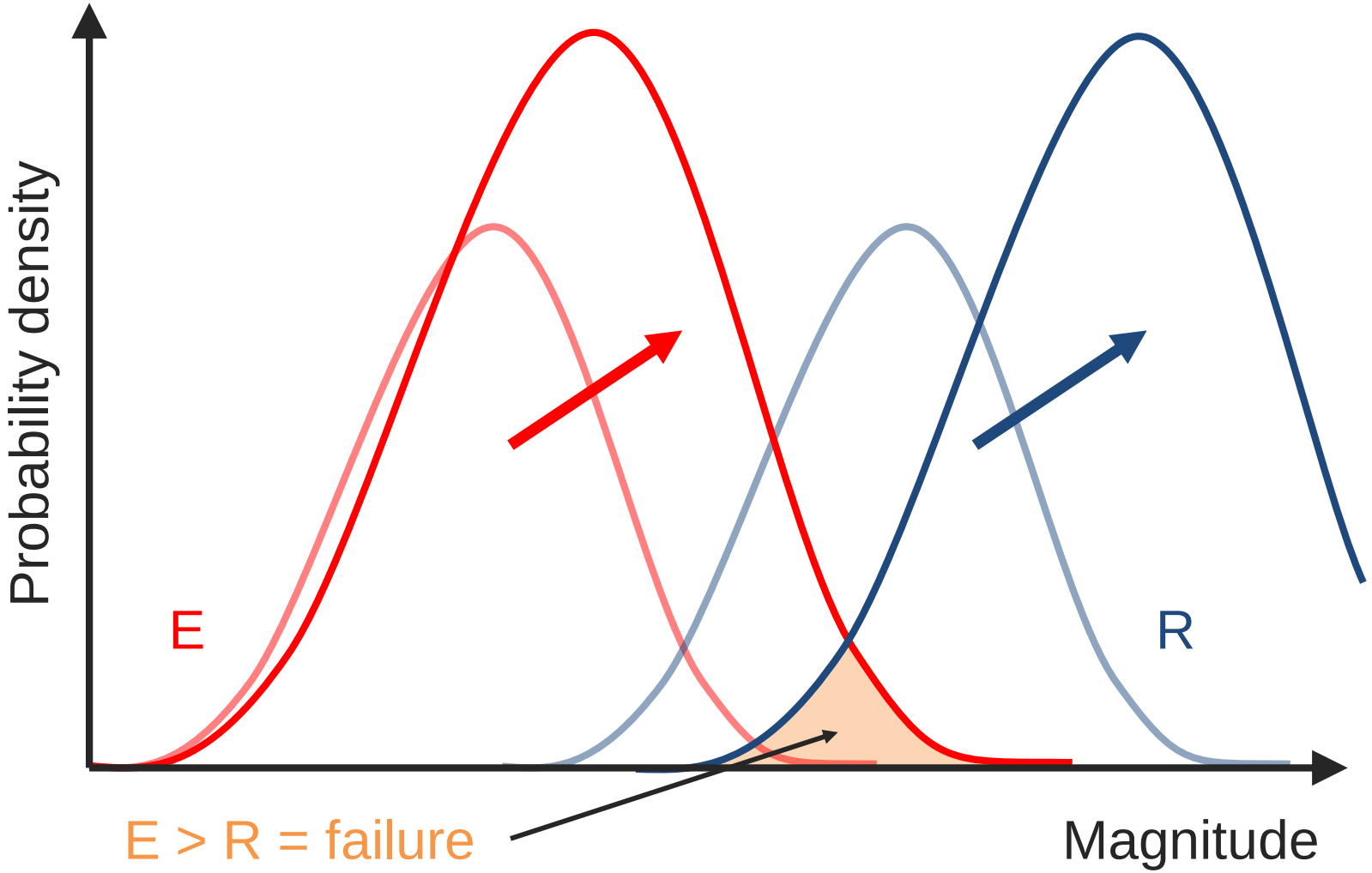

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Reactive evolution

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Reactive evolution

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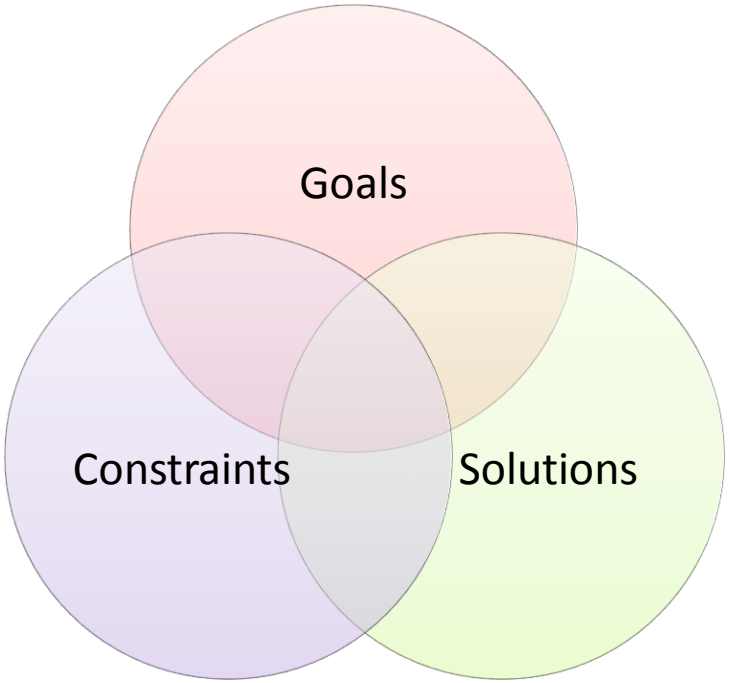
So, what exactly are we trying to achieve?

"…securing reasonable standards of health and safety for persons in and about buildings…"

"…protect people, property and the environment from the destructive effects of fire"



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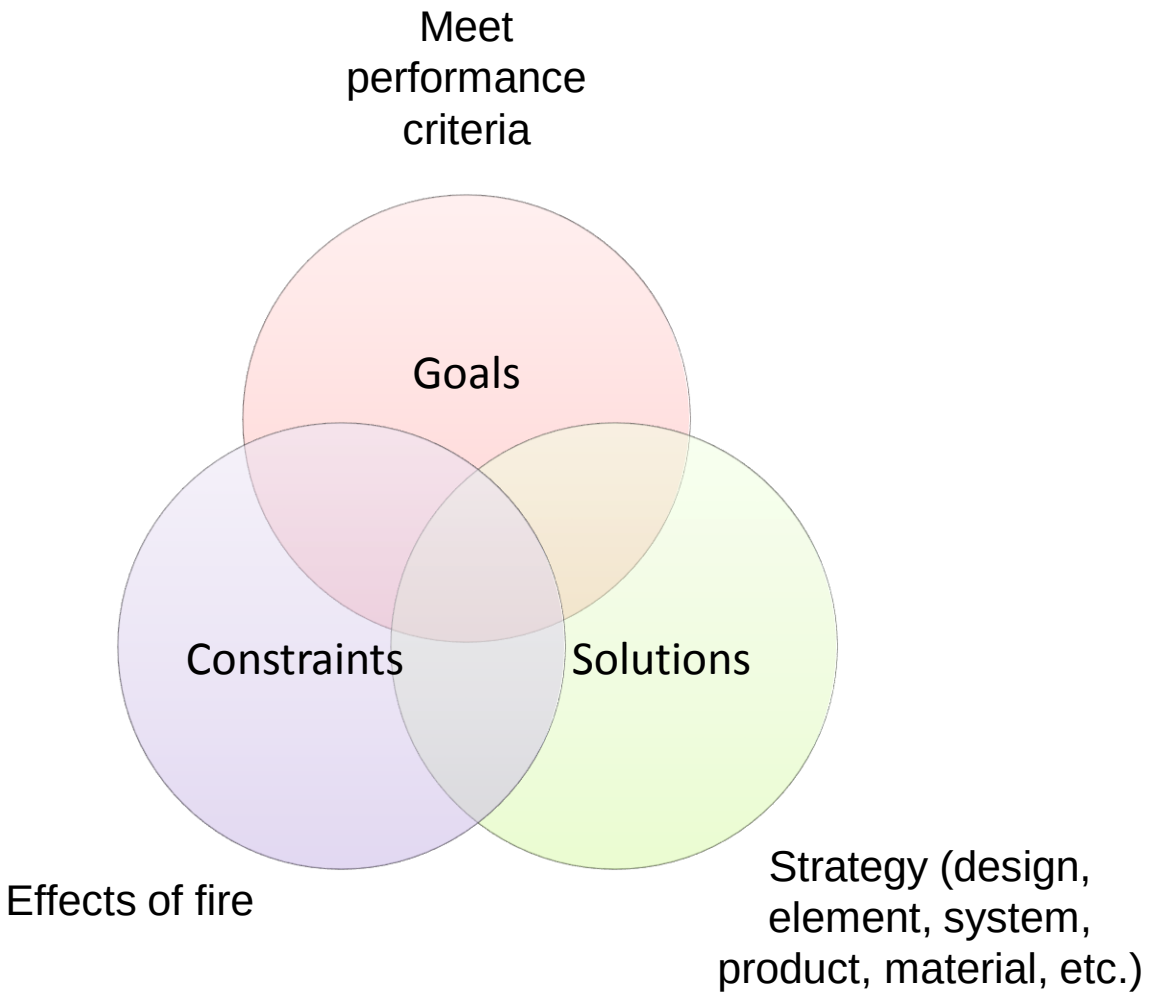
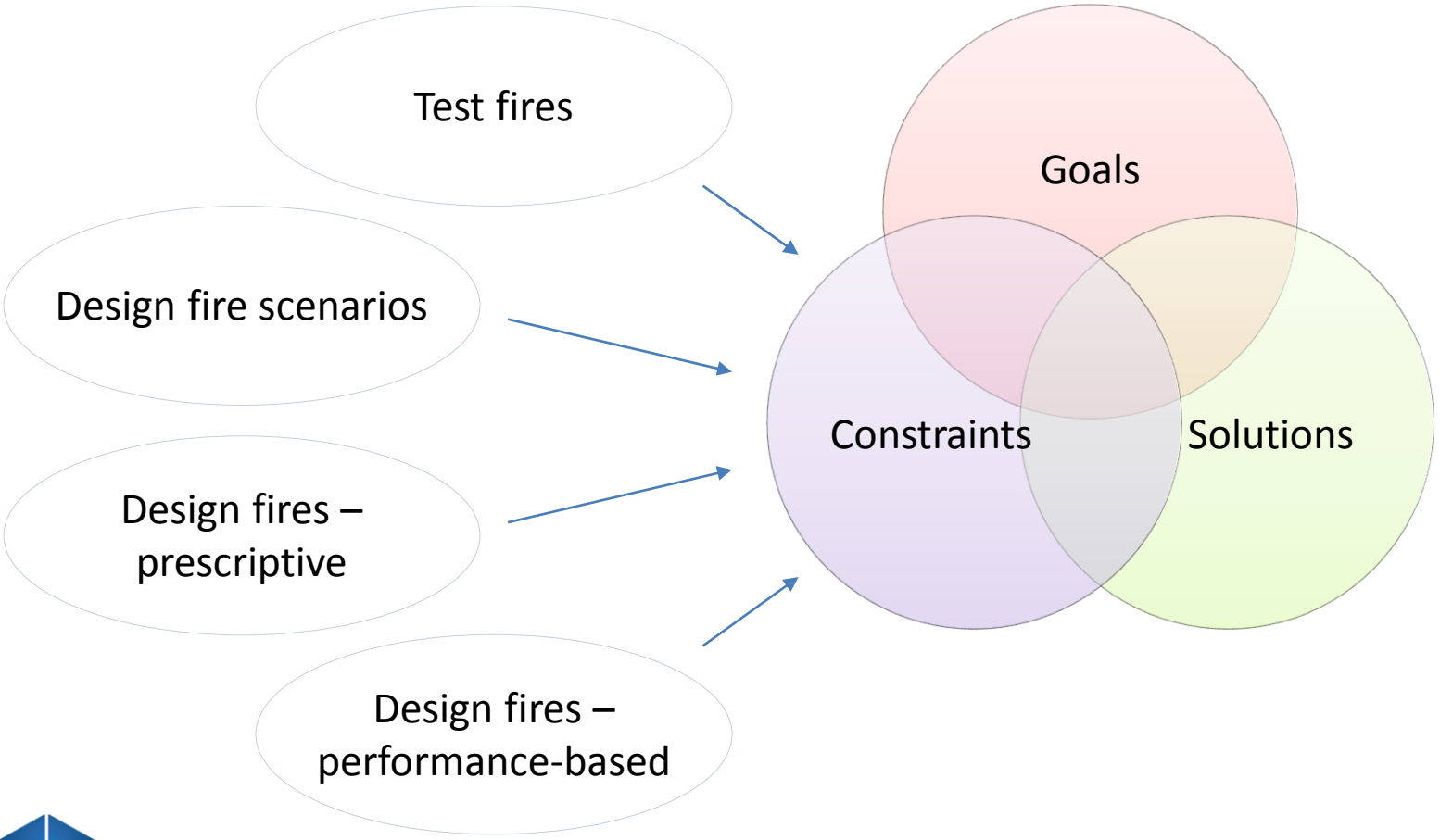
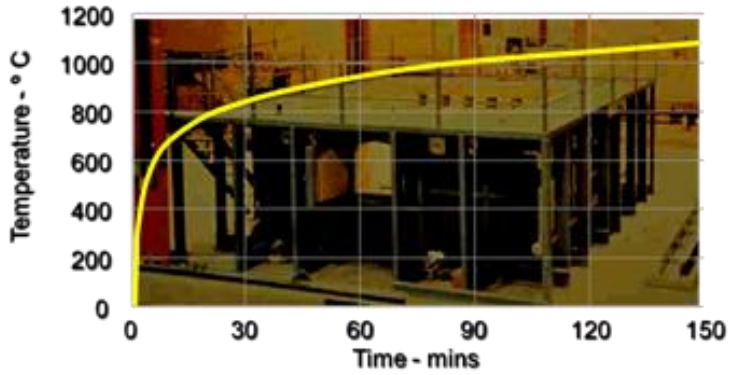


What are the "effects of fire"?
How do we test our strategies against them?



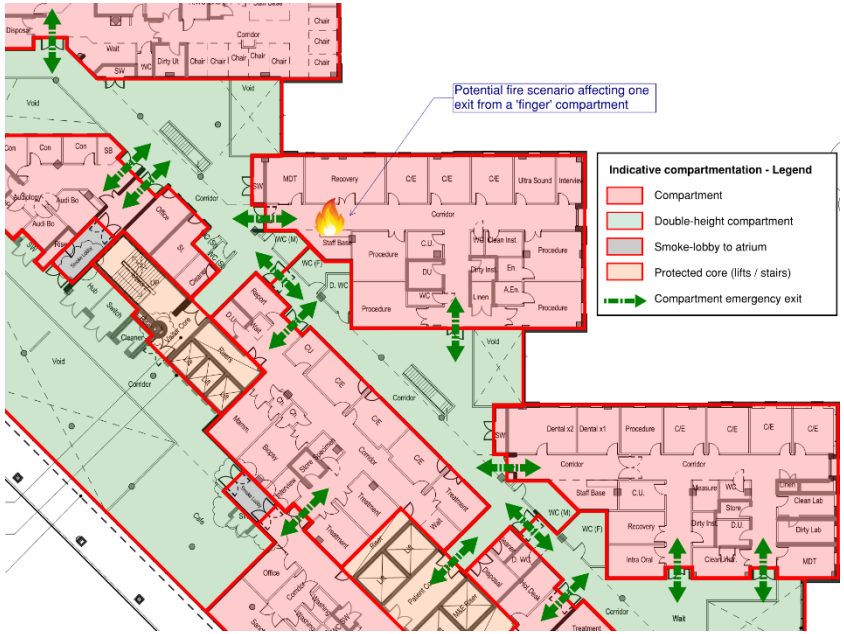
Test fires

- Standardised conditions & performance criteria
- Intended as comparative metrics, not to represent 'real' fires
- Small scale to full-scale assemblies
- e.g.
  - standard fire test (BS 476, ISO 834)
  - combustibility test
  - surface spread of flame test



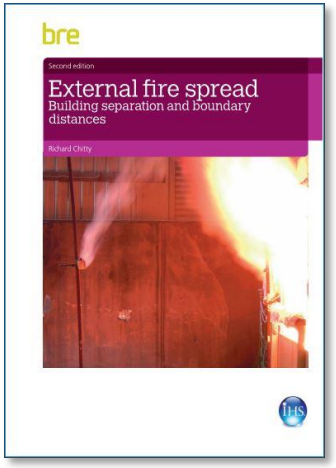
Design fire scenarios

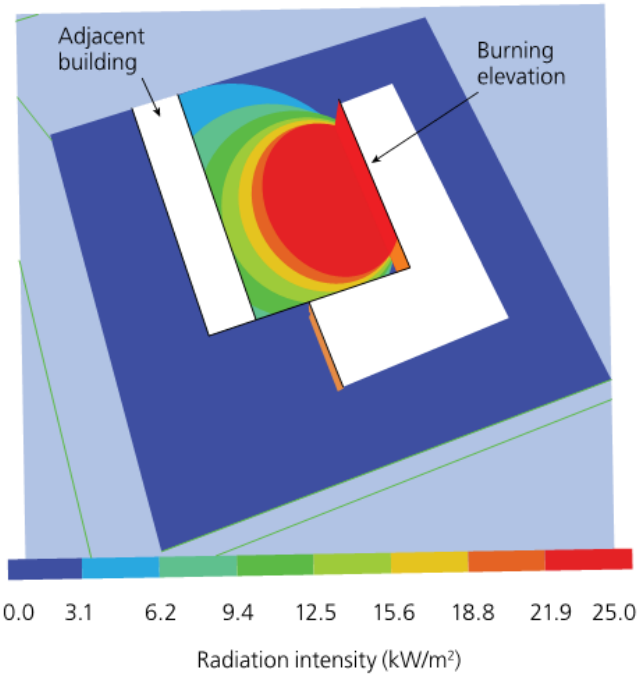
- Conceptual – “effects of fire" not defined in terms of severity
- Characterised by location, likely area 'affected', growth rate, etc.
- Inform the strategy, provisions & response for evacuation, containment, mgmt., firefighting, etc.



Design fires – prescriptive approach

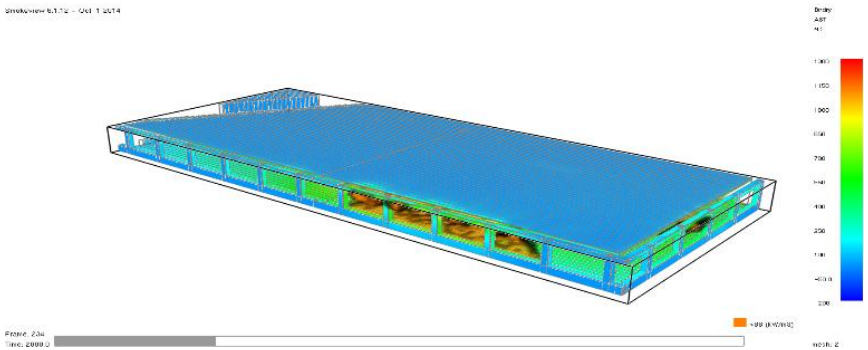
- Standard approaches based on science, experience, tests, etc.
- Usually intended as conservative representations of 'real' fires
- Standard performance criteia
- e.g.
  - Structural FR – standard fire
  - Façade unprotected areas – steady state radiator (e.g. BR 187)

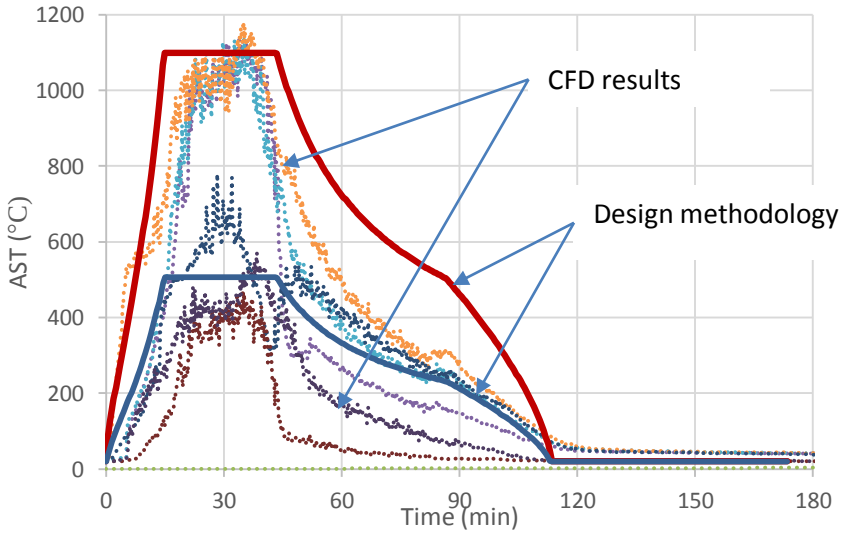




Design fires – performance-based approach

- More accurate representations of 'real' fires
- Consider characteristics of the building, fire load, etc.
- Appraise:
  - Fire and smoke movement
  - Temperature development
  - Heat transfer & thermo-mechanical response





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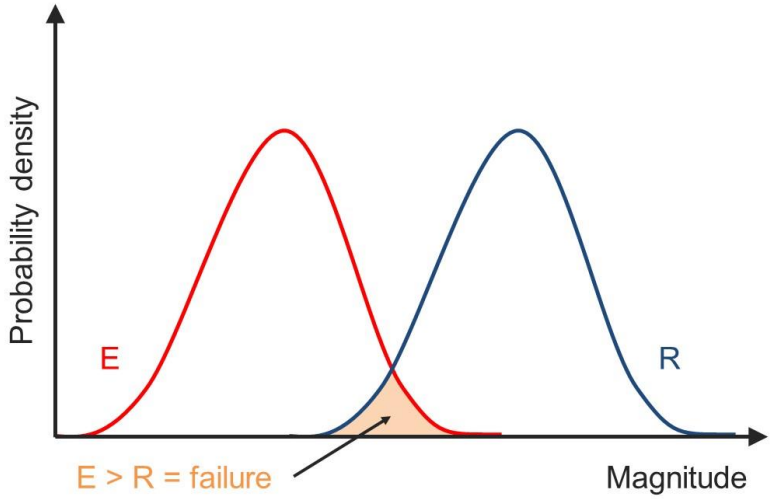
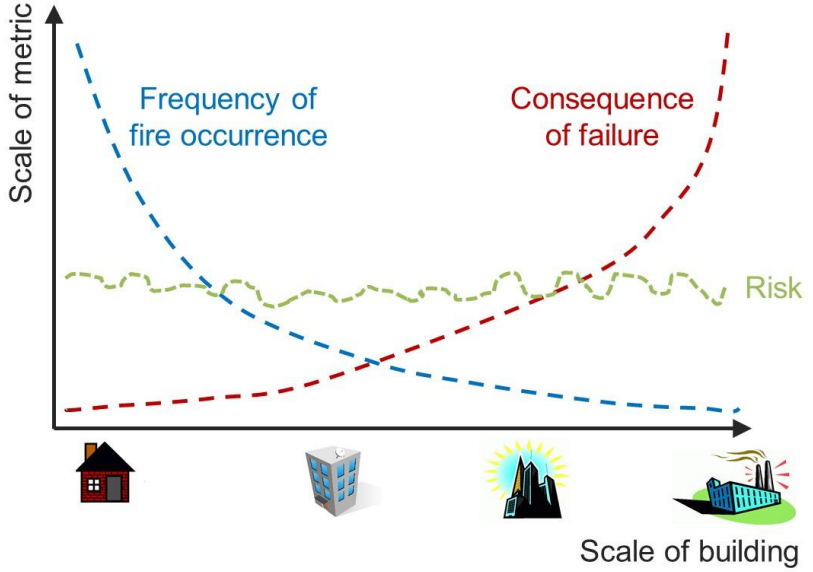
What constitutes reasonable safety?

- If we “pass” under the relevant “fire effects”…
  - Safety achieved… right?
  - We know this… due to precedent…?
- Are the “fire effect” representations appropriate?
- Is there sufficient precedent?





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tall buildings

how are we faring?

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A lot done. A lot more to do?

- UK: so far so good…
- Globally: not so good?
  - Some loss of life
  - Significant property damage
- Risks being identified, appraised and addressed as they emerge
- Will this be enough?

09:50 - 10:20 Is there a Fire Safety Problem with Tall Building Facades?
Andrew Kay - Siderise

10:20 - 10:50 A Forensic Examination of Tall Building Façade fires
Martin Edwards – Probyn-Miers

11:10 - 11:40 Are we using the Wrong Design Fires for Tall Building Fire Strategies in light of recent full height fires?
Eoin O'Loughlin – Trenton Fire

11:40 - 12:10 Should Lifts be used for Evacuation of Tall Buildings?
Santeri Suoranta & Sasha Brozek – Kone

12:10 – 12:30 **Q&A**

12:30 - 14:00 **Visit FIREX Exhibition and Lunch Break**

14:00 - 14:30 Protective Security Advances
UK Government Security Adviser, CPNI

14:30 - 15:00 Is Stay Put/Remain in Place strategy in Residential Tall Buildings valid?
Tom Gilbert – Frankham RMS

15:00 – 15:30 The role of Passive Fire Protection in Tall Buildings
Wilf Butcher - AFSP

15:30 - 16:00 Can we Fight and Extinguish Full Height Tall Building Fires?
Mark Fishlock – Horizonscan

Tall Buildings
fire safety network

Council on Tall Buildings and Urban Habitat

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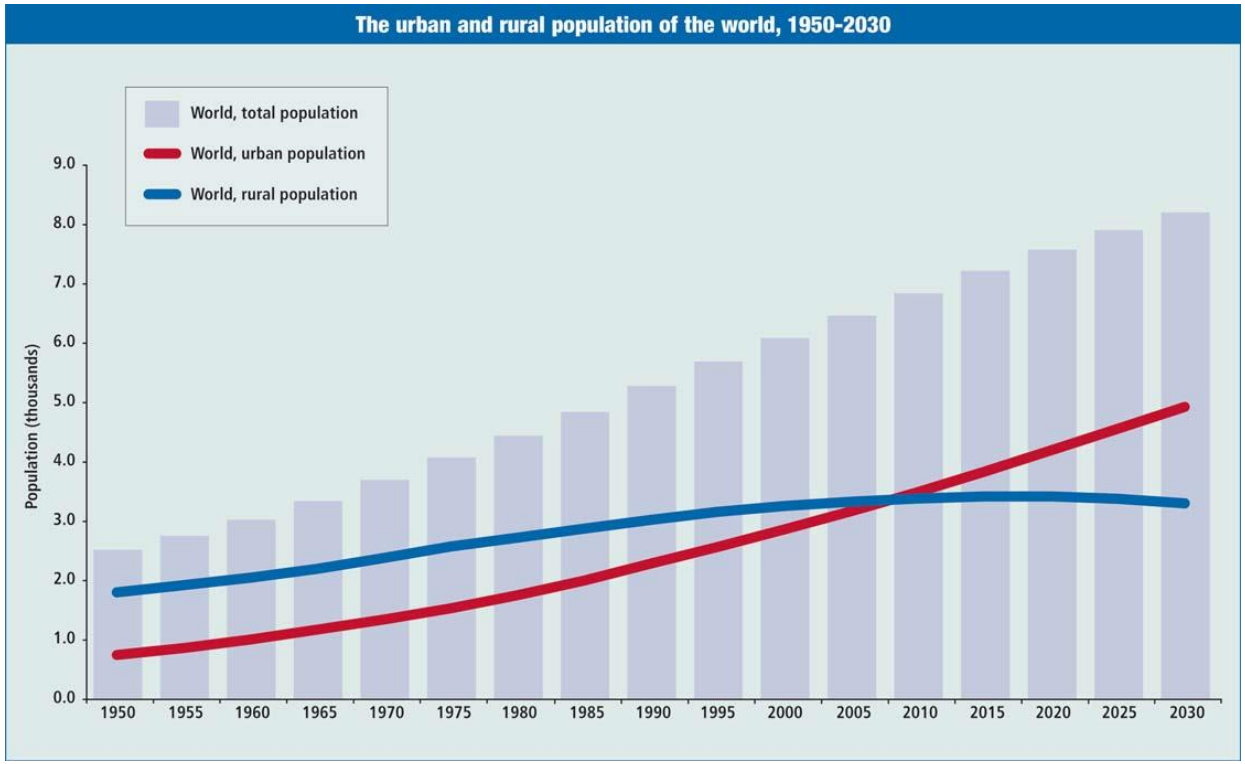
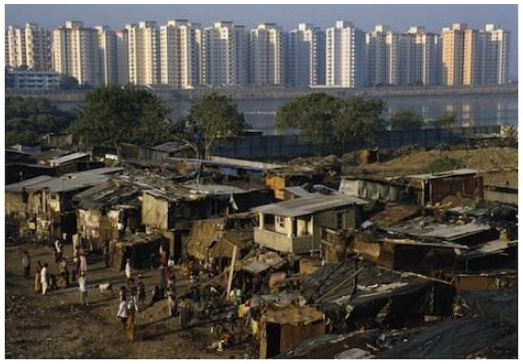
Are we ready for the future?





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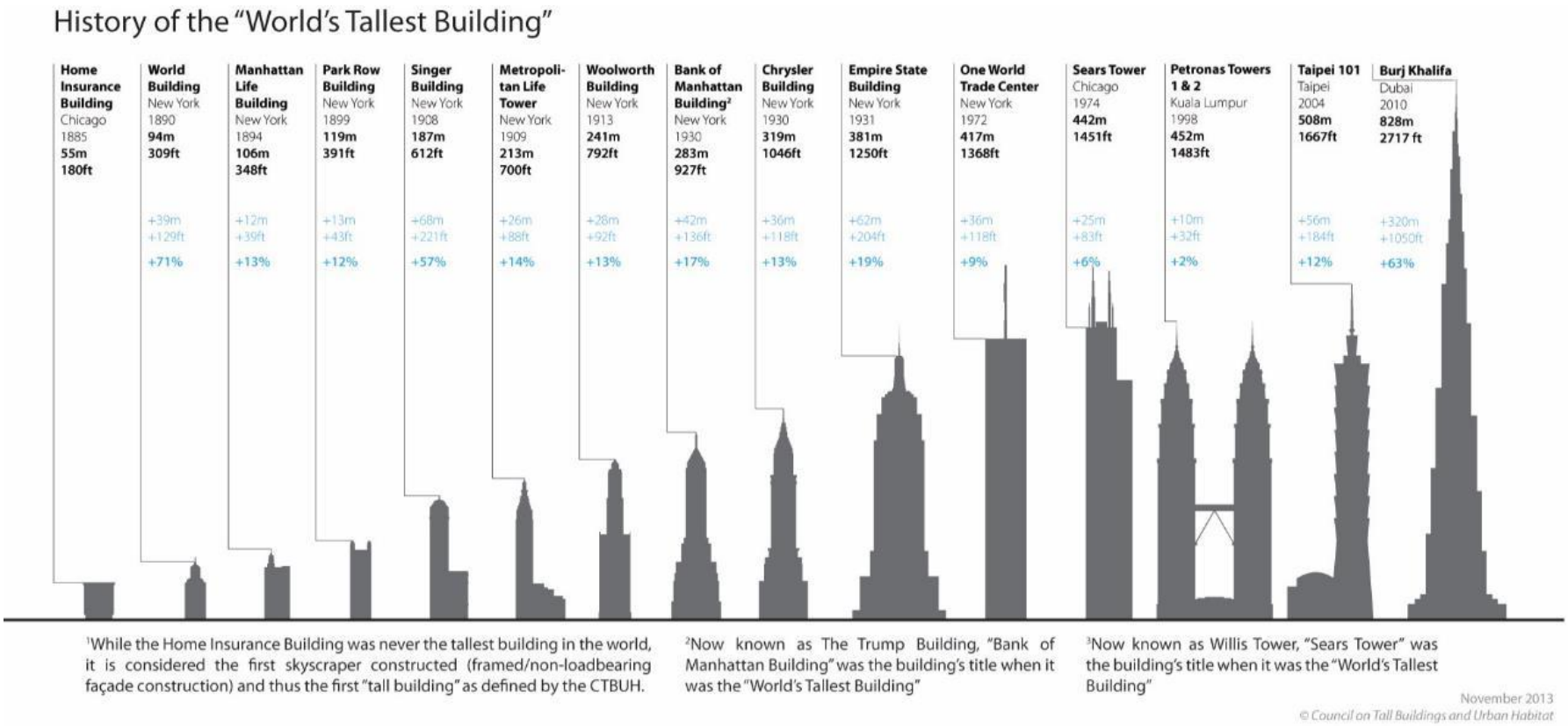

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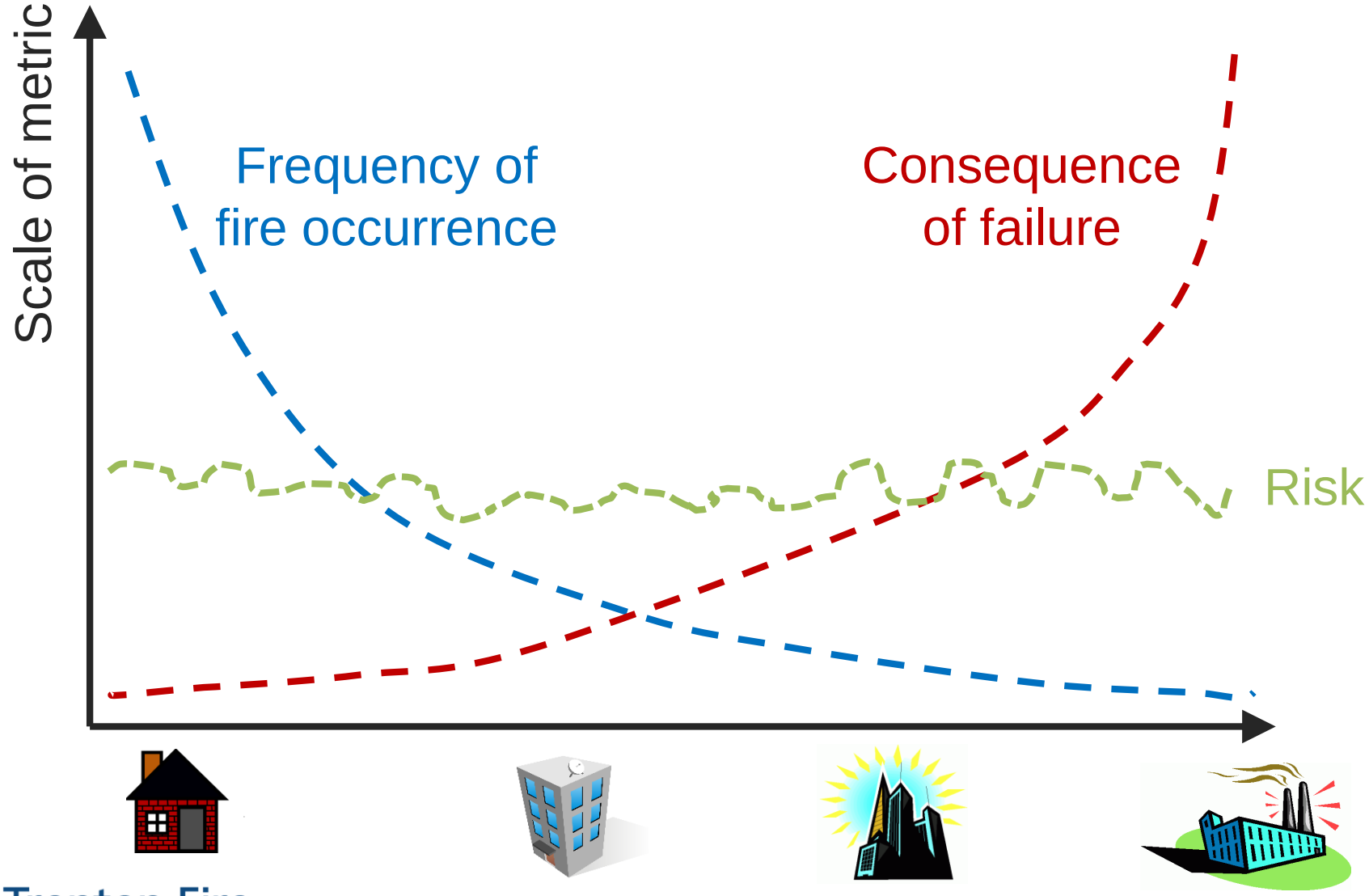

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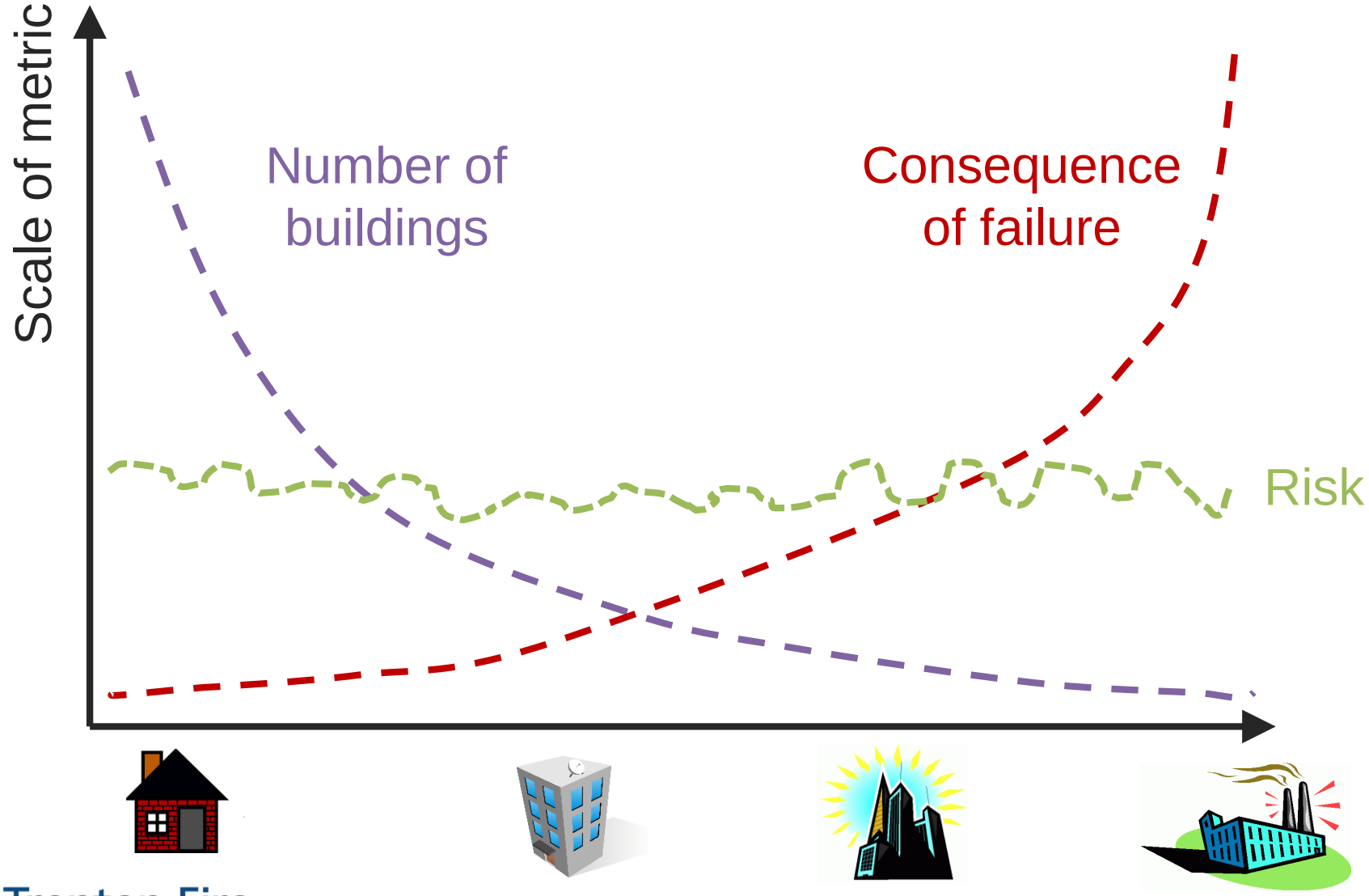

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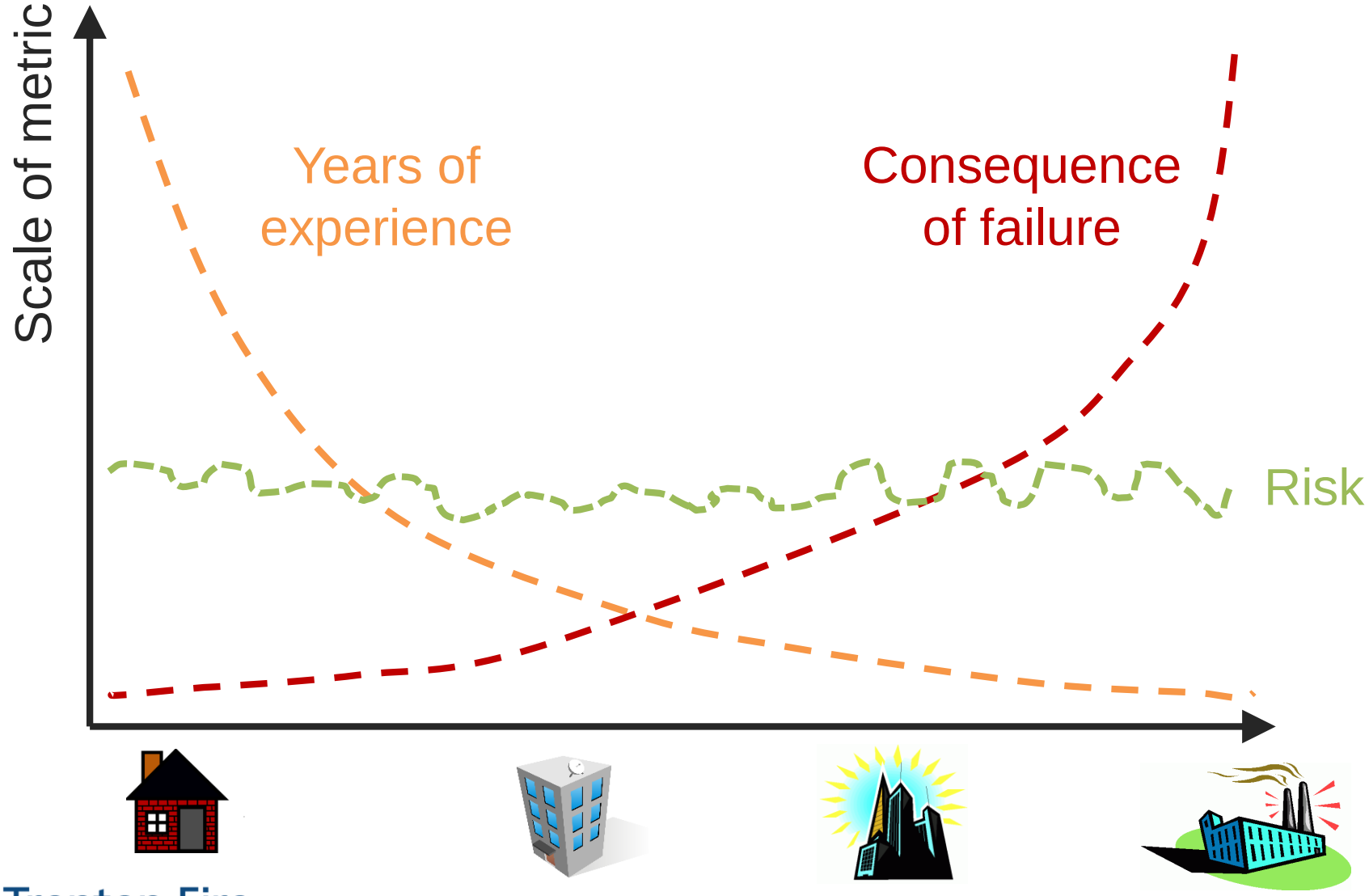

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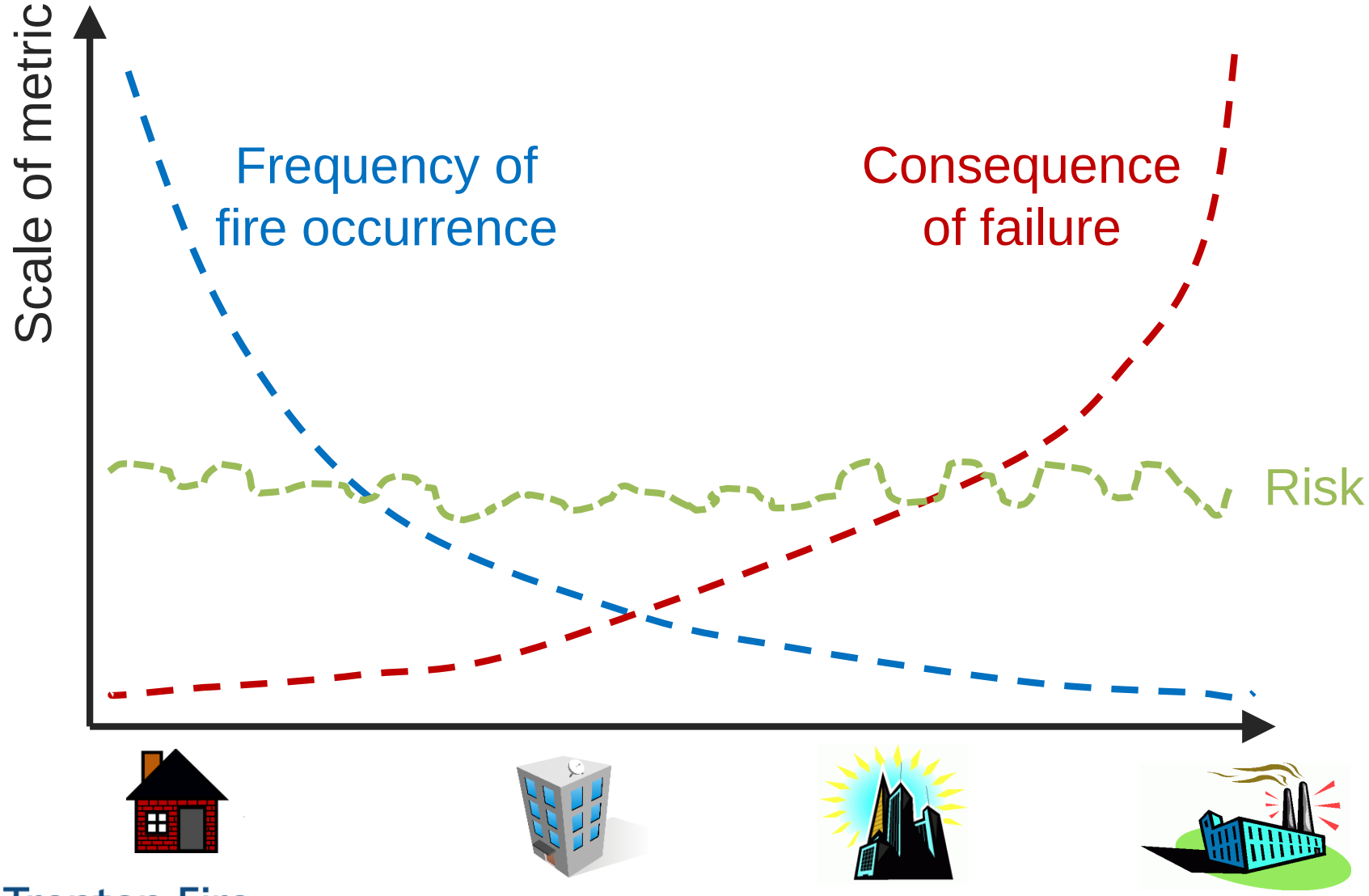

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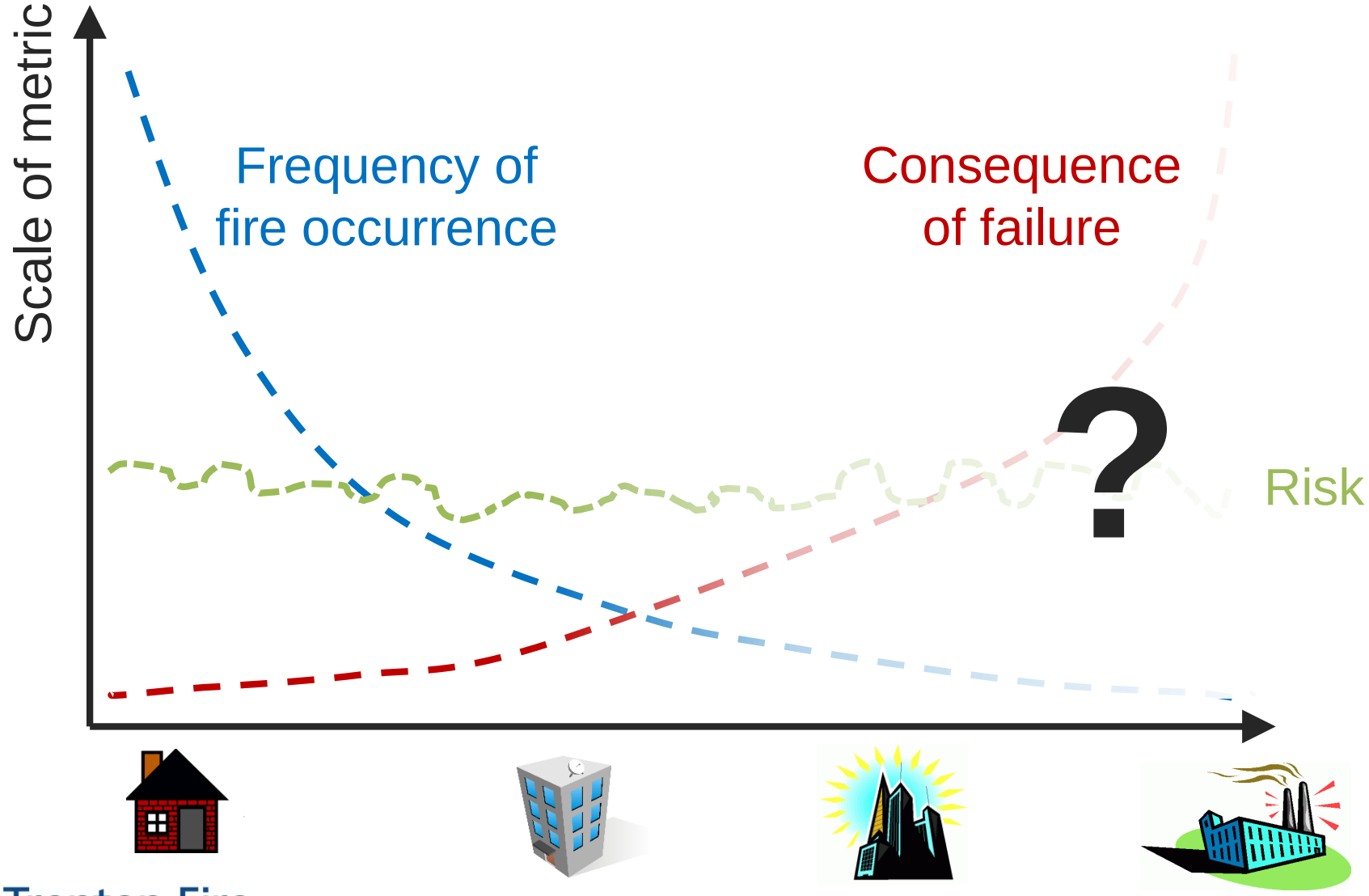

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tall buildings

fire safety strategies

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Tall building fire safety strategies

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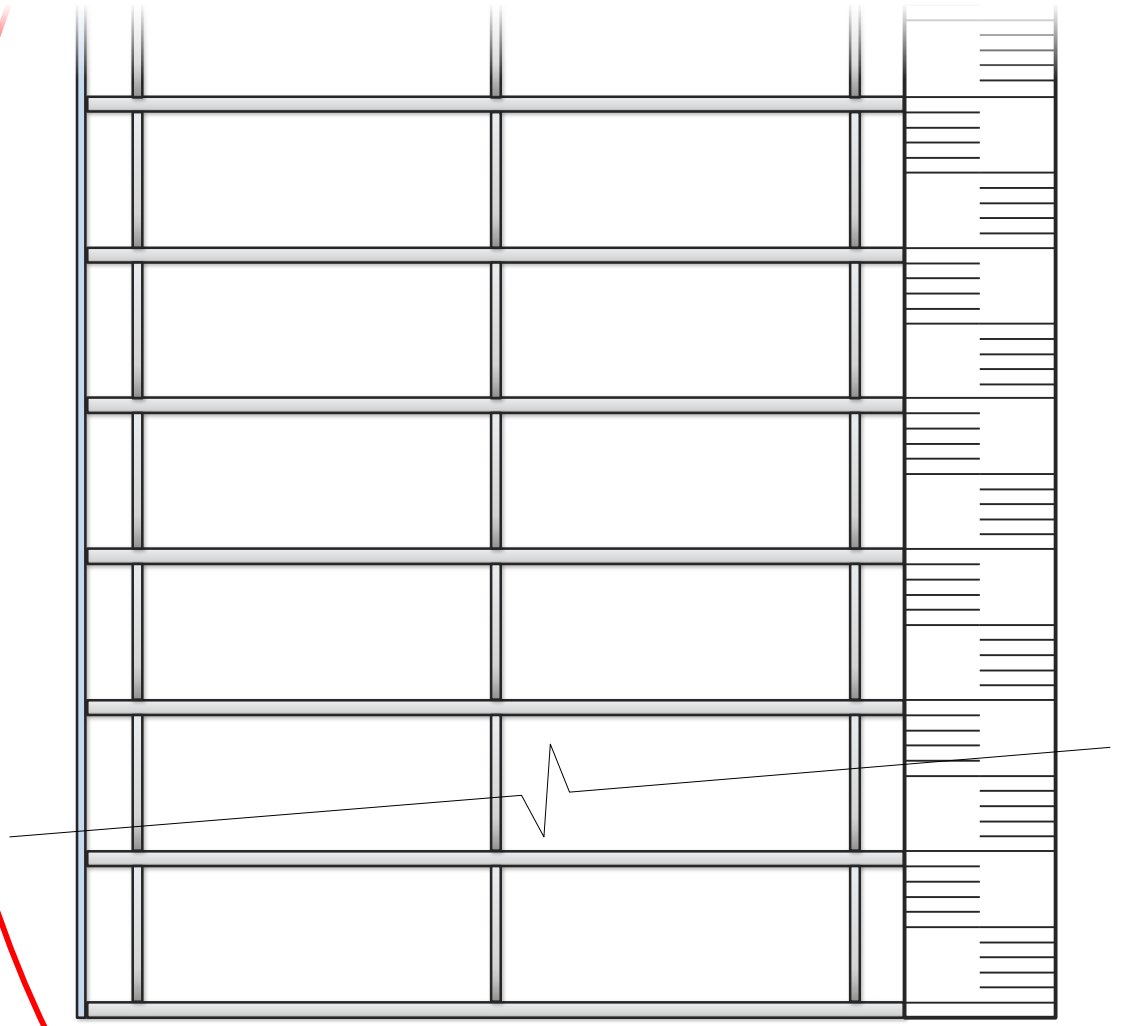

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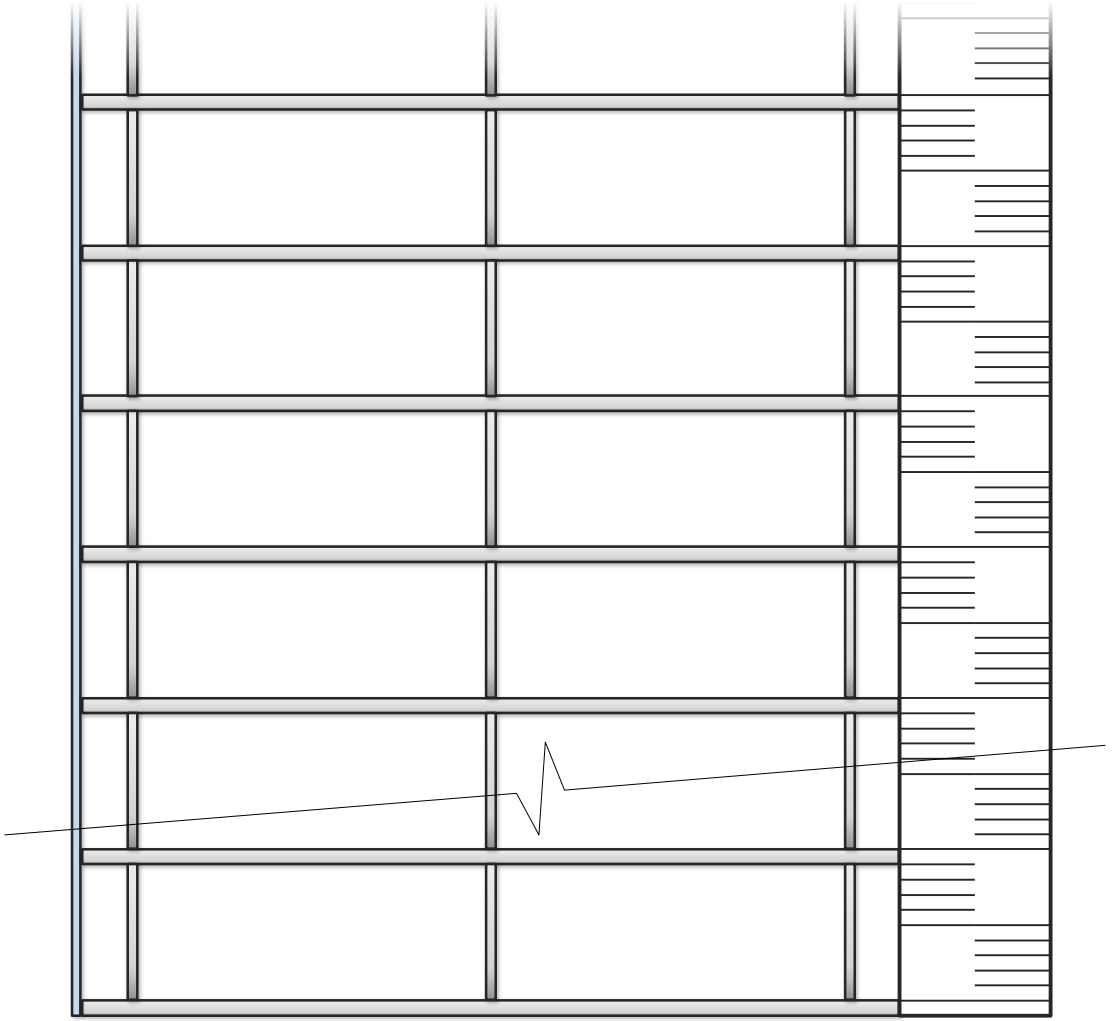

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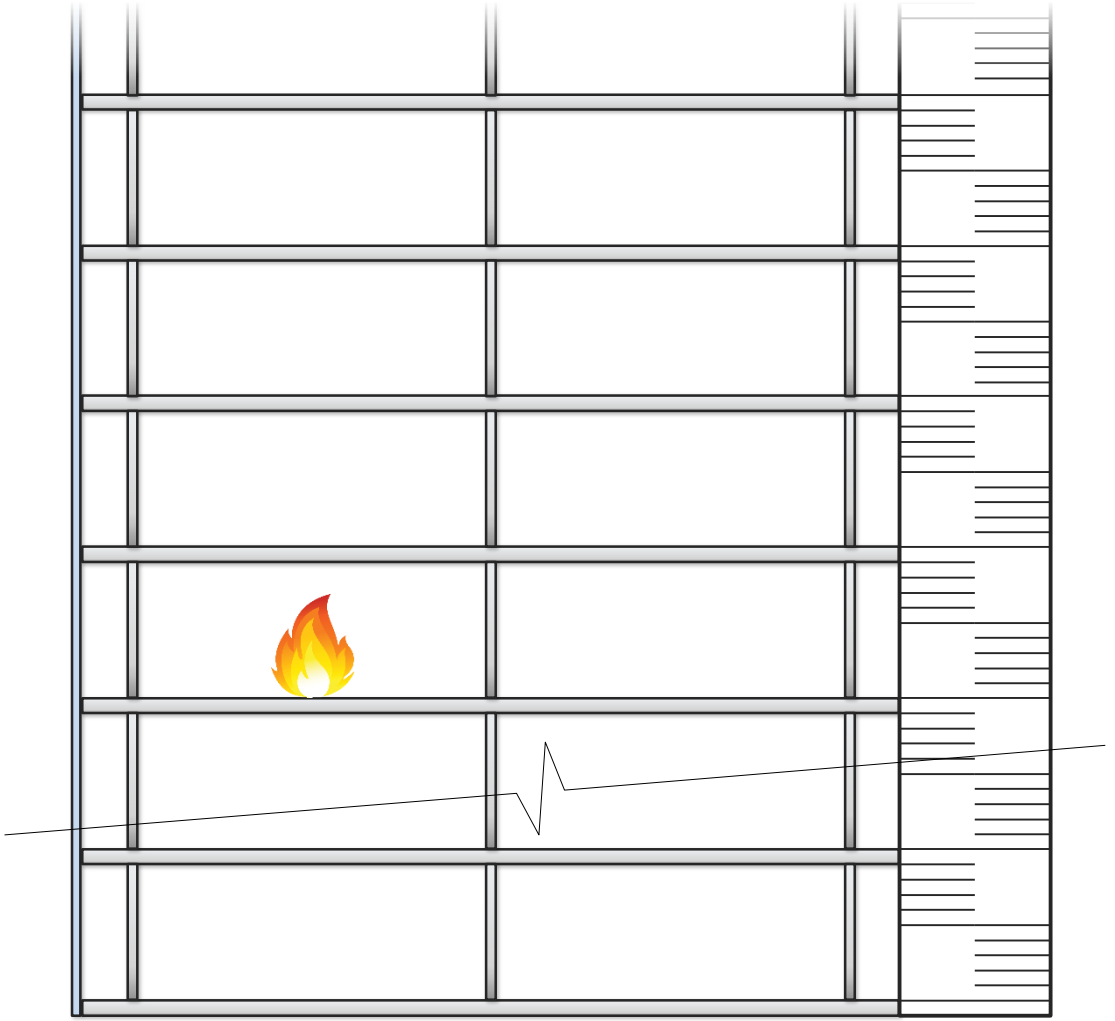

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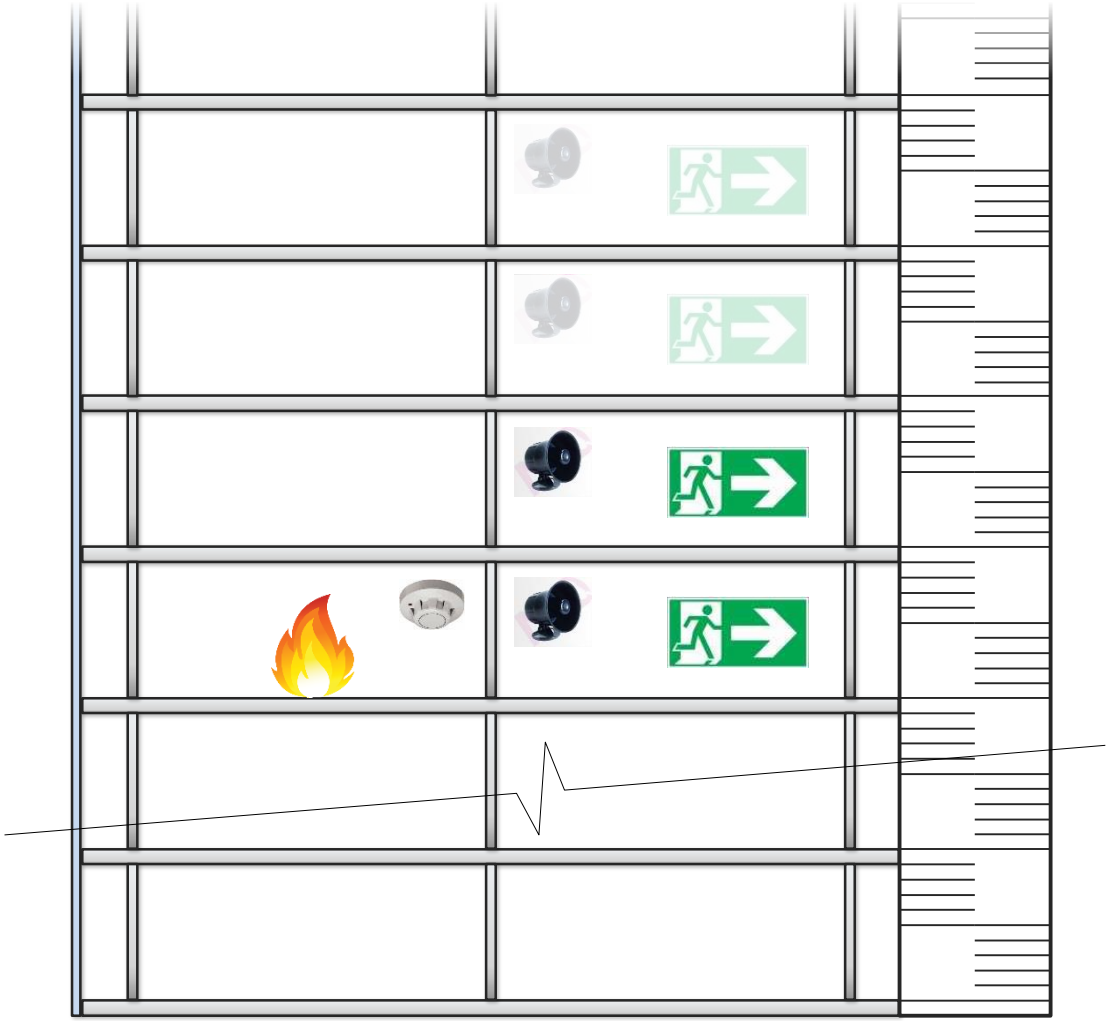
Tall building fire safety strategies

- Evacuate floors at risk (phased, 2 at a time)



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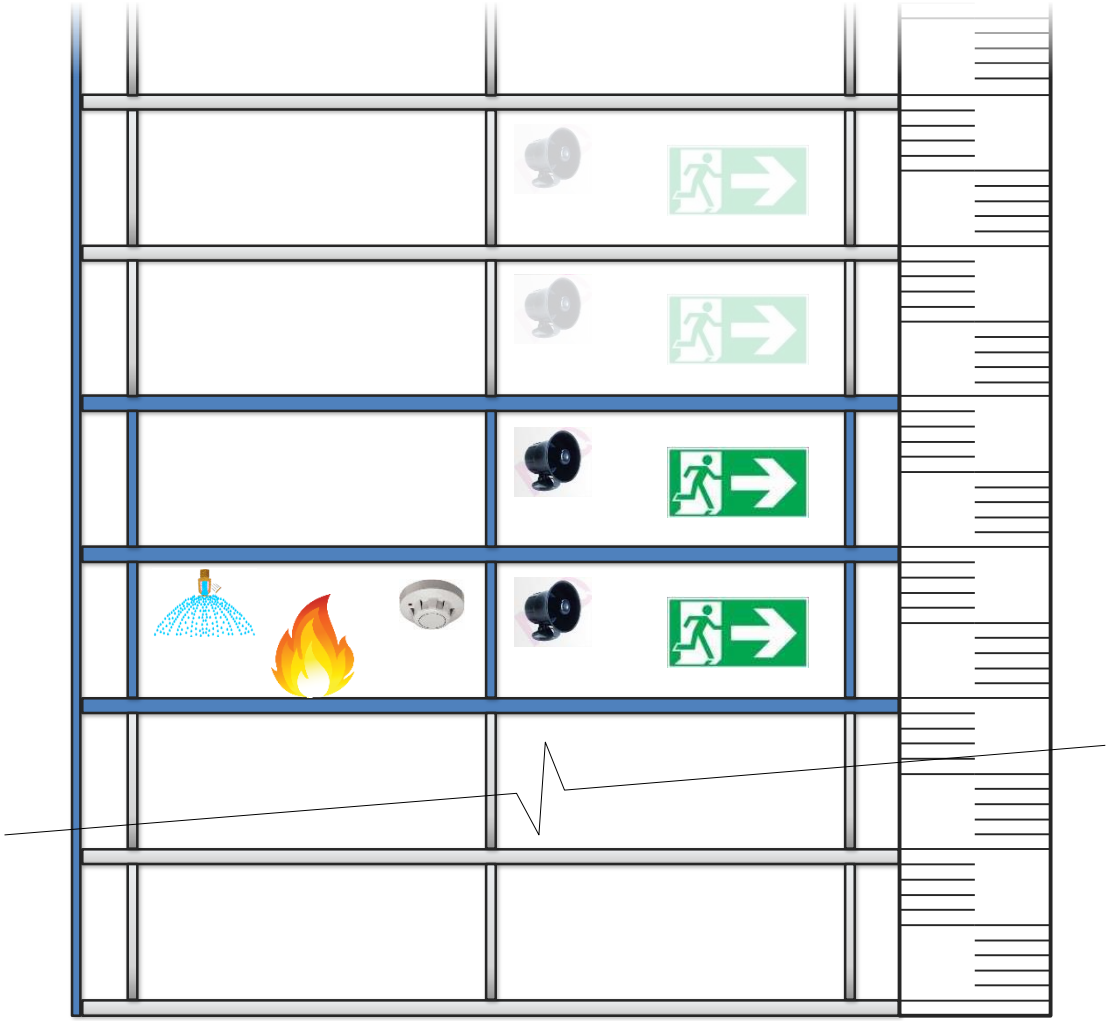
Tall building fire safety strategies

- Evacuate floors at risk (phased, 2 at a time)
- Restrict fire & smoke spread in the building



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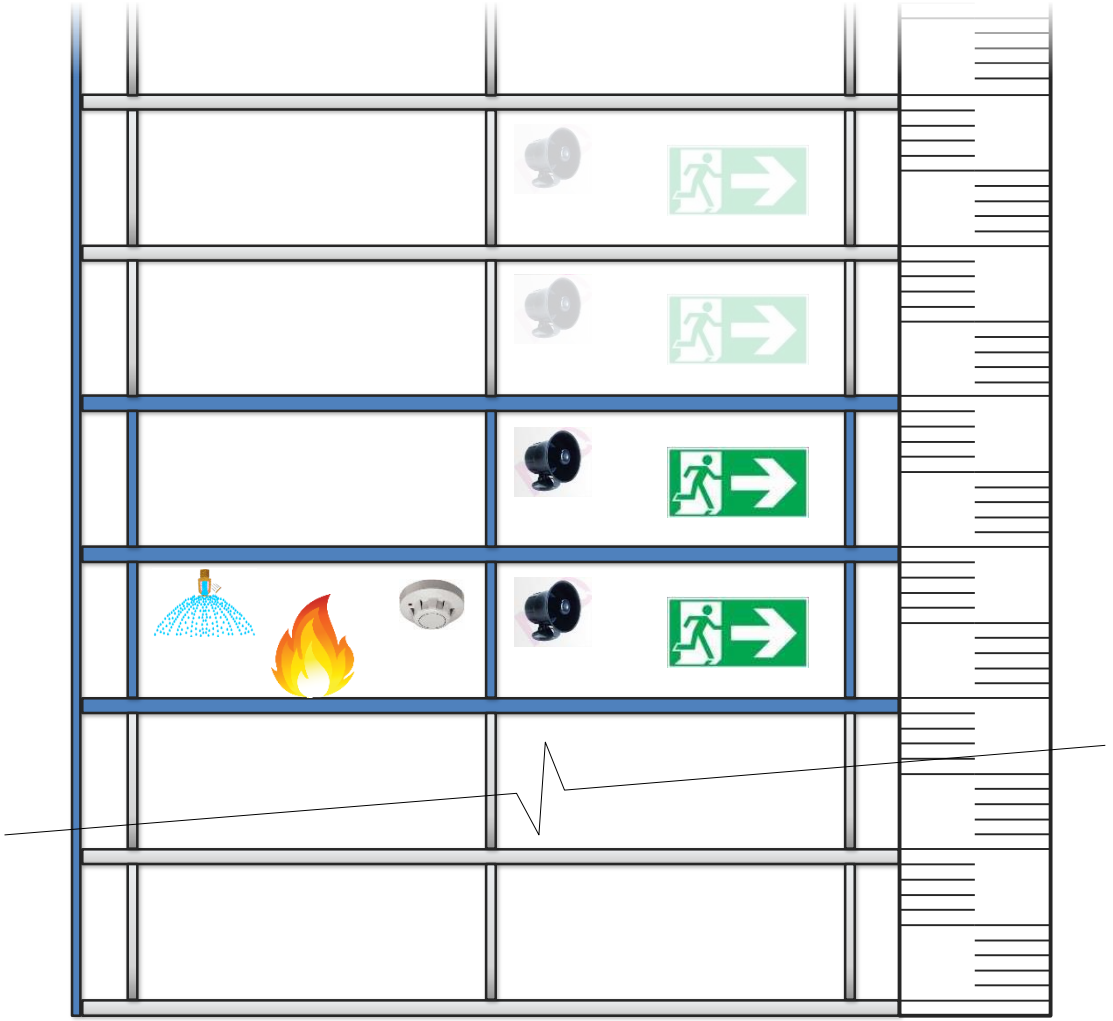
- Prevent collapse



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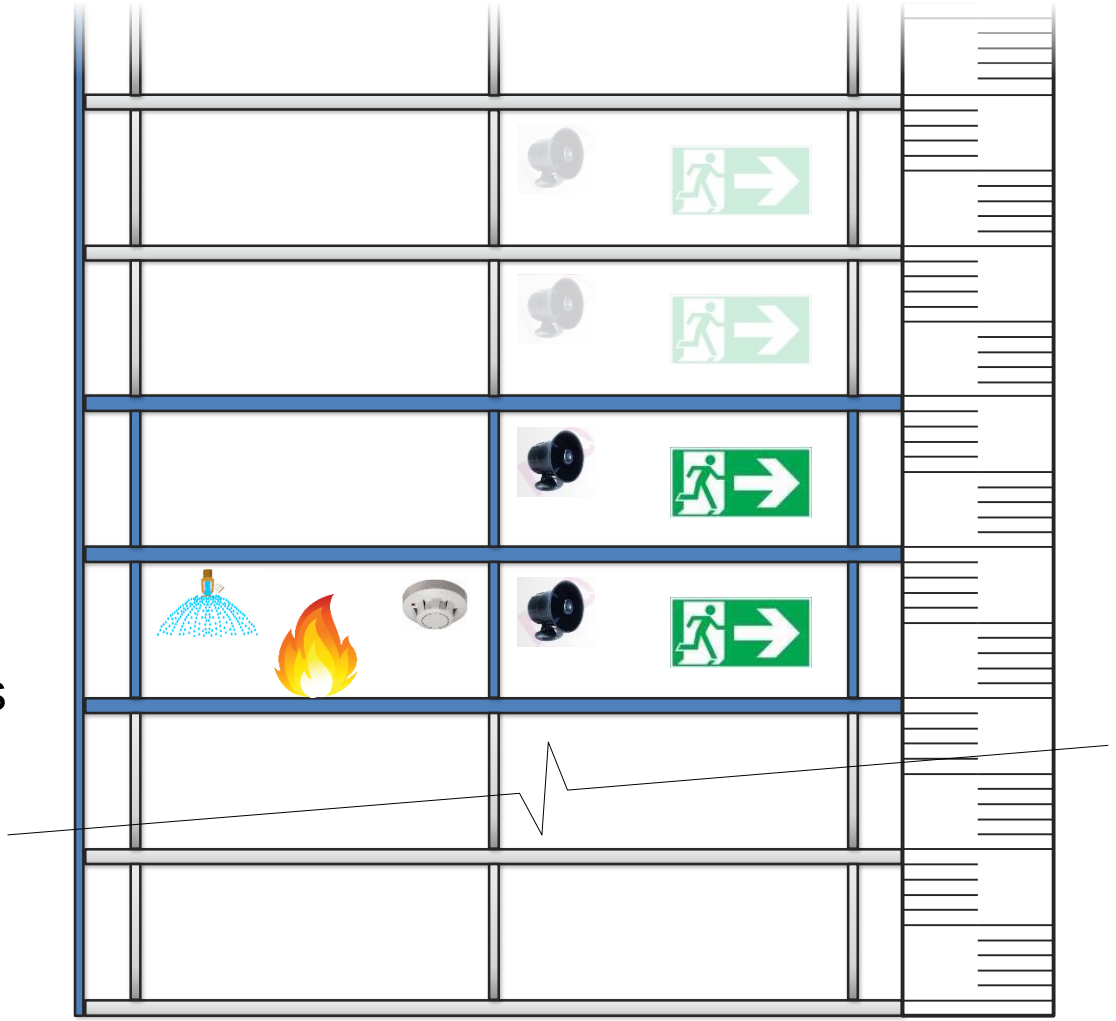
- Prevent fire spread to other properties / parts of the building



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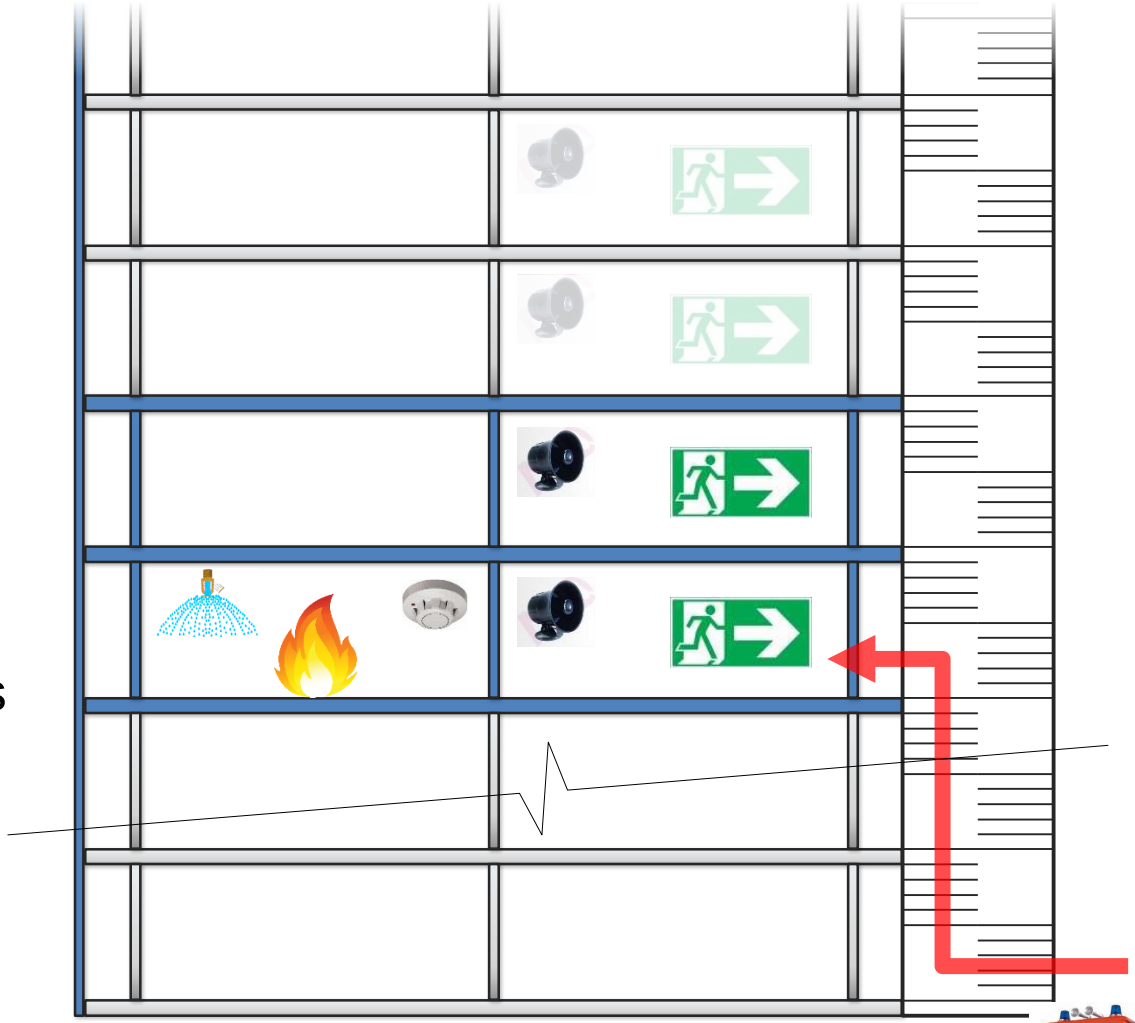
Tall building fire safety strategies

- Evacuate floors at risk (phased, 2 at a time)
- Restrict fire & smoke spread in the building
- Prevent collapse
- Prevent fire spread to other properties / parts of the building
- Provide firefighting access and facilities



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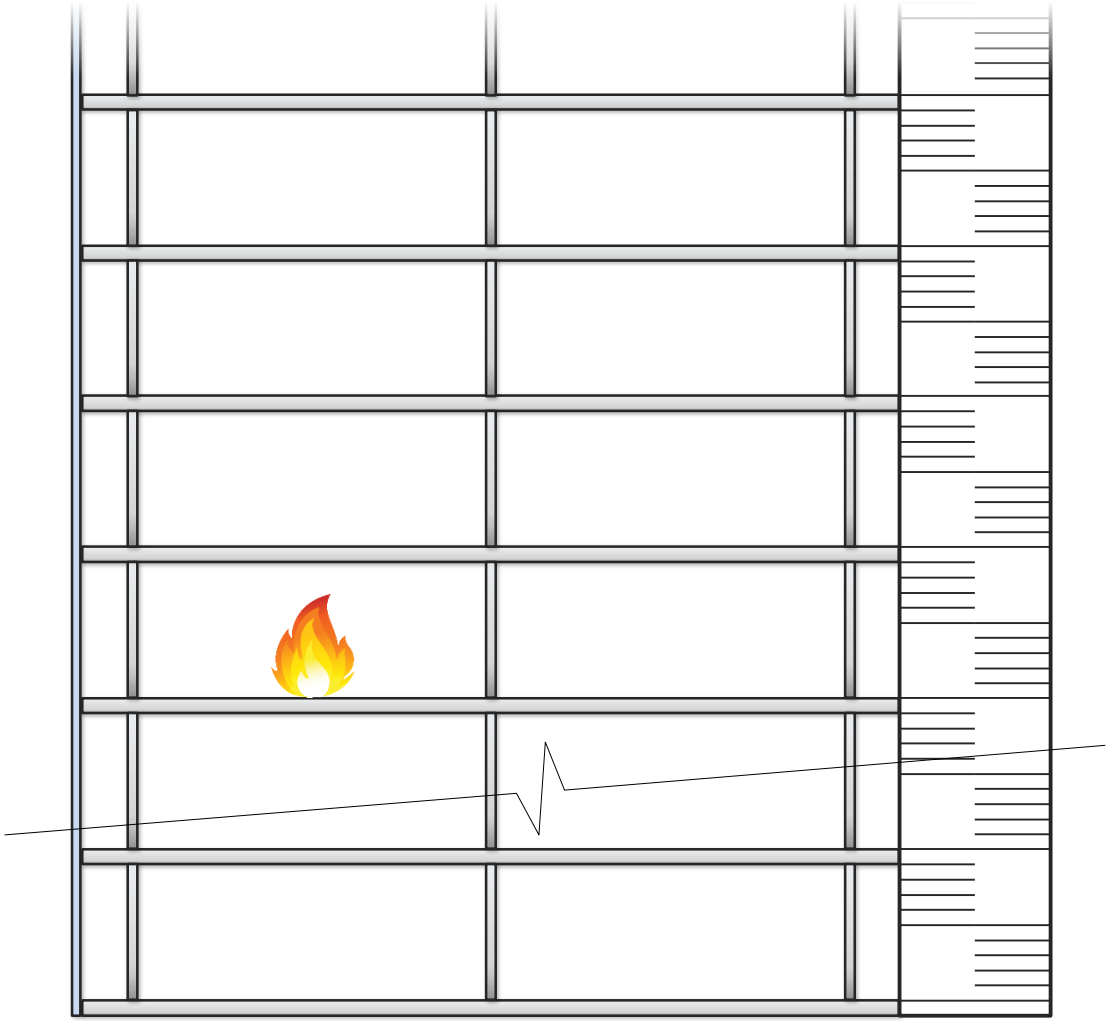
How do multi-level fires impact on fire safety strategies?

How do they compare with the fire events / effects we design for?

Impact of multi-level fires – evacuation



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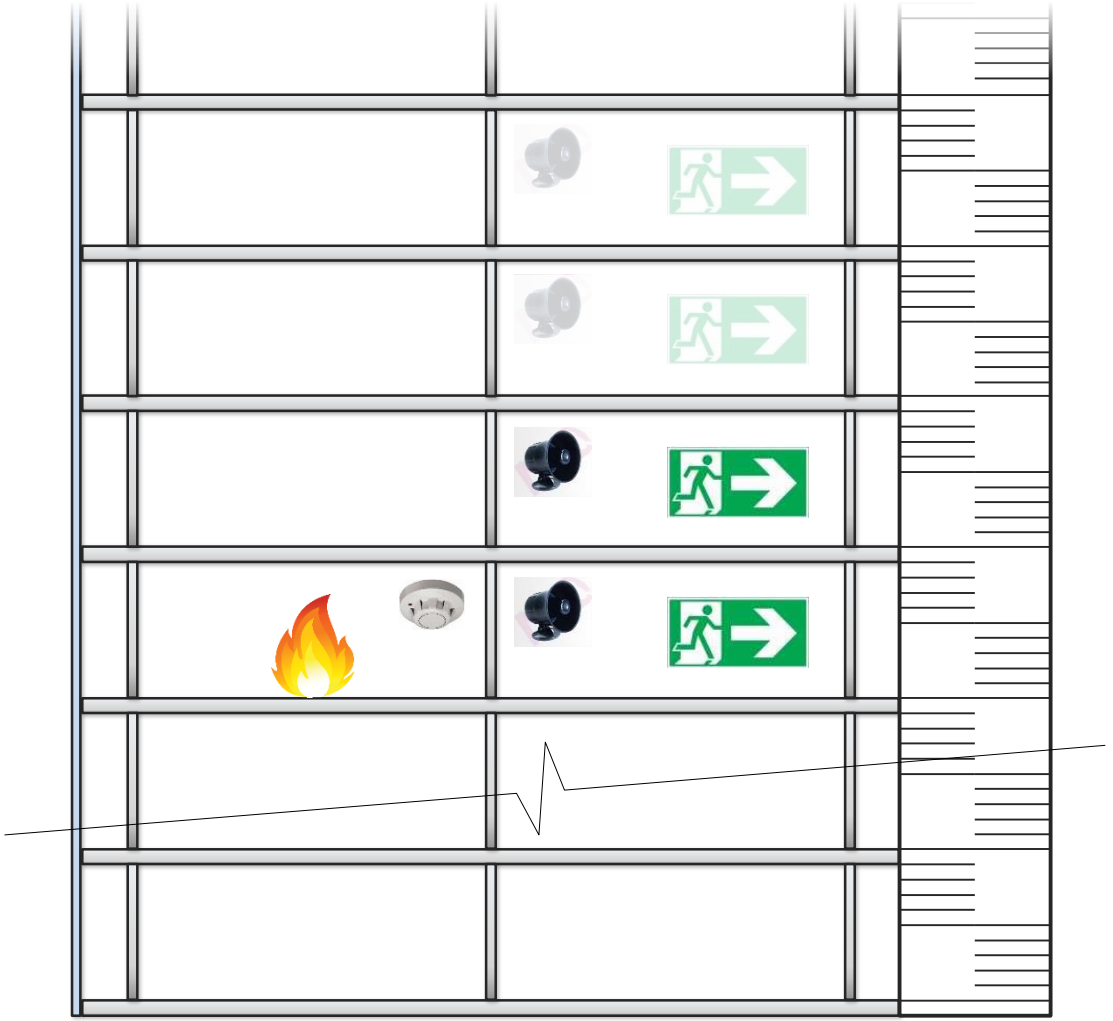

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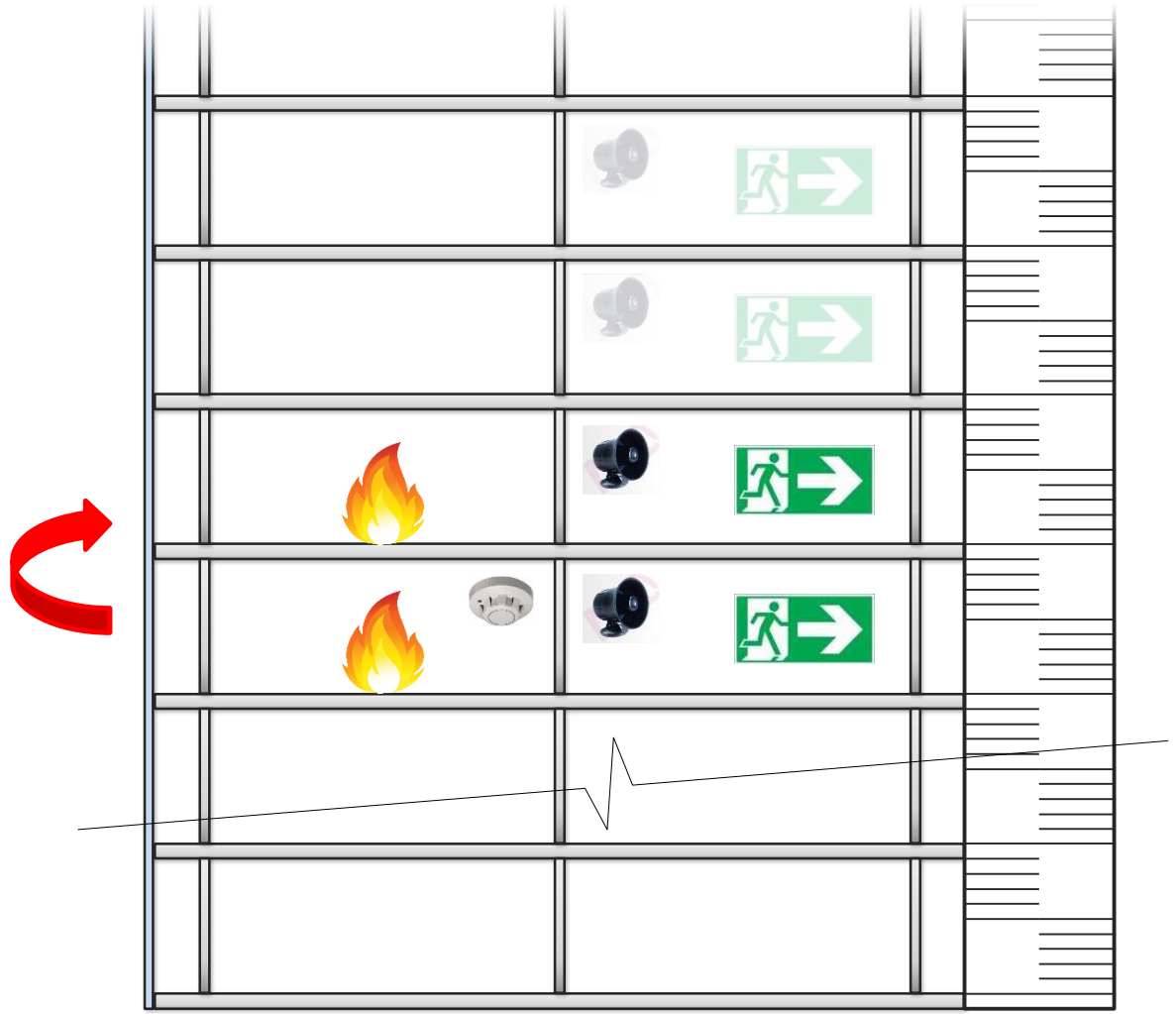
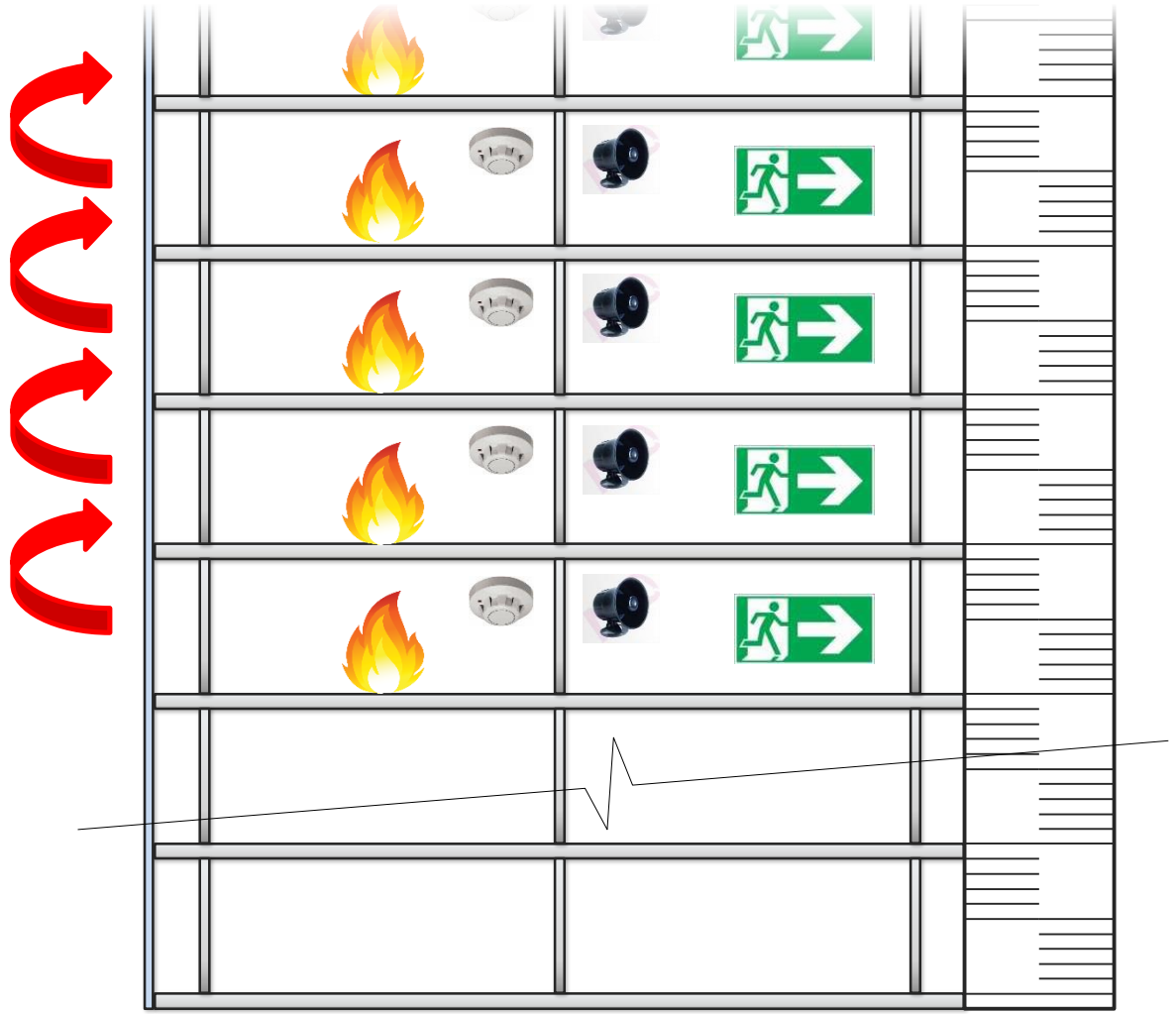
Impact of multi-level fires – evacuation



Trenton Fire

Impact of multi-level fires – evacuation



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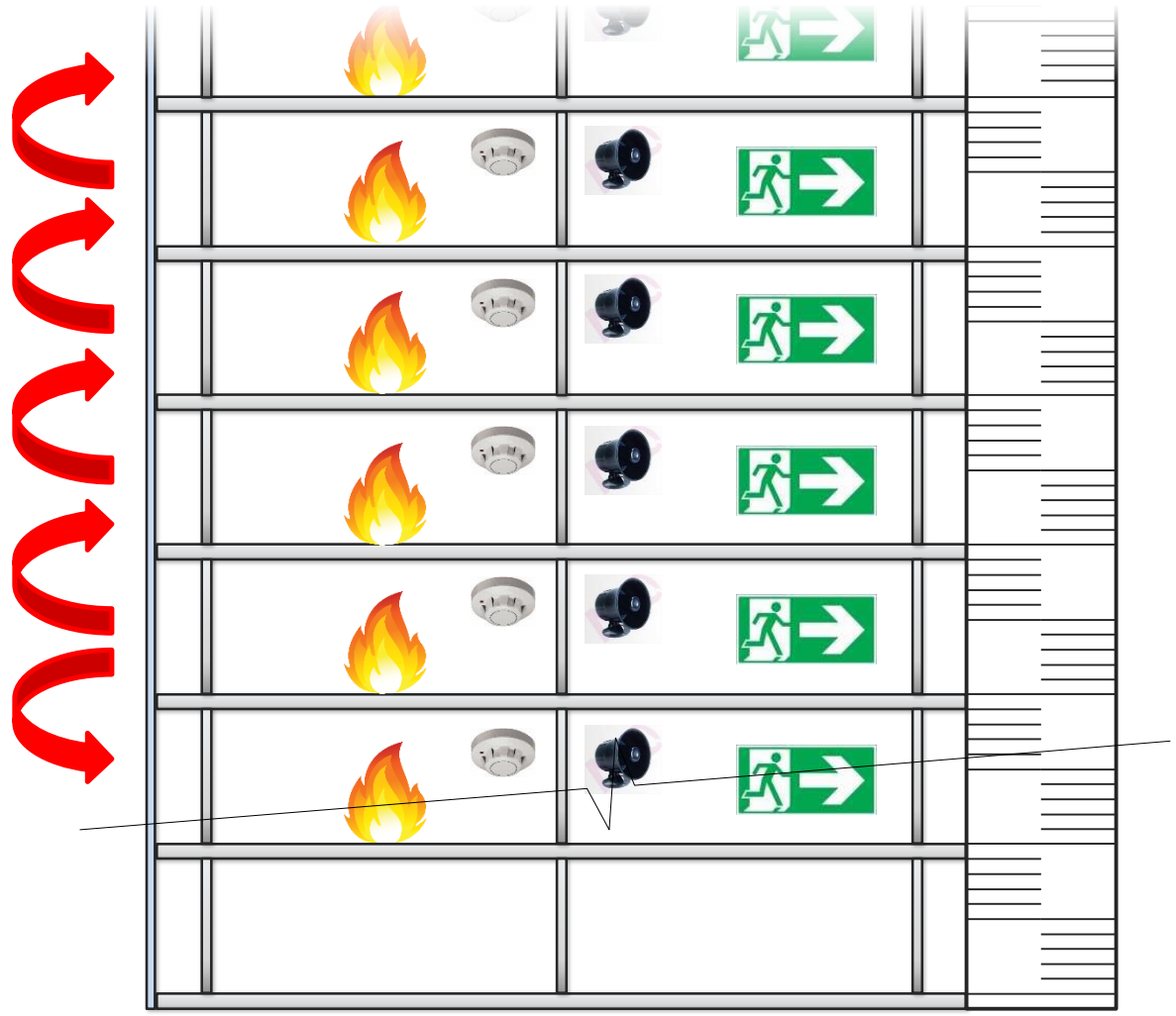
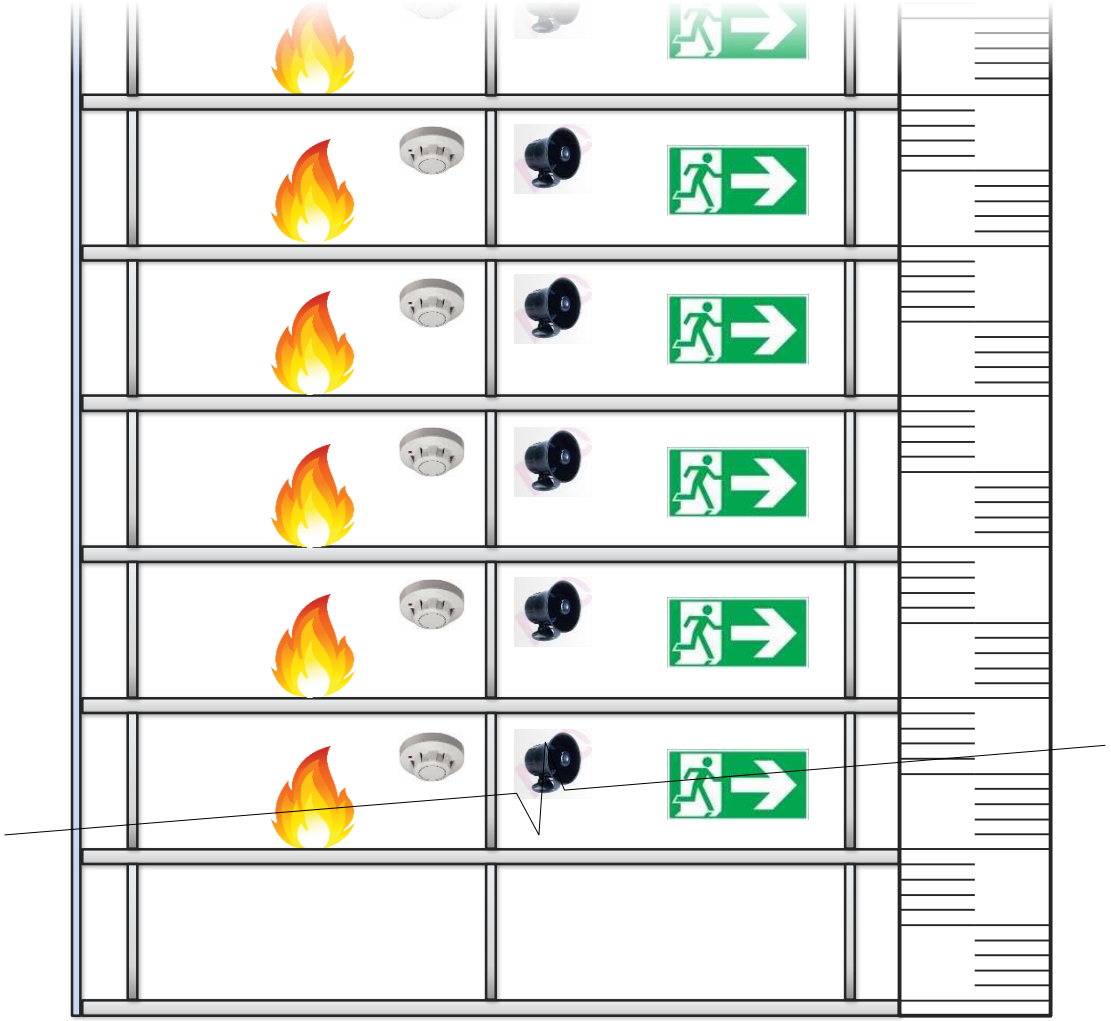
Impact of multi-level fires – evacuation



Trenton Fire

Impact of multi-level fires – evacuation

- Egress philosophy?
  - ‘Defend in place’
  - Phased
- Egress provisions?
  - Alternative routes
  - Capacities
  - Merging flows
- Cause & effect?
  - Detection & alarm
  - Smoke control systems
- Interaction with firefighting access?
- Fire safety mgmt.?



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Impact of multi-level fires – evacuation

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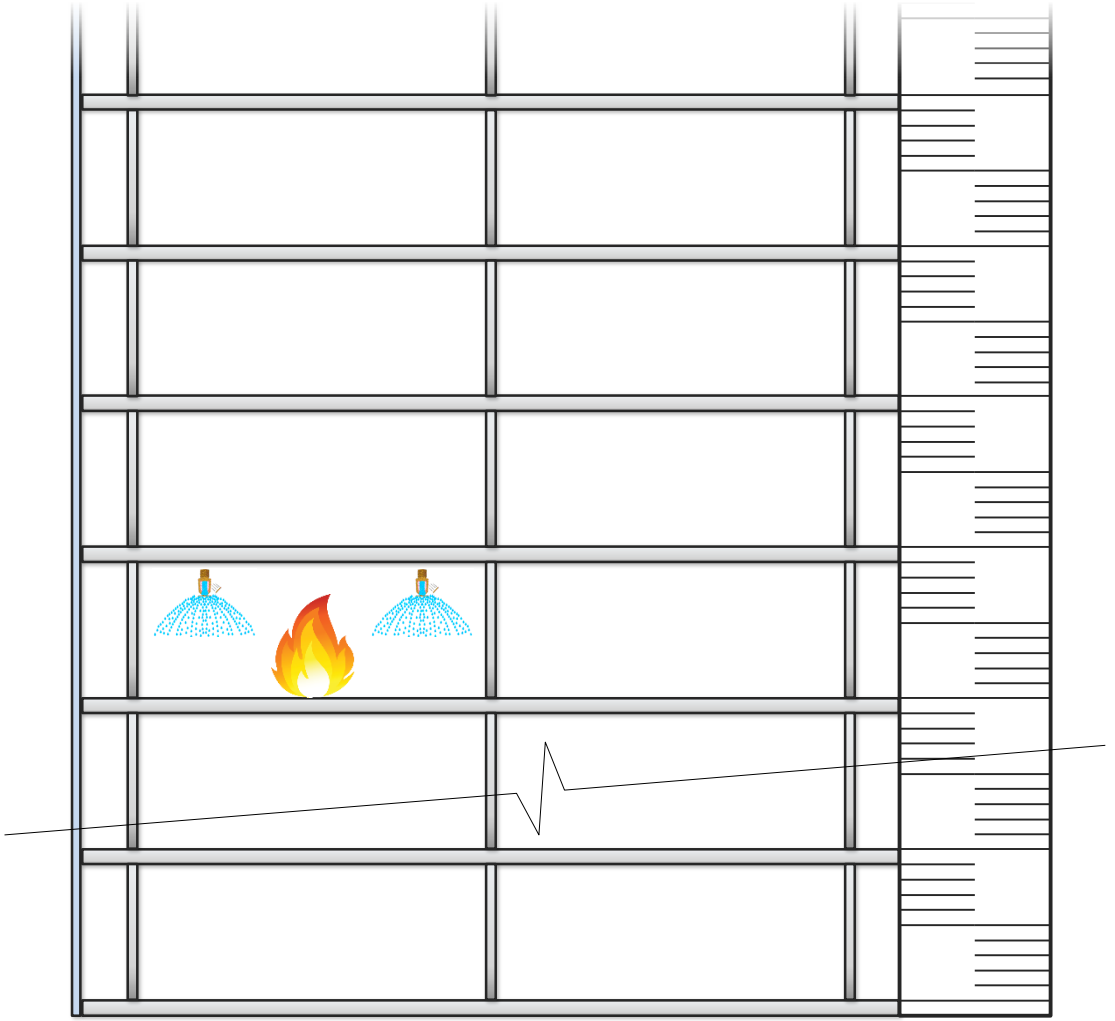
Impact of multi-level fires – suppression

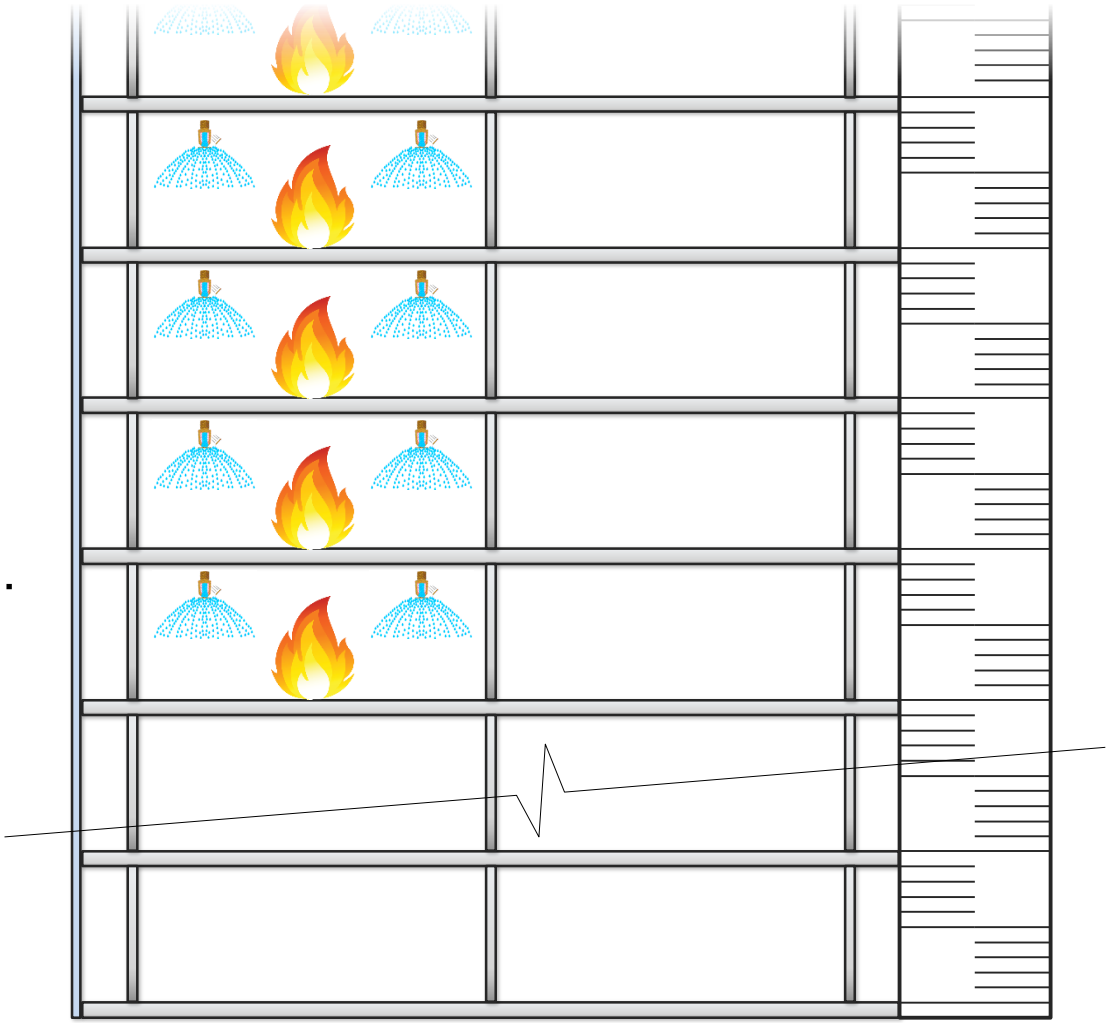
- e.g. sprinklers, water-mist
- Typically designed to address a single seat of fire
  - Number of heads
  - Discharge density
  - Duration (stored water)



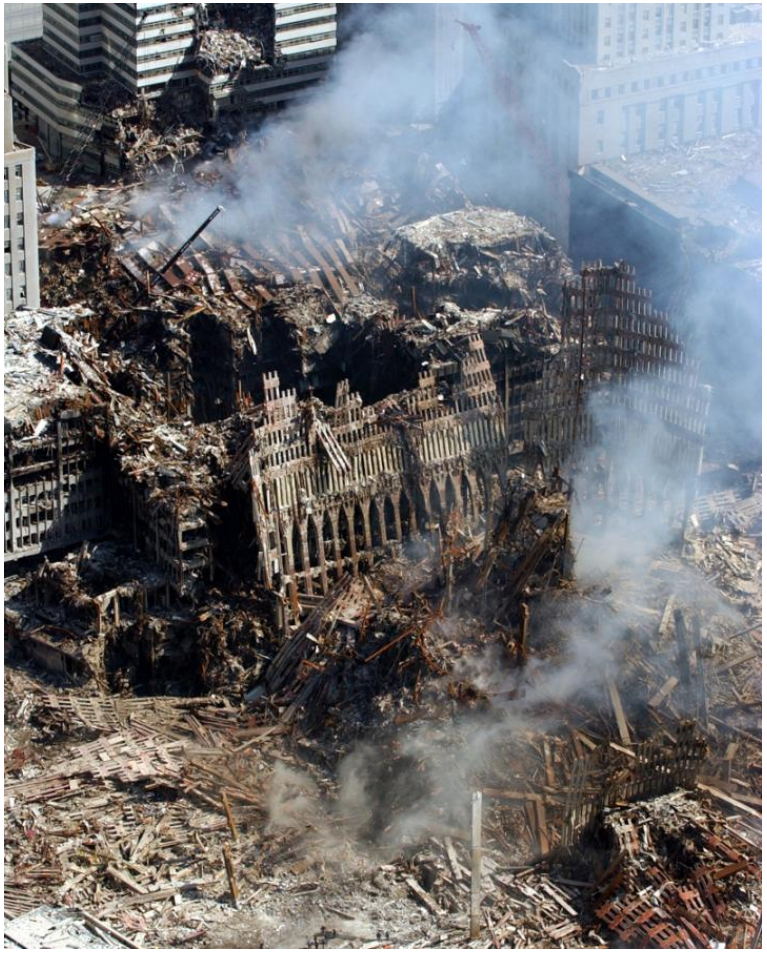
Trenton Fire

Impact of multi-level fires – suppression

- e.g. sprinklers, water-mist
- Typically designed to address a single seat of fire
  - Number of heads
  - Discharge density
  - Duration (stored water)
- Multiple fire locations…
  - More heads…
  - Sufficient water?
  - Sufficient pressure?
  - Successful suppression?



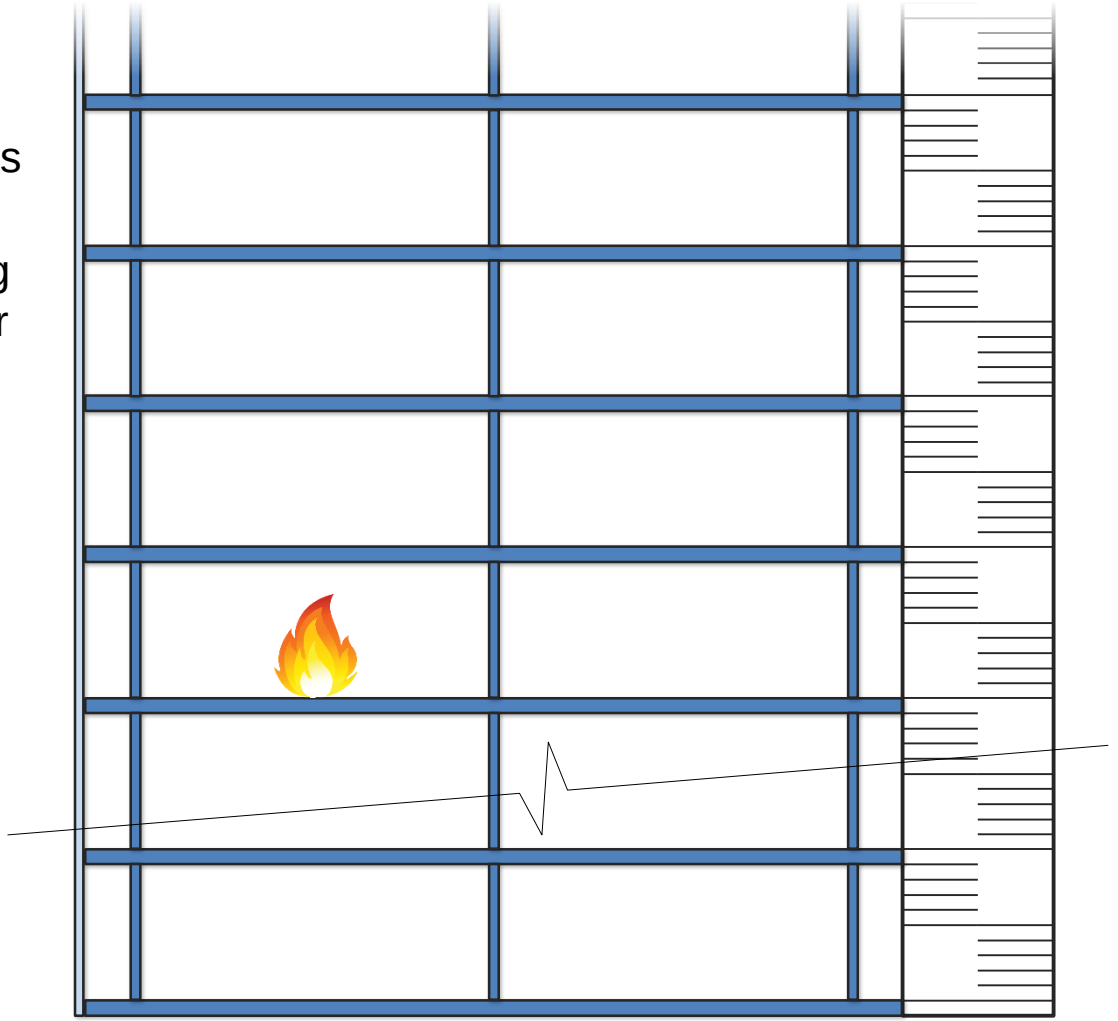
Impact of multi-level fires – suppression



Trenton Fire

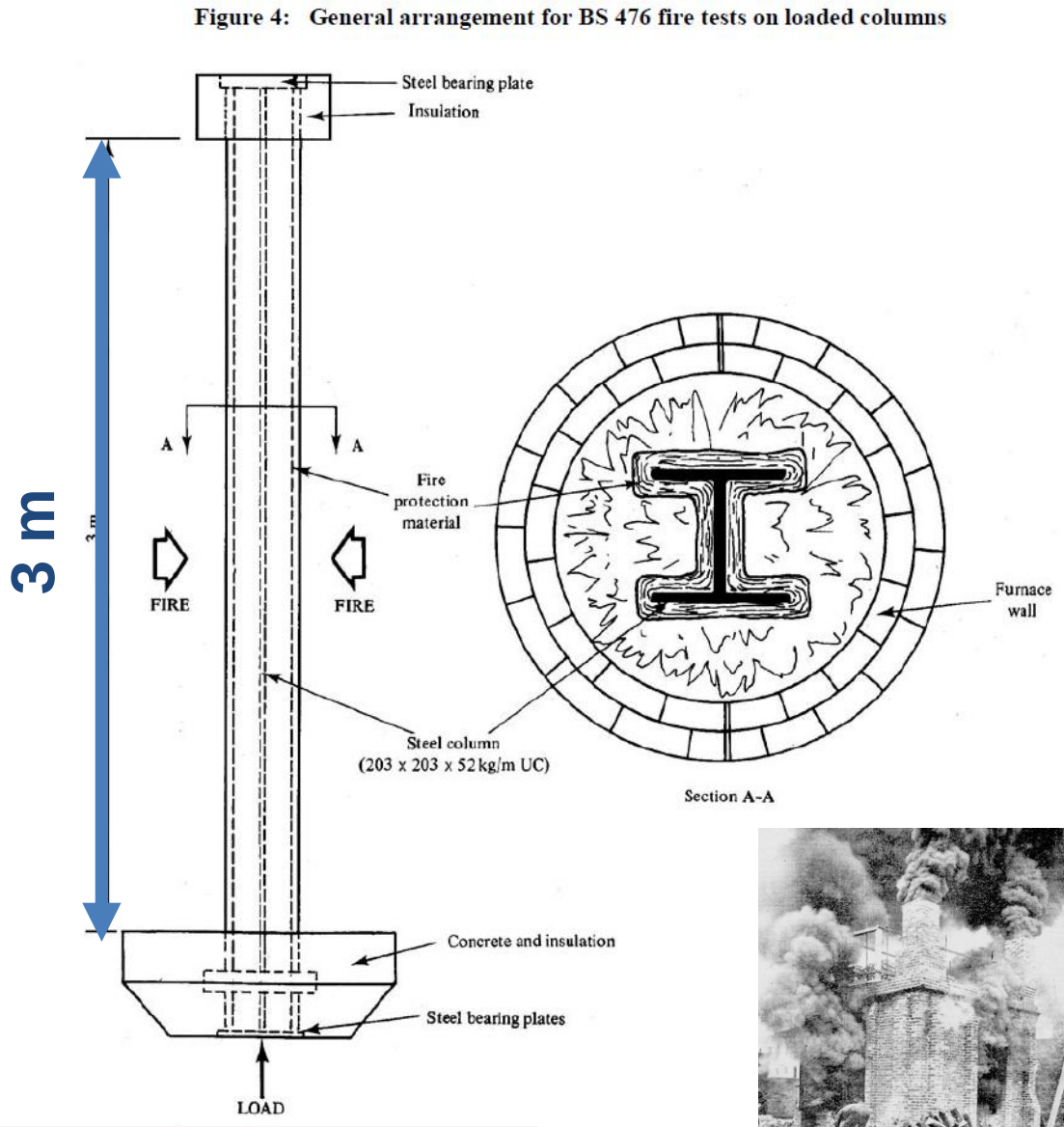
Impact of multi-level fires – structure

- Fire resistance design
  - e.g. beams, columns, slabs, load-bearing walls
  - Performance benchmarked by testing isolated elements under standard furnace tests



Impact of multi-level fires – structure

- Fire resistance furnace test for columns
- Single, isolated, short-span (and non-combustible…) element

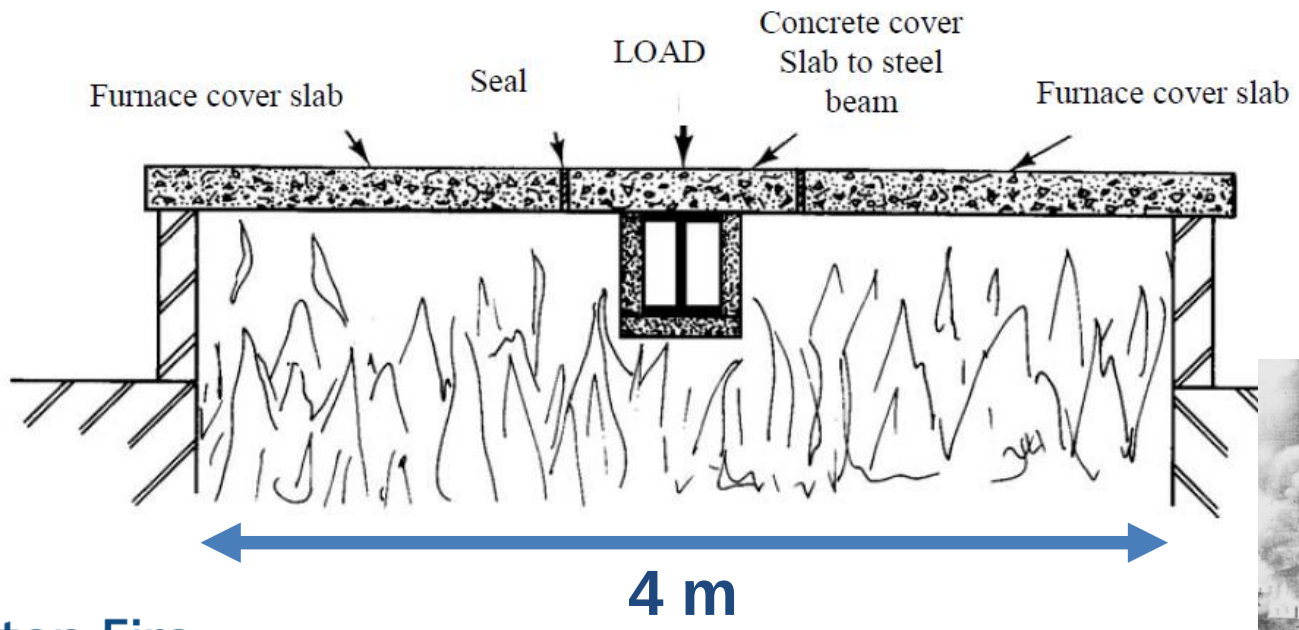


Trenton Fire

Impact of multi-level fires – structure

- Fire resistance test for beams
- Single, isolated, short-span (and non-combustible…) element

Figure 3: General arrangement for BS 476 fire tests on beams



Trenton Fire

Impact of multi-level fires – structure

- Fire resistance design
  - e.g. beams, columns, slabs, load-bearing walls
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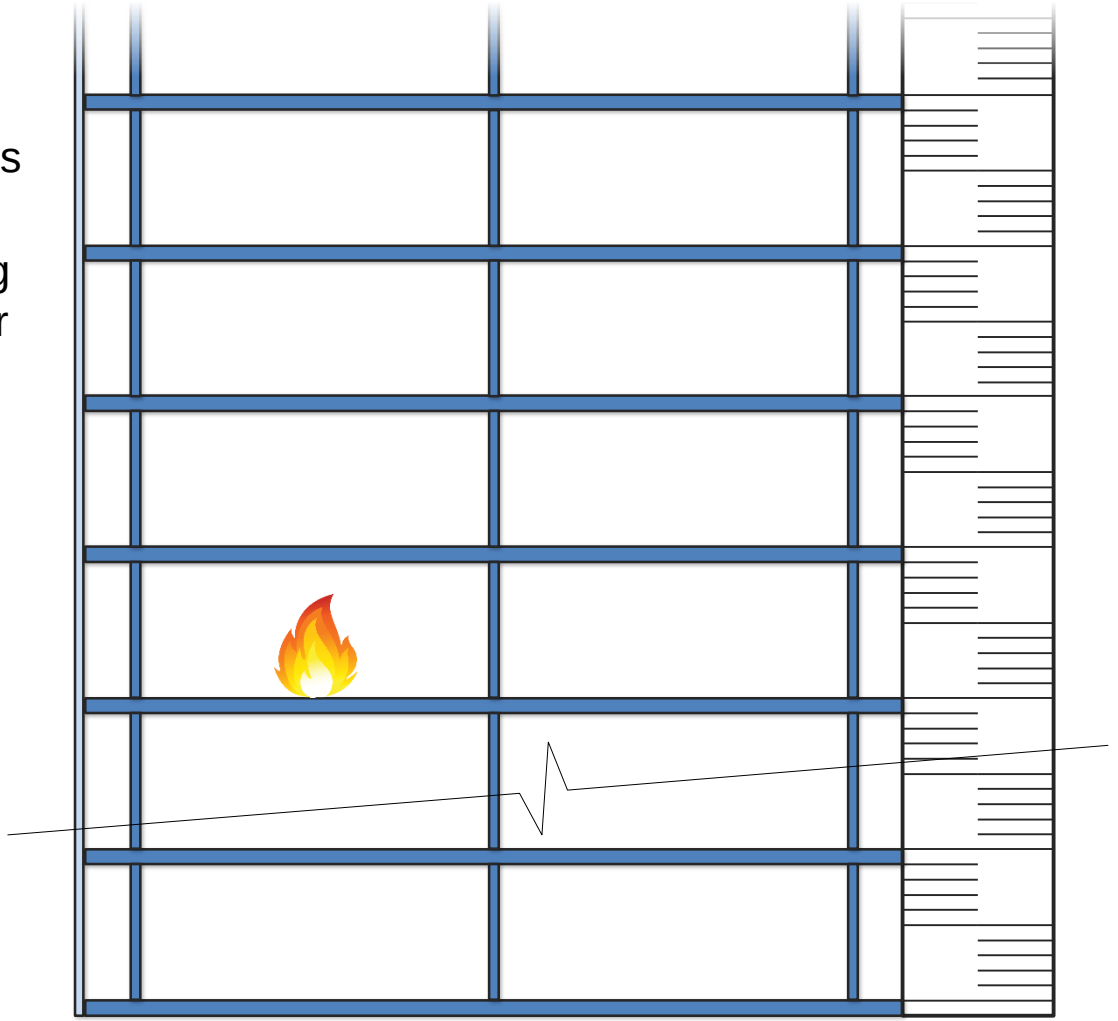

Impact of multi-level fires – structure

- Fire resistance design
  - e.g. beams, columns, slabs, load-bearing walls
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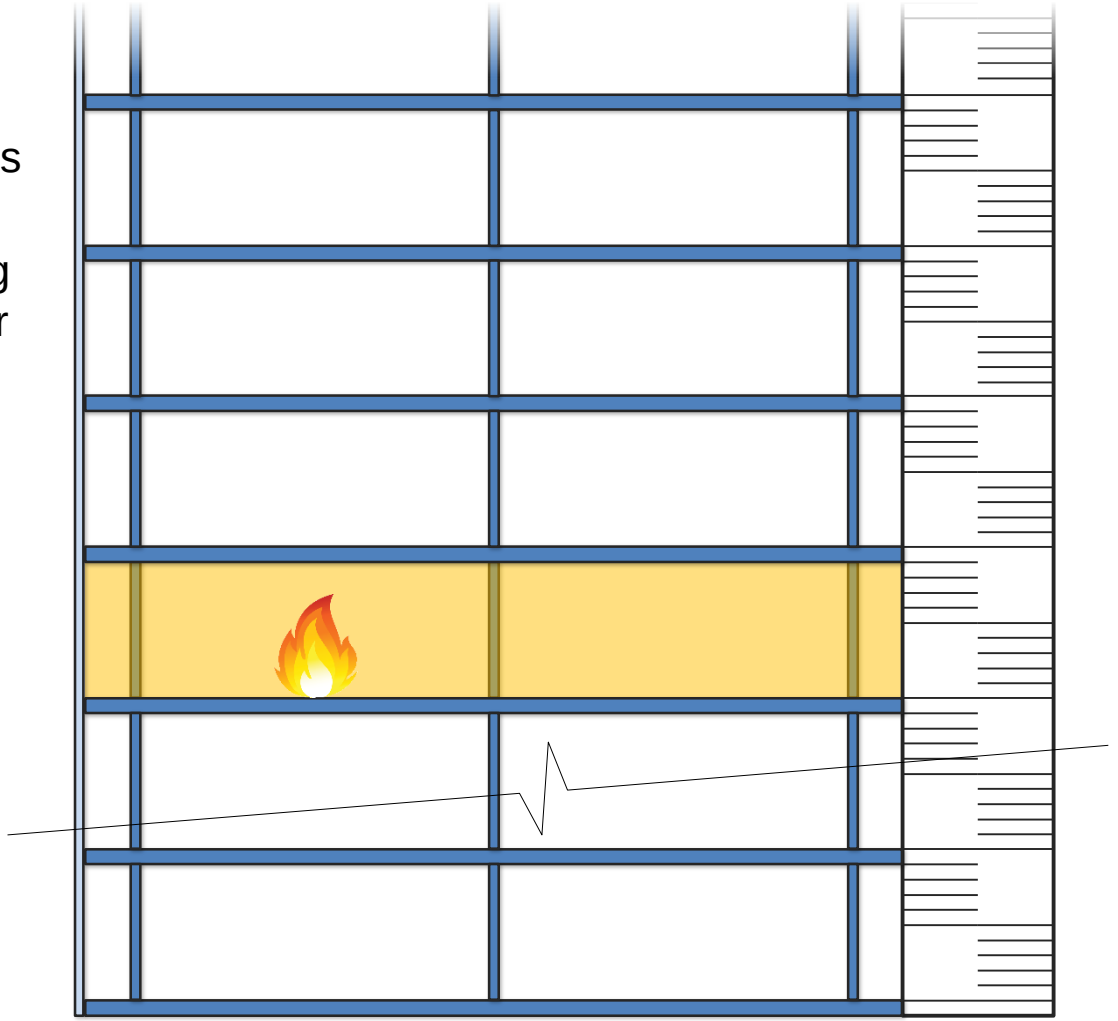

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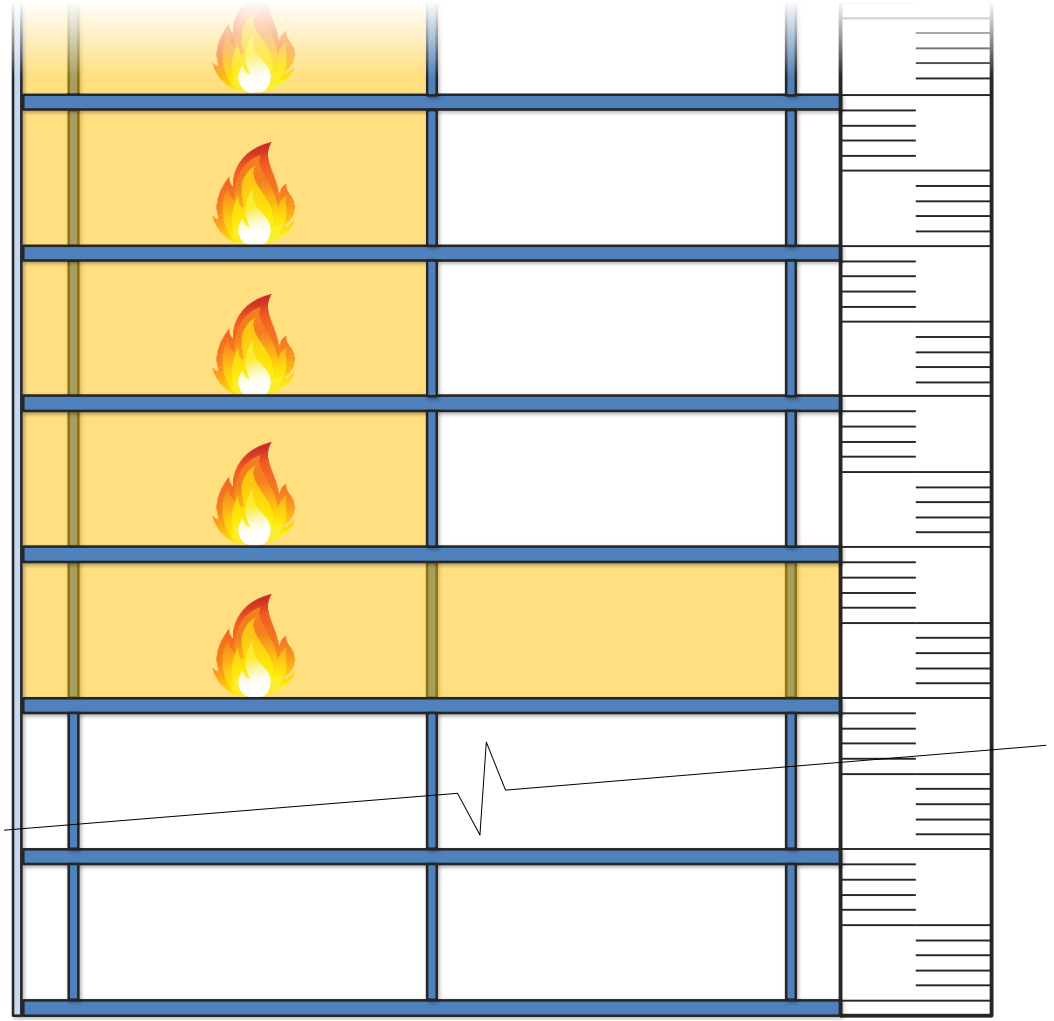
Impact of multi-level fires – structure

- Fire resistance design
  - e.g. beams, columns, slabs, load-bearing walls
  - Performance benchmarked by testing isolated elements under standard furnace tests
- Unforeseen fire effects?
  - Exposure on more sides
  - Pre-heating
- Global (second order) structural effects?
  - More thermal expansion
  - Impact on end restraints
  - Eccentric loads
  - Contraction in cooling



Impact of multi-level fires – structure

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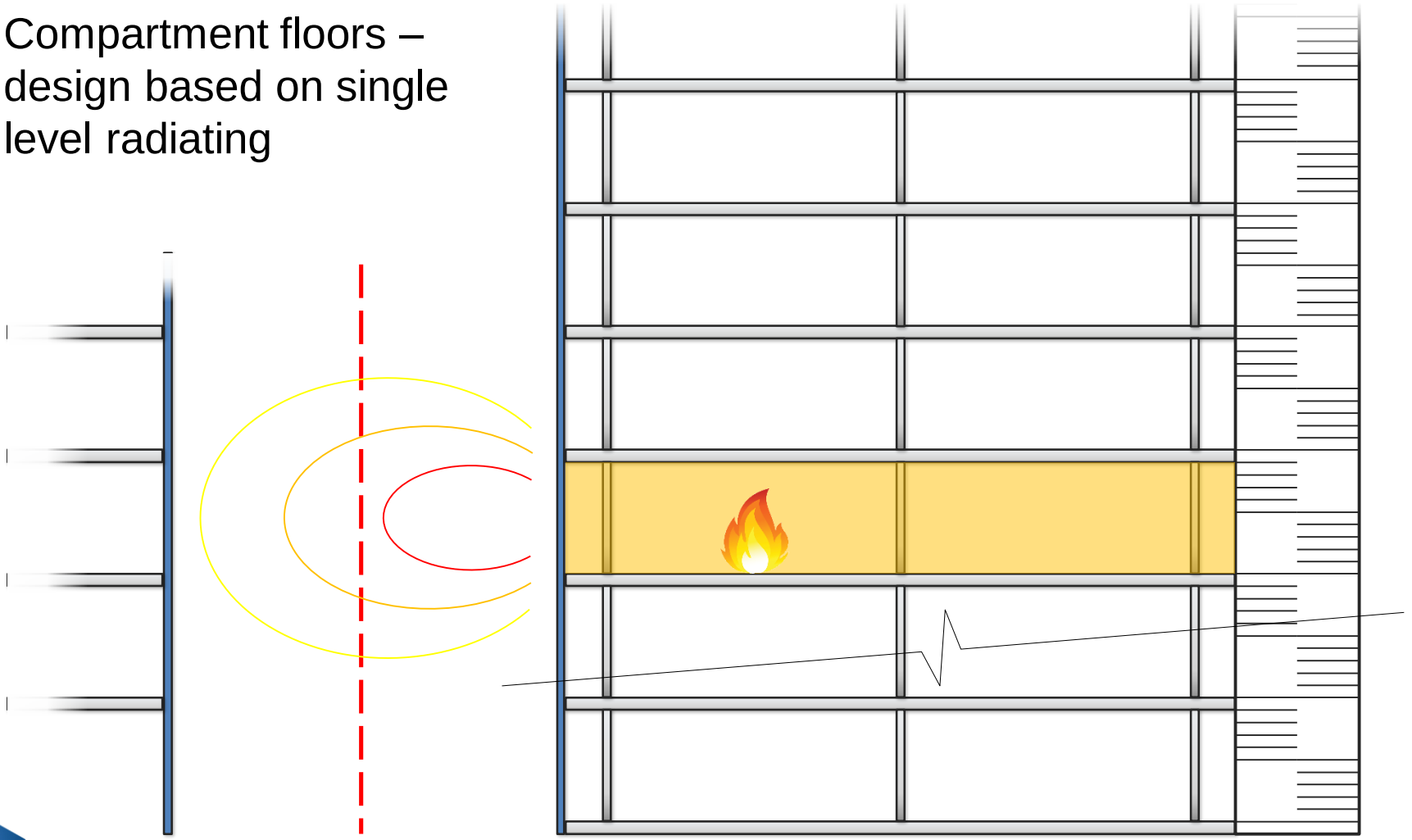
Impact of multi-level fires – external spread

Compartment floors – design based on single level radiating



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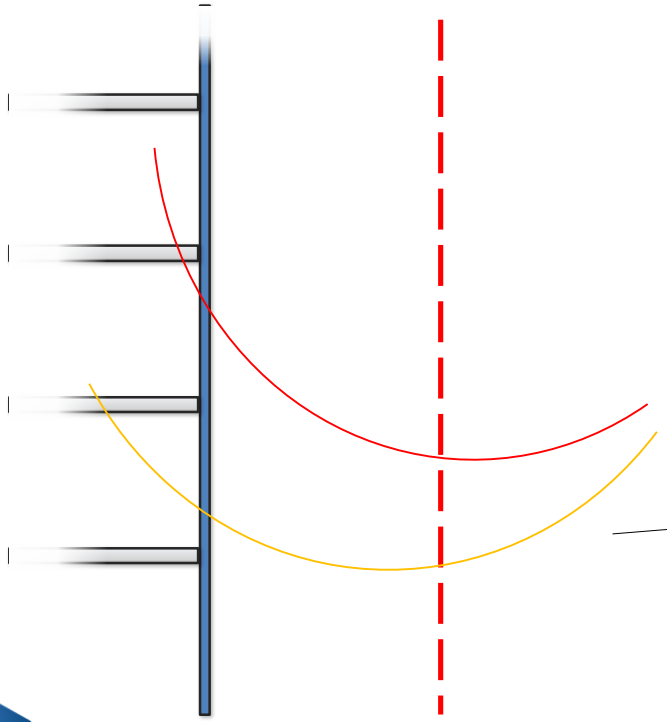
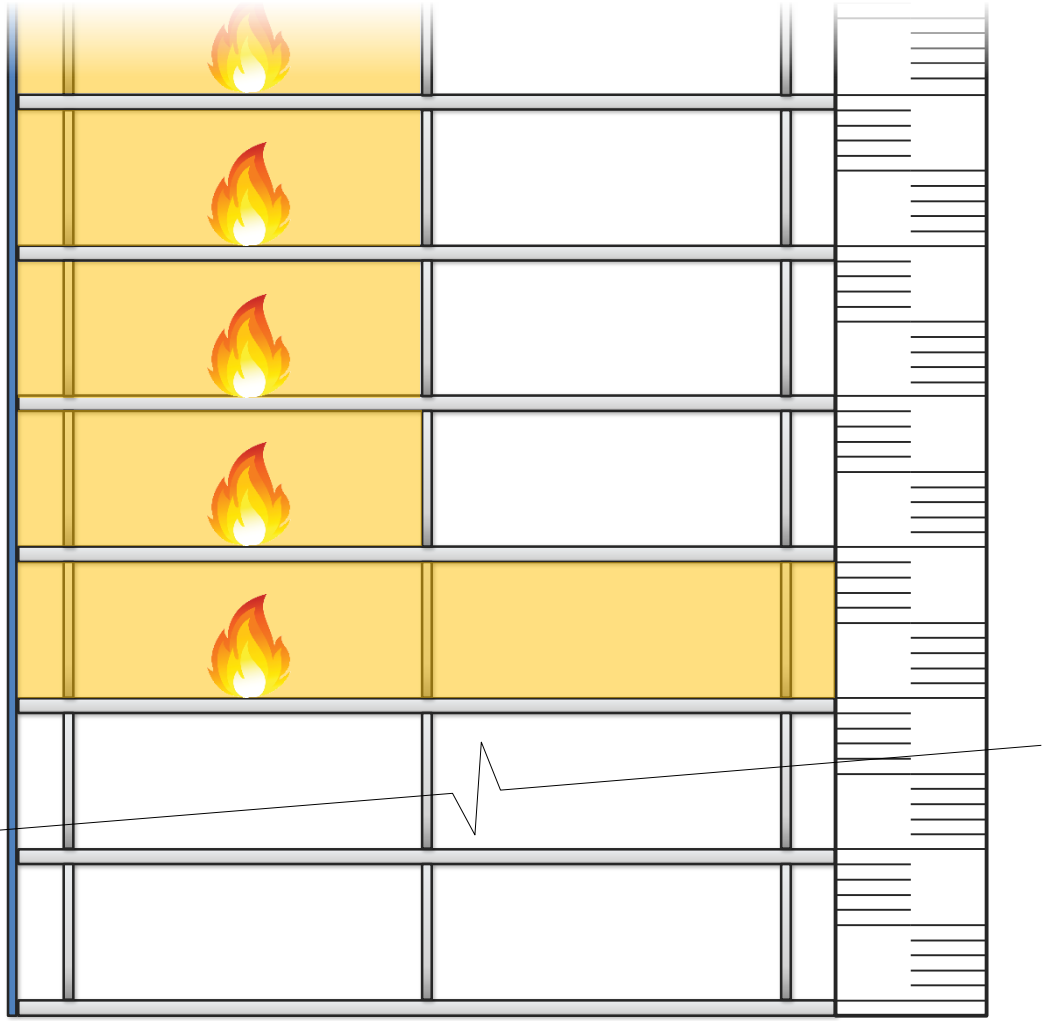
Impact of multi-level fires – external spread

Floor-to-floor compartmentation breached – significantly more radiation observed





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Impact of multi-level fires – external spread

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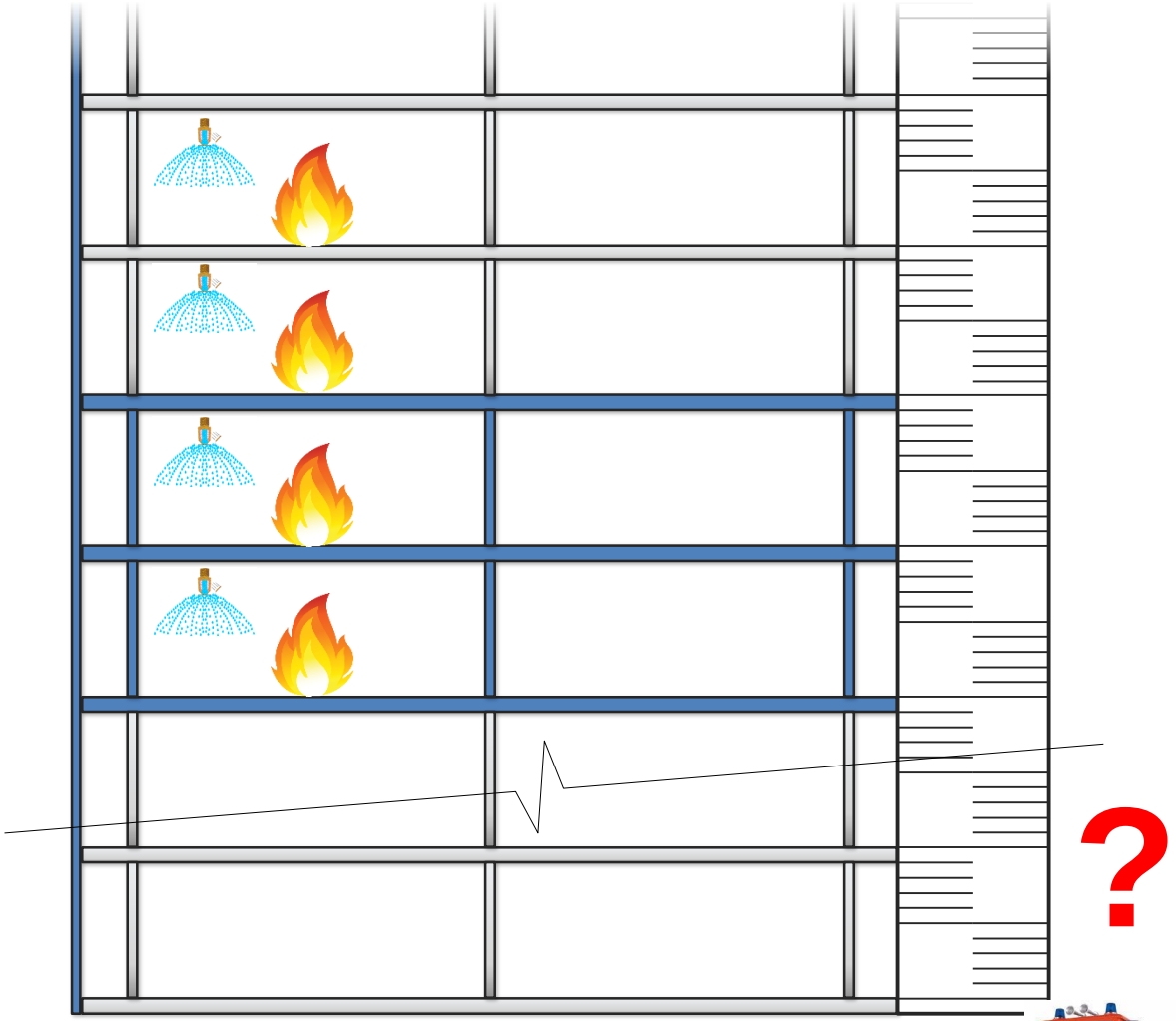
Impact of multi-level fires – fire brigade

- Access and facilities
- Both firefighting and rescue operations
- Some key principles
  - One seat of fire
  - Fire should not readily spread downwards
  - Fire spread upwards should be restricted

Trenton Fire

Impact of multi-level fires – fire brigade

- Access and facilities
- Both firefighting and rescue operations
- Some key principles
  - One seat of fire
  - Fire should not readily spread downwards
  - Fire spread upwards should be restricted
- Multi-level fires
  - Decision-making challenges
  - Operational challenges
  - Interaction with evacuation
  - Safety of firefighters



Impact of multi-level fires – fire brigade

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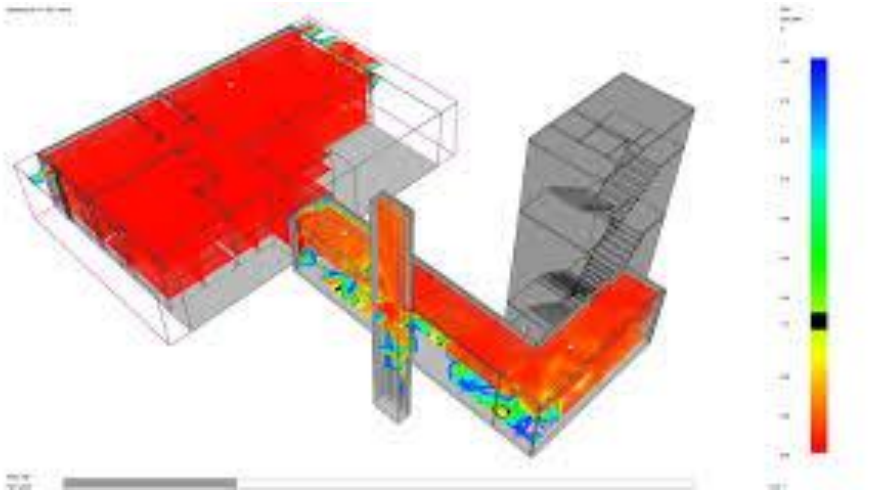
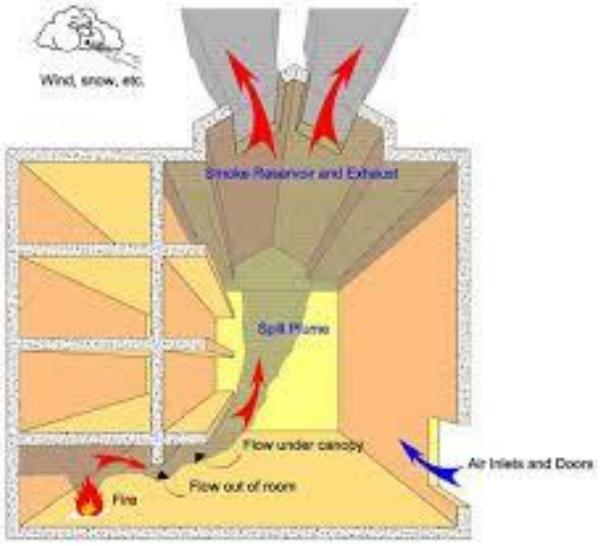
Impact of multi-level fires – others…

- Residential corridor smoke extract systems



- Atrium smoke control systems



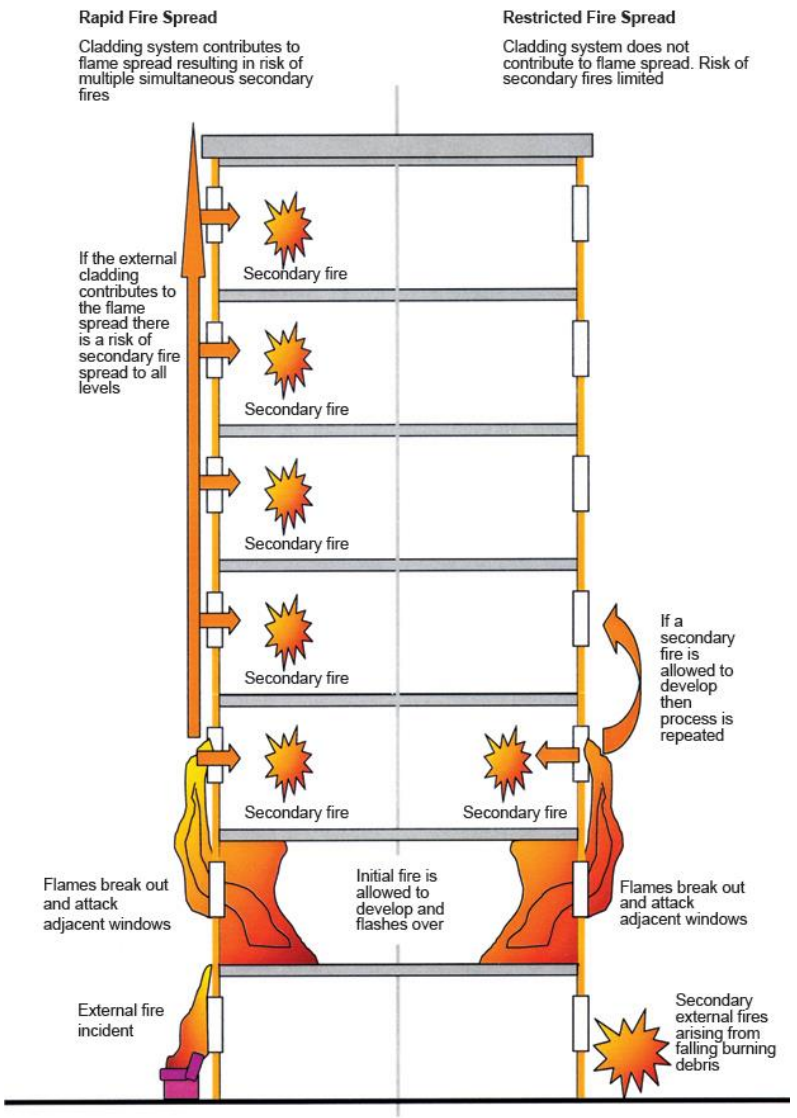
So, what can we say about multi-level fires?

- Not generally considered in design
- Invalidate many aspects of our fire safety strategies
- Consequences can be high
- Exacerbated in tall buildings

But we already know this…

- Fire spread between floors takes time

- We put measures in place to mitigate the rate of spread
  - Compartmentation
  - Fire-stopping
  - Spandrels
  - Cavity barriers
  - Surface spread of flame limits
  - Combustibility limits
  - Overall performance



BR 135 (BRE, 2013)

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However, if we get just one aspect wrong…

- Fire spread between floors takes time

- We put measures in place to mitigate the rate of spread
  - Compartmentation
  - Fire-stopping
  - Spandrels
  - Cavity barriers
  - Surface spread of flame limits
  - **Combustibility limits**
  - Overall performance

multi-level façade fires

a warning sign?

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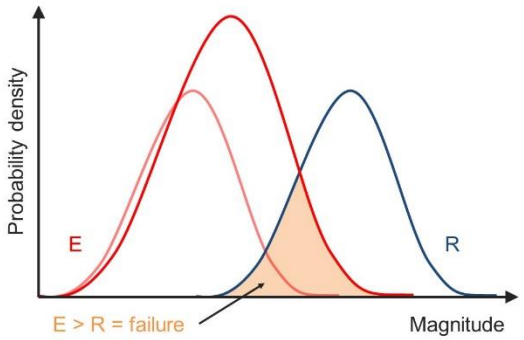
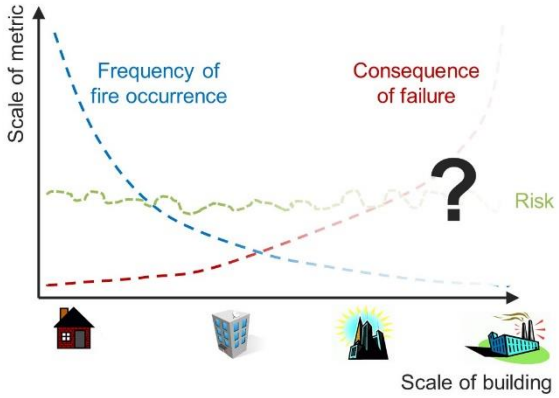
Highlighting a wider issue

- Single failures or oversights can have far-reaching impacts for a fire safety strategy
- Greater uncertainty, greater consequence – what is the risk?
- Can we afford to be reactive?
- What else should we be considering / questioning?





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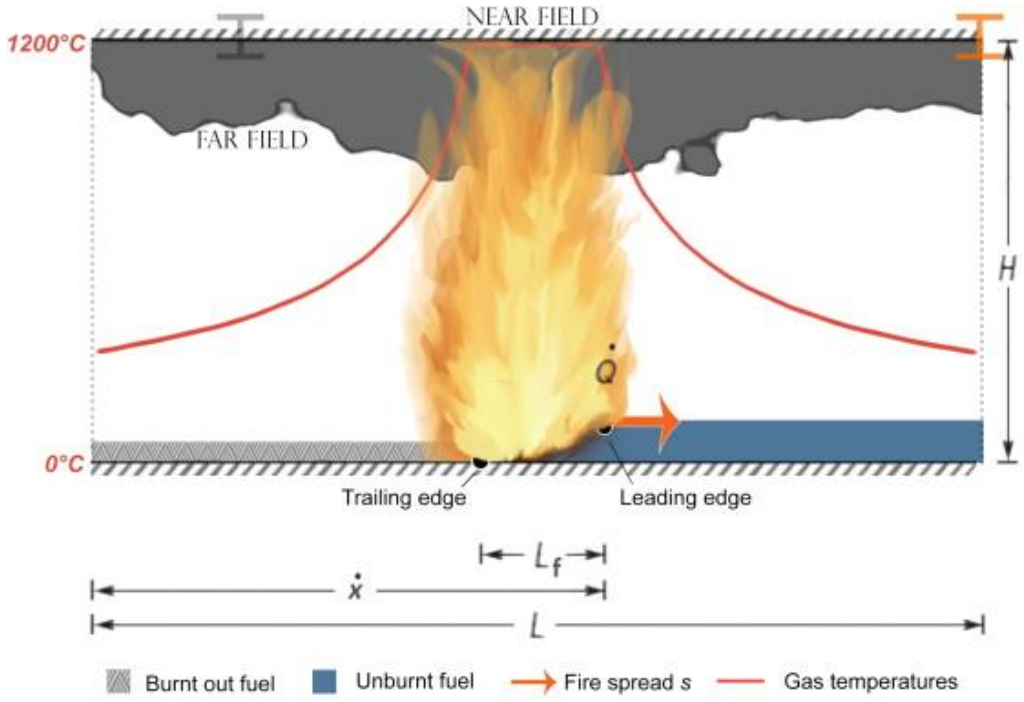
Wind-driven fires

Travelling fires



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Fires in timber frame buildings

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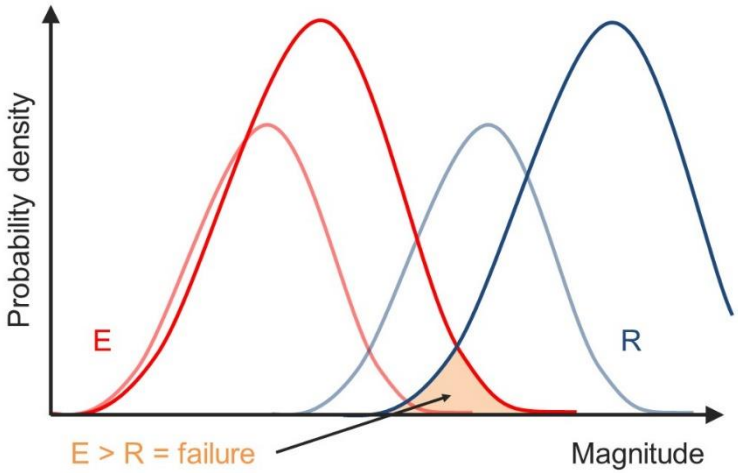
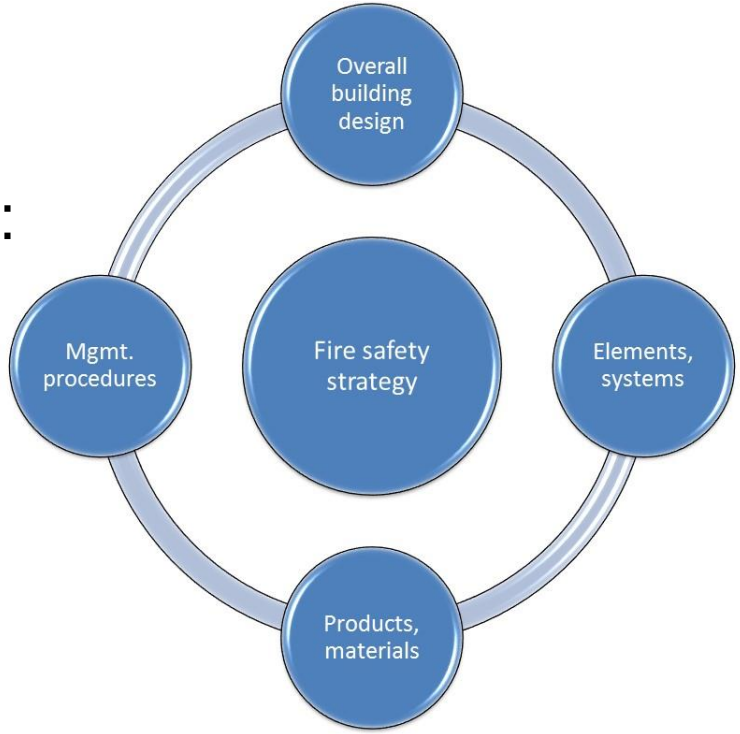
What can we do?

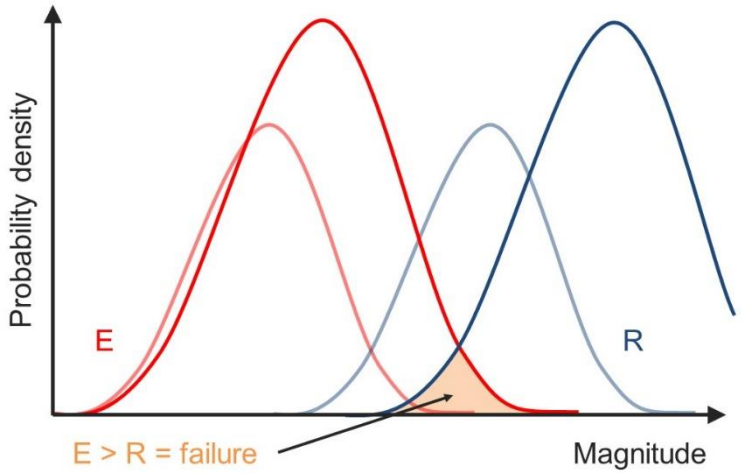
- To ensure risk is:
  - acceptable
  - commensurate with scale
- To ensure strategies are:
  - appropriate for tall buildings
  - followed through in construction
- To ensure suitability / validity of:
  - test fires
  - design fire scenarios
  - design fires – prescriptive
  - design fires – performance-based

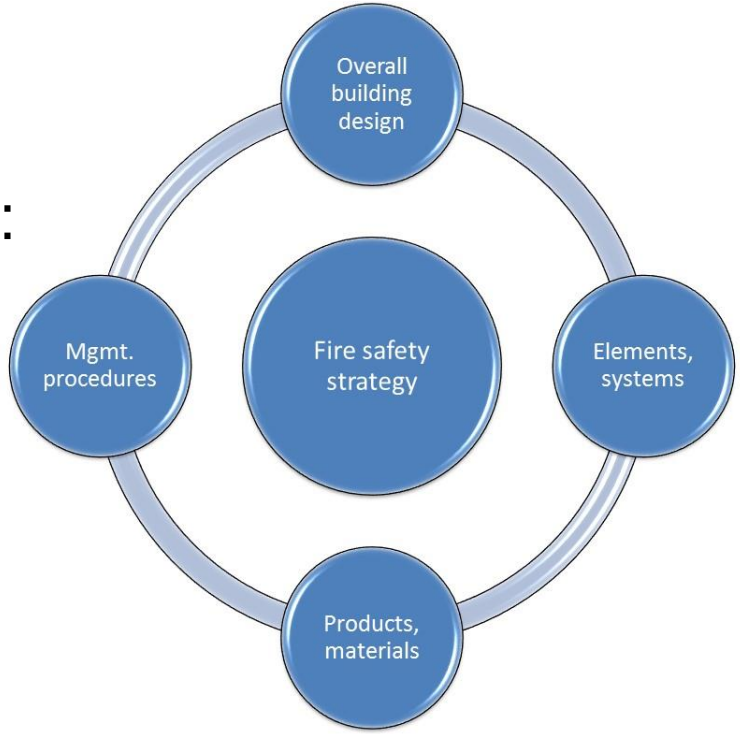




What can we do?

- To ensure risk is:
  - acceptable
  - commensurate with scale
- To ensure strategies are:
  - appropriate for tall buildings
  - followed through in construction
- To ensure suitability / validity of:
  - test fires
  - design fire scenarios
  - design fires – prescriptive
  - design fires – performance-based
- **Be proactive**





conclusions

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~~Conclusions~~ Parting questions

Collectively & individually…

- What are we trying to achieve?
- Are our methods for design, testing and implementation appropriate?
- Are they ready for the buildings of tomorrow?
- Can we be proactive to ensure that they are?

"… the choice of level of detail in any part of an engineering procedure must to some extent be governed by the crudest part of that procedure"

Elms, 1985

“The magic numbers embodied in regulations are accepted without any question whilst any engineering solution is subjected to a disproportionately high standard of proof.”

M. Law, 1994

Thank you

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