BRE: Some applications of UK fire statistics

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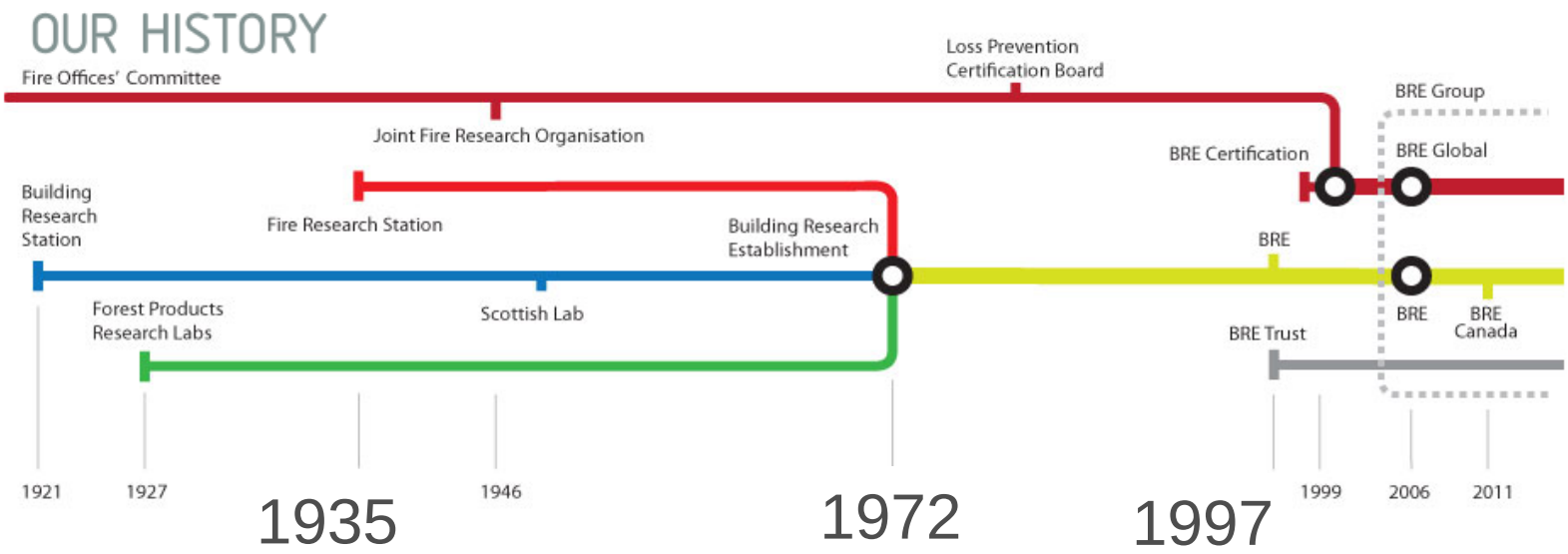
FRSUG, London, 13th November 2015

Part of the BRE Trust



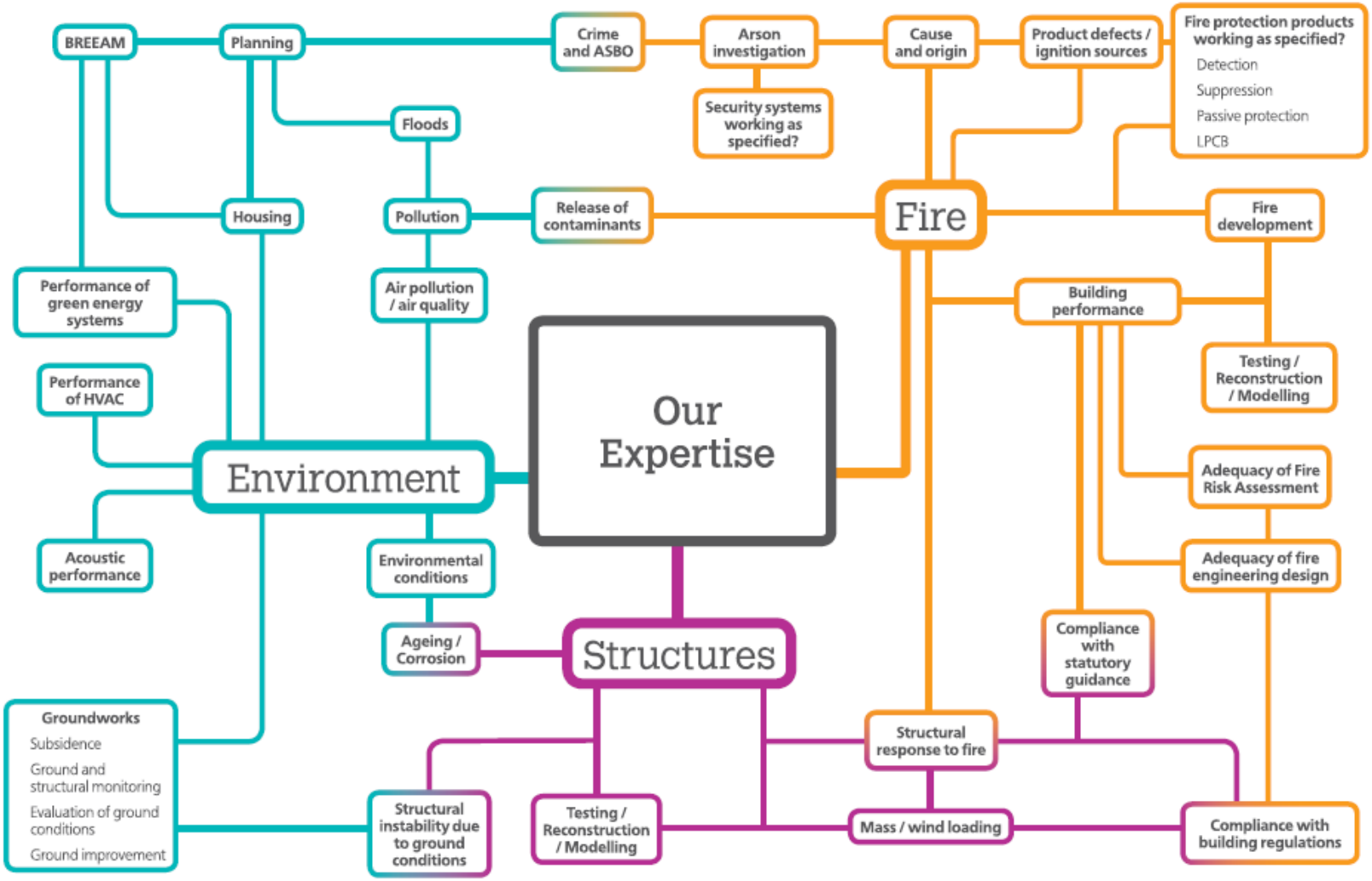
Fire safety group history:

The Fire Research Station was formed in 1935 by various interested parties

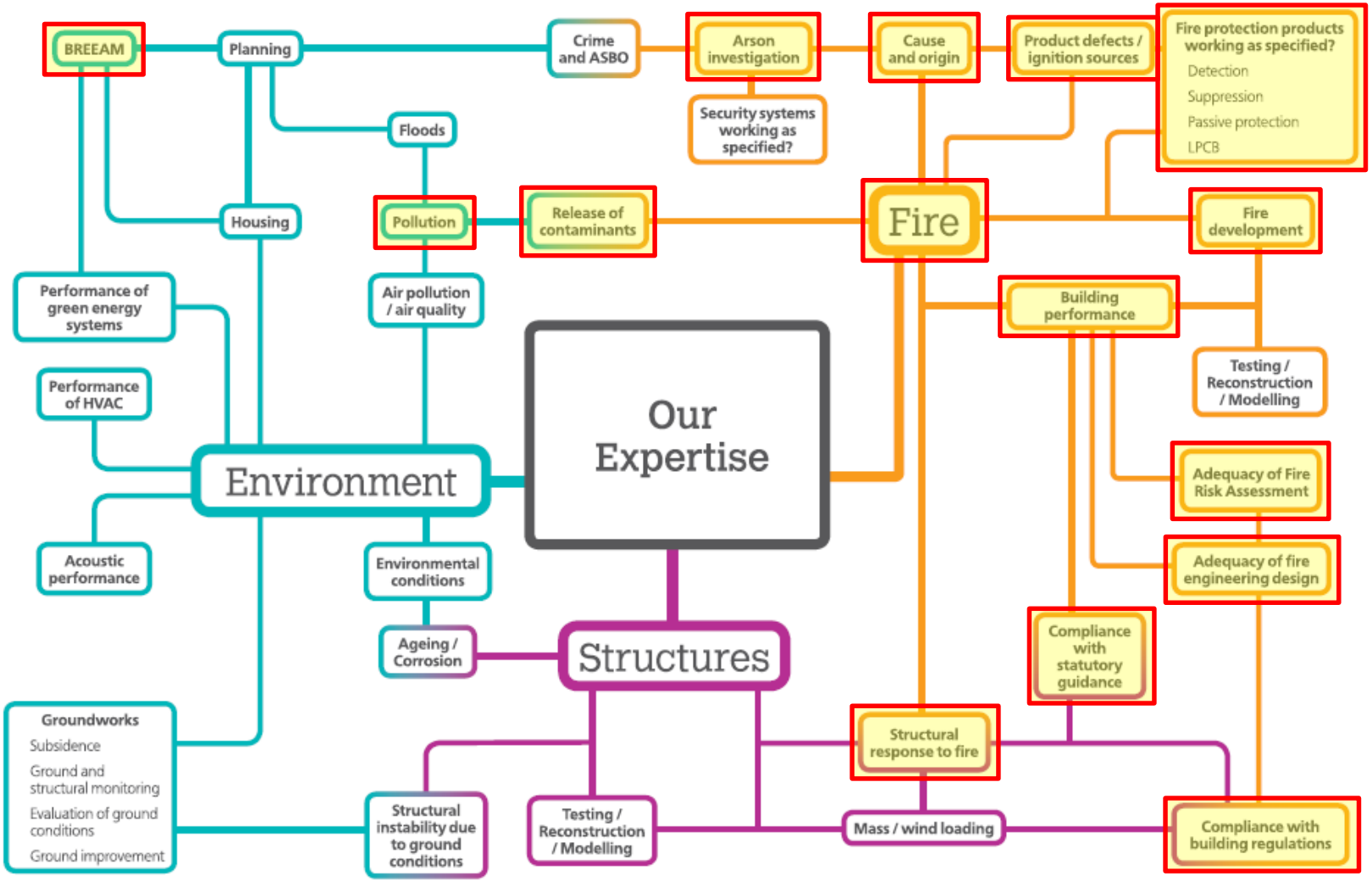
Amalgamated into the Building Research Establishment

BRE privatised in 1997 - owned by BRE Trust to retain the authority and independence

BRE areas of practice



BRE areas of practice – uses for Fire Statistics



Some applications of fire statistics

- Three examples
- Chosen for interesting features which could impact on other studies

1. **Fires in warehouses:** combining data from different sources
2. **Compartment size:** effect on fire size & life safety
3. **Fires in vehicles:** fire frequency and fire size

Example 1: fires in warehouses

Cost-effectiveness of sprinklers in warehouses

- Study whether it is cost effective to install and maintain sprinklers in warehouses.
- "Full cost of fire" :
  - life safety (deaths and injuries),
  - property loss (building and contents),
  - economic (business and wider economy),
  - social (impacts on individuals and local communities), and
  - environmental (CO_2 emissions, water used in fire fighting, production of building waste and resources in the rebuild).

- Full report downloadable from:

http://www.business-sprinkler-alliance.org/category/reports/

Correlating incidents in FPA and IRS databases

- FPA database only includes fires where loss > £100k

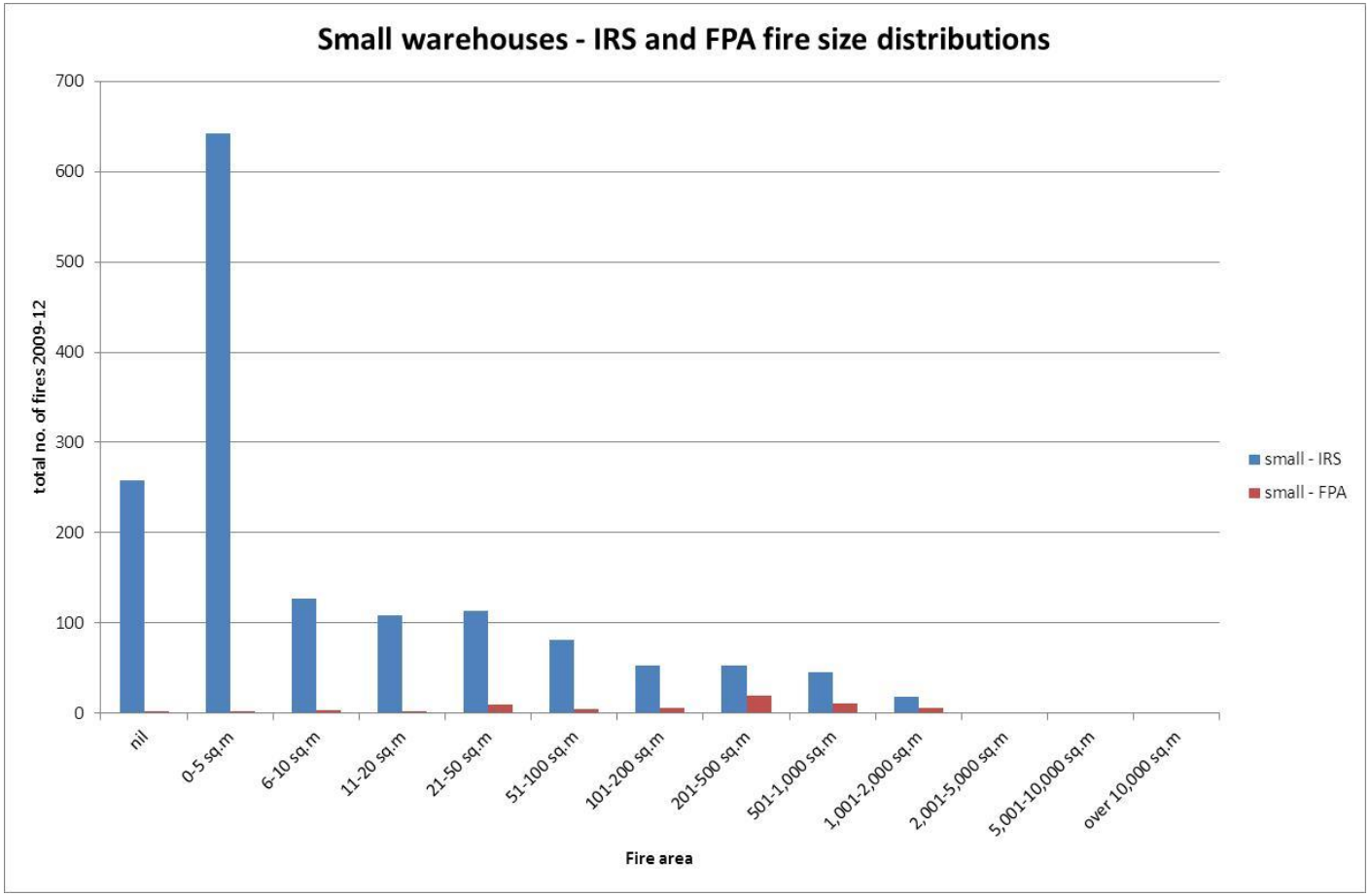
- FPA database had 151 records for warehouse fire losses 2009-12
- IRS database had over 8,000 records of warehouse, industrial and retail fires during the same period (mainly industrial)

- The following criteria were used to correlate the actual fire events:
  - Same date of origin (taken as an essential requirement for a match)
  - Similar time of origin
  - Same or similar postcode
  - Consistent damage areas

- It was possible to link 85 of the FPA records (85/151 = 56%) with fires in the IRS data 2009-12

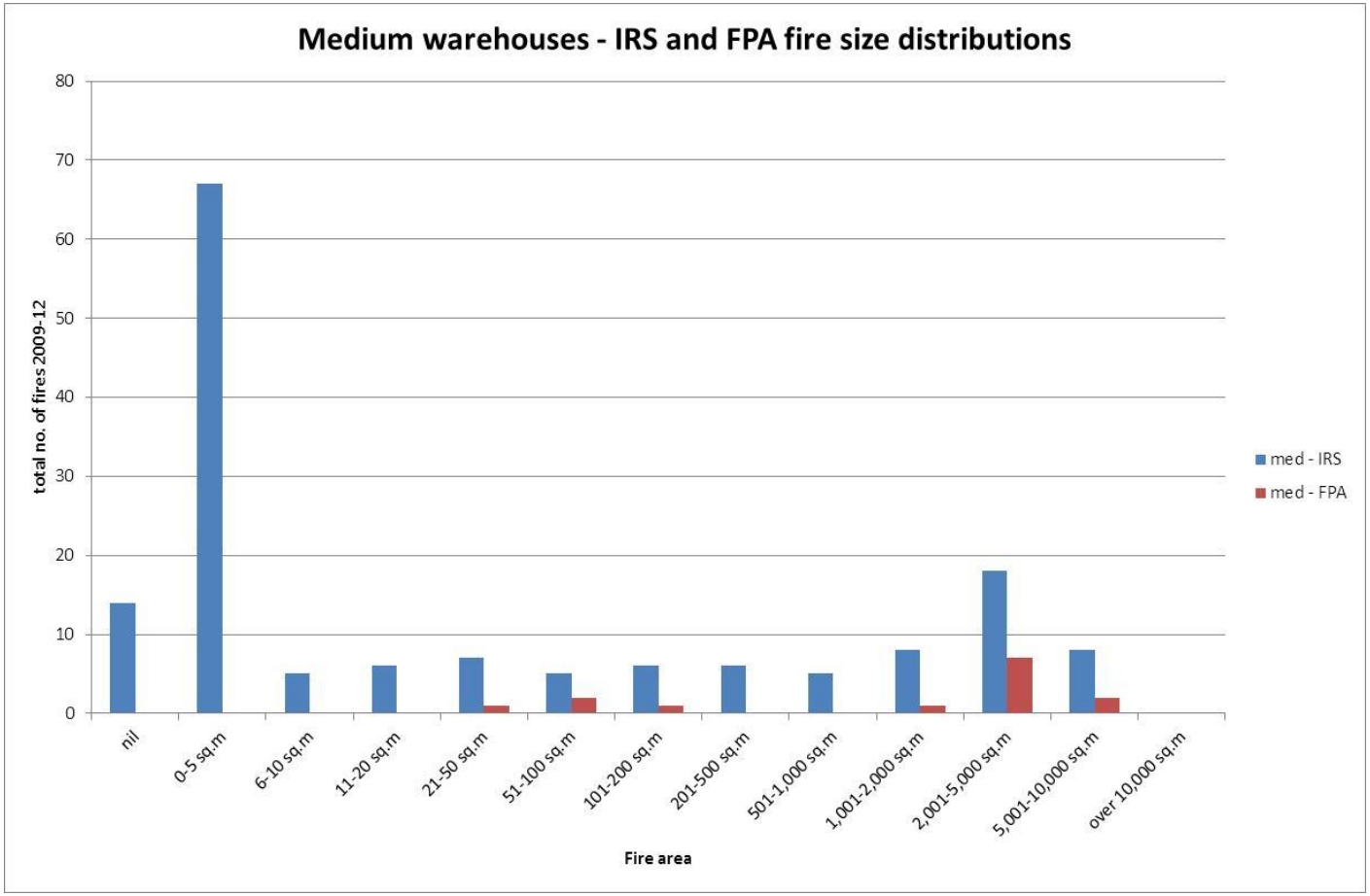
Small warehouses – IRS & FPA data

Comparison of the distributions of fire sizes captured in (a) the IRS database (b) the subset of matched fires from the FPA database



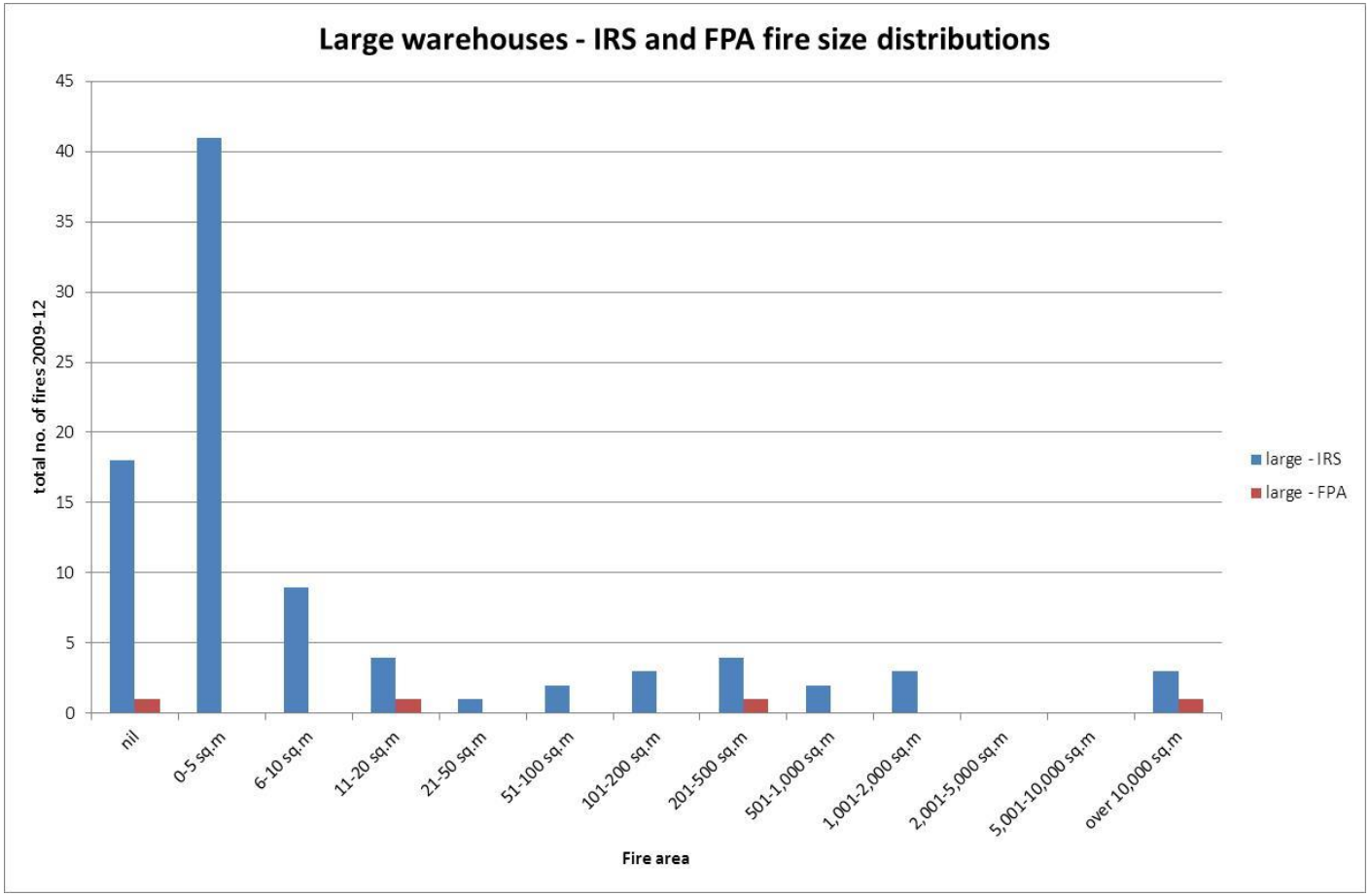
Medium warehouses – IRS & FPA data

Comparison of the distributions of fire sizes captured in (a) the IRS database (b) the subset of matched fires from the FPA database



Large warehouses – IRS & FPA data

Comparison of the distributions of fire sizes captured in (a) the IRS database (b) the subset of matched fires from the FPA database



FPA data – issues

Data missing from the FPA dataset.

Losses can be:

- Genuinely less than £100k
- Over £100k in value but a deductible, application of average, etc. results in a loss under £100k - report therefore missed from database
- Over £100k but a deductible, application of average, etc. results in over £100k but deficient by the deductible sum
- Over £100k but not registered
- Over £100k but not insured by a means the FPA database has any capability to collect

Estimation of “lower bound” costs of fire / smoke damage

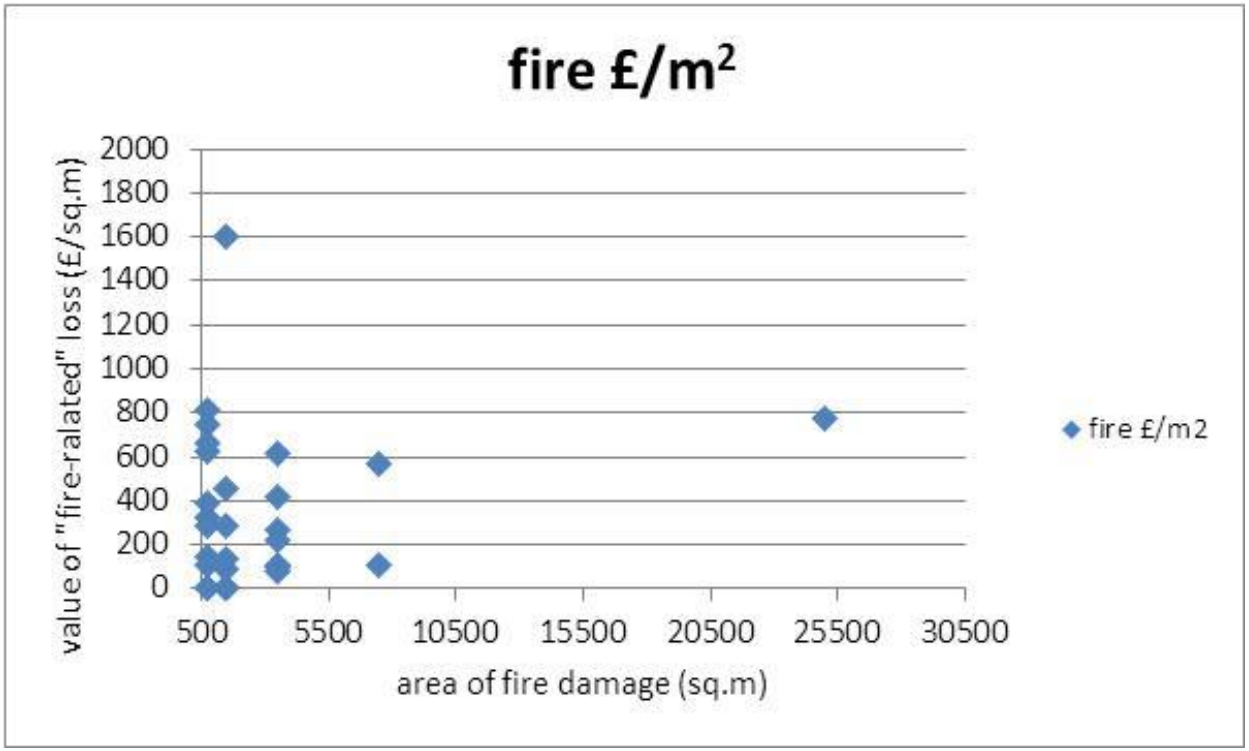
Assumption – linear fit (cost proportional to area)

Lower bound –

1. Match the fires in the FPA database with those in the IRS database as described earlier.
2. For those fires where a match can be found, assign fire damage and smoke (total) damage areas, and calculate the “fire” loss (FPA) divided by the fire area (IRS), and “smoke” loss (FPA) divided by the smoke area (IRS).
3. Calculate the average loss per m^2 from the subset of larger fires (where most of the fires should exceed the threshold value of £100k, thereby minimising bias).

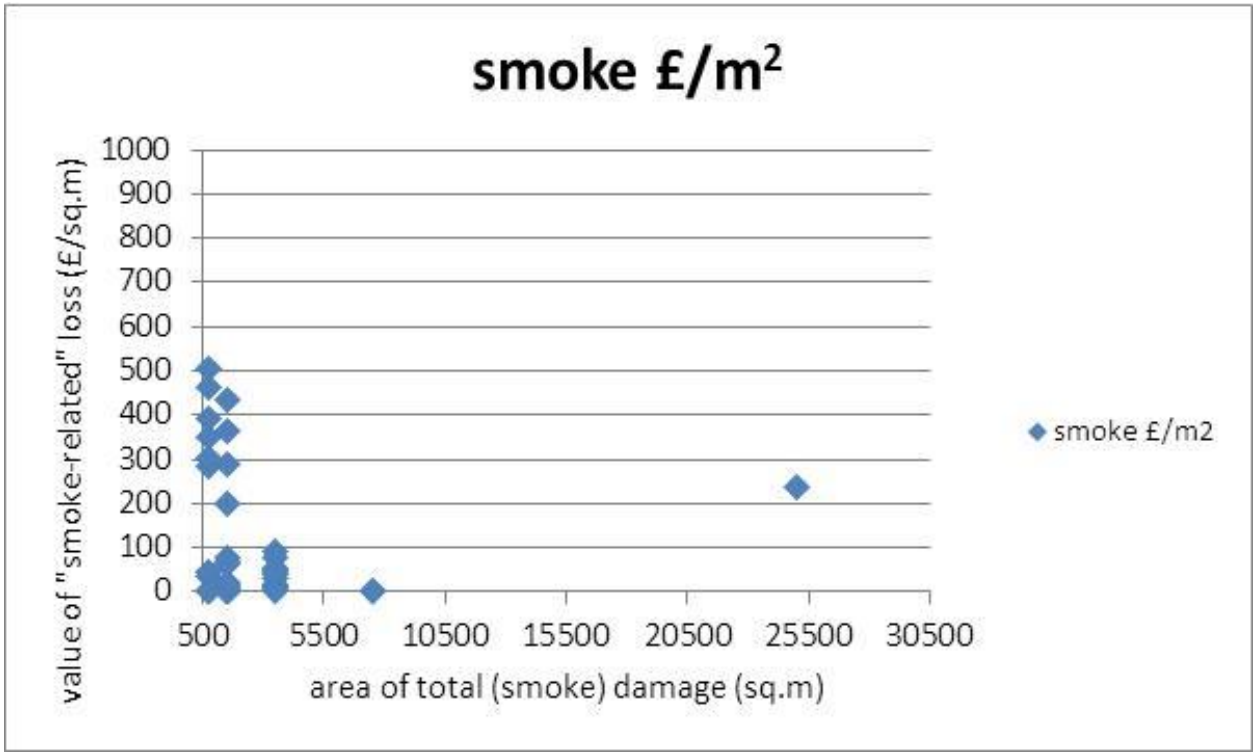
This is a lower estimate because the FPA losses do not include deductibles, under-insurance, etc.

“Fire losses” per sq.m of fire damage – lower bound



Matched fires with A_{fire} > 750 m^2: 29 fires, total area of fire damage 74,750 m^2, “fire” cost £37.8m => £506 / m^2

“Smoke losses” per sq.m of total (i.e. smoke) damage – lower bound



Matched fires with A_{fire} > 750 m^2: 29 fires, total area of smoke damage 83,000 m^2, “smoke” cost £9.6m => £116 / m^2

Upper bound estimate of cost £ / m^2

- Total fire damage = 112,000 m^2 per year (from IRS 2009-12 data)
- Total smoke damage = 252,000 m^2 per year (from IRS 2009-12 data)
- Assume – total “fire-related” and “smoke-related” loss = total insured value (£2,655 per m^2) (value provided by FM)
- From FPA database, ratio of total “fire-related” loss to total “smoke-related” loss is 68% : 32%

Hence:

- Value of “fire-related” loss is £2,250 / m^2
- Value of “smoke-related” loss is £405 / m^2

Example 1: Conclusions from the fire statistics

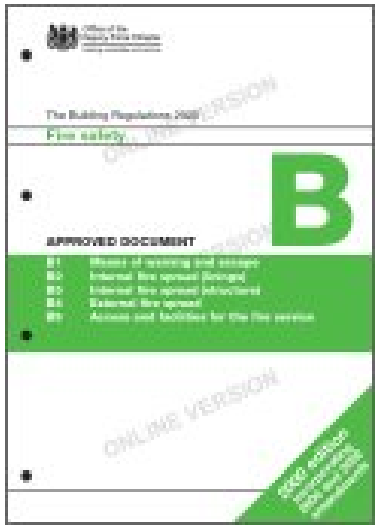
	Lower bound:	Upper bound:
• Fire-related costs	£506 / m^2	£2,250 / m^2
• Smoke-related costs	£116 / m^2	£405 / m^2

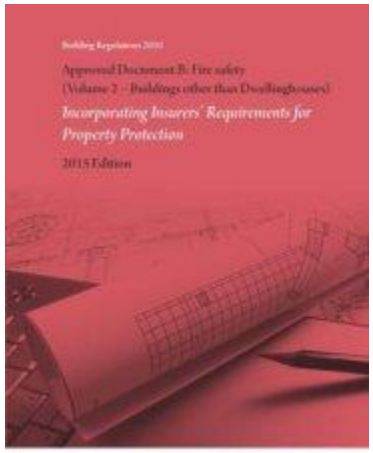
- Direct fire losses account for ~ 90% of all losses

- Sprinklers cost-effective in warehouses above 2,000 m^2 floor area

Example 2: compartment sizes

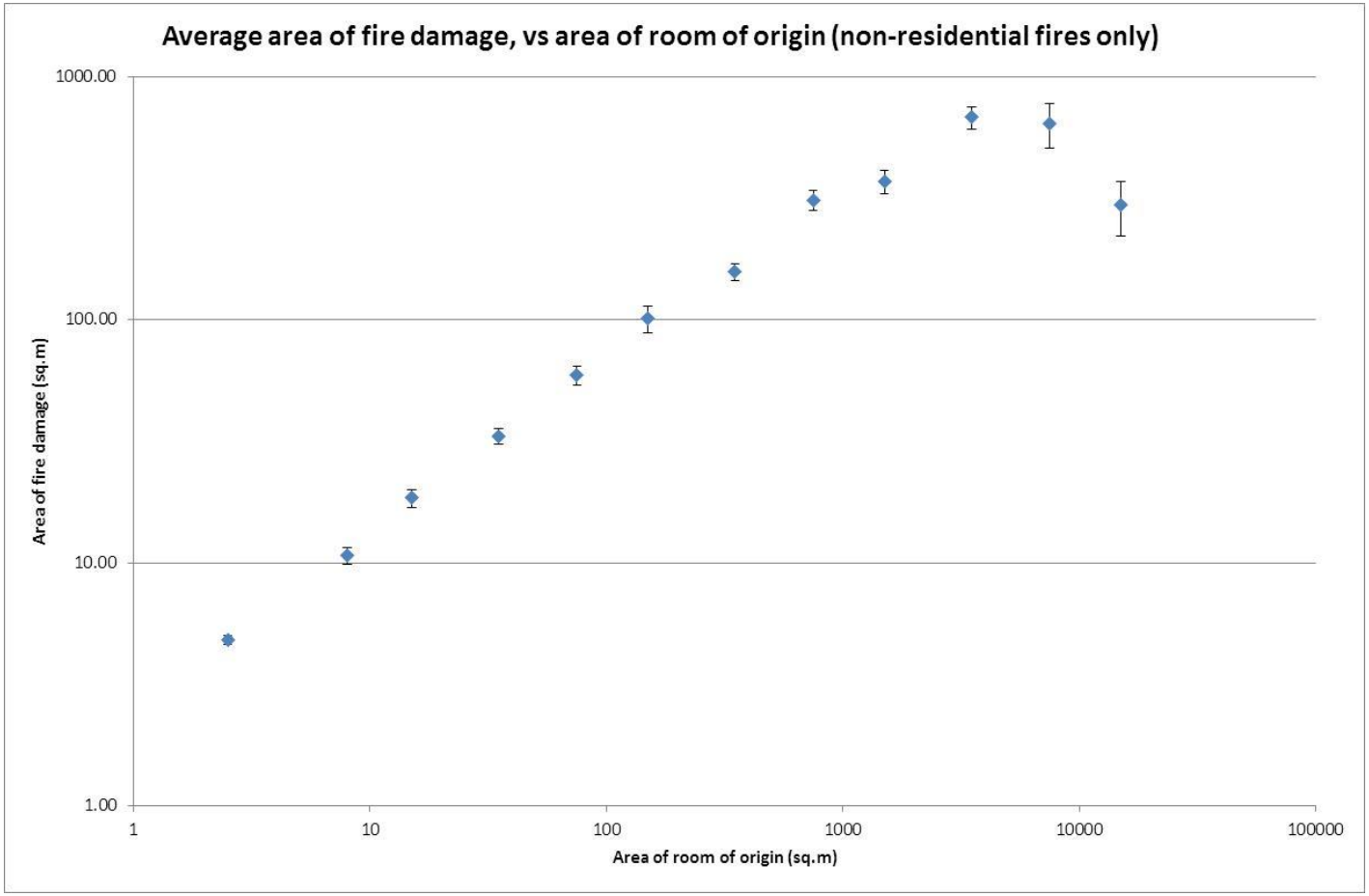
- Guidance to the building regulations (Approved Document B, Fire safety, B3 Table 12) provides limitations on the maximum size of compartments
- For single-storey buildings there is no limit on the maximum size of compartment in the industrial category. Note this category would include large single -storey portal frames with a height to the eaves up to 18m.
- Requirements from the insurance industry restrict the maximum floor area in industrial buildings to 7000m² in the absence of an approved automatic sprinkler system





RISCAuthority

Effect of compartment size on average fire area



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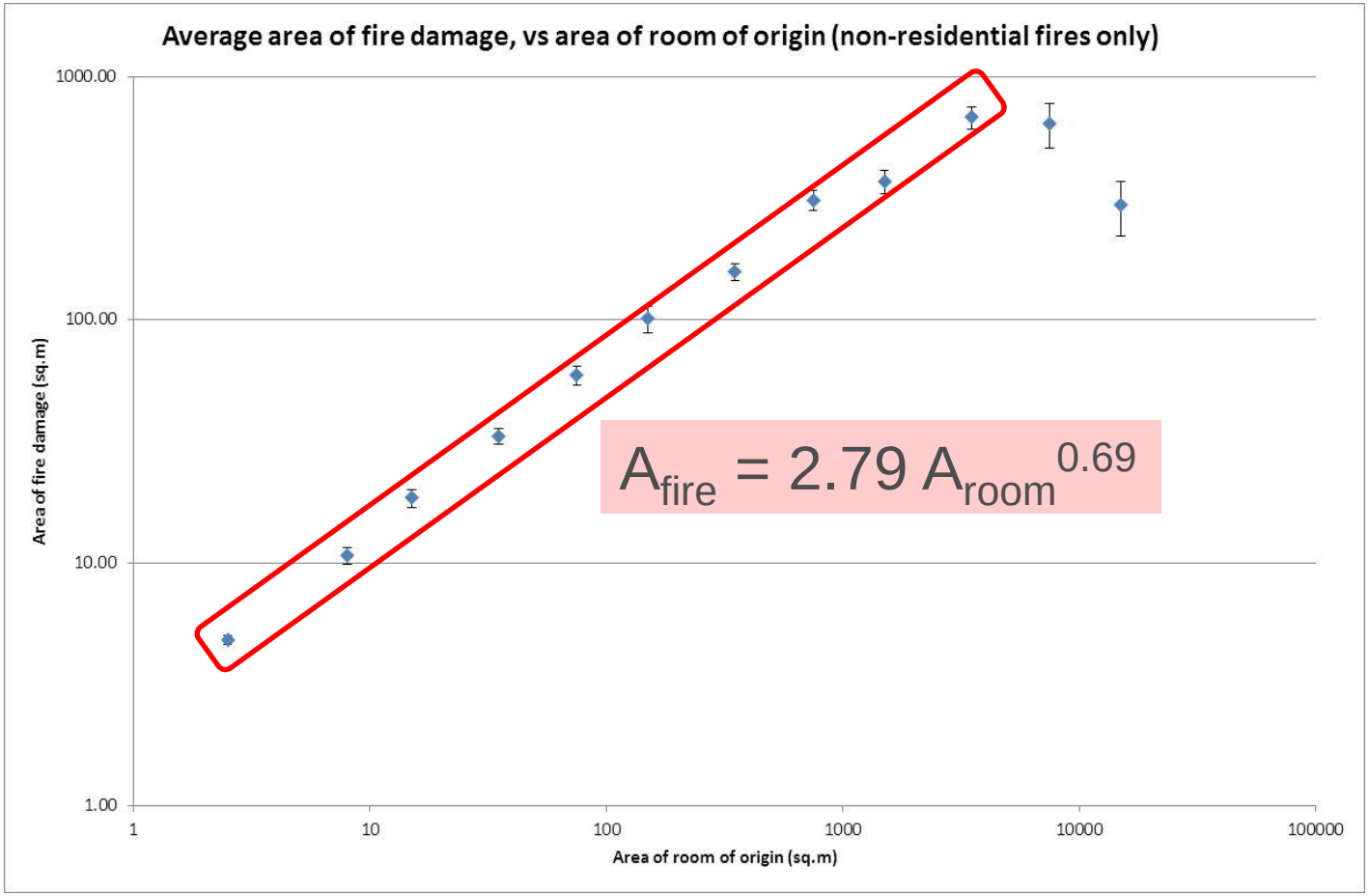
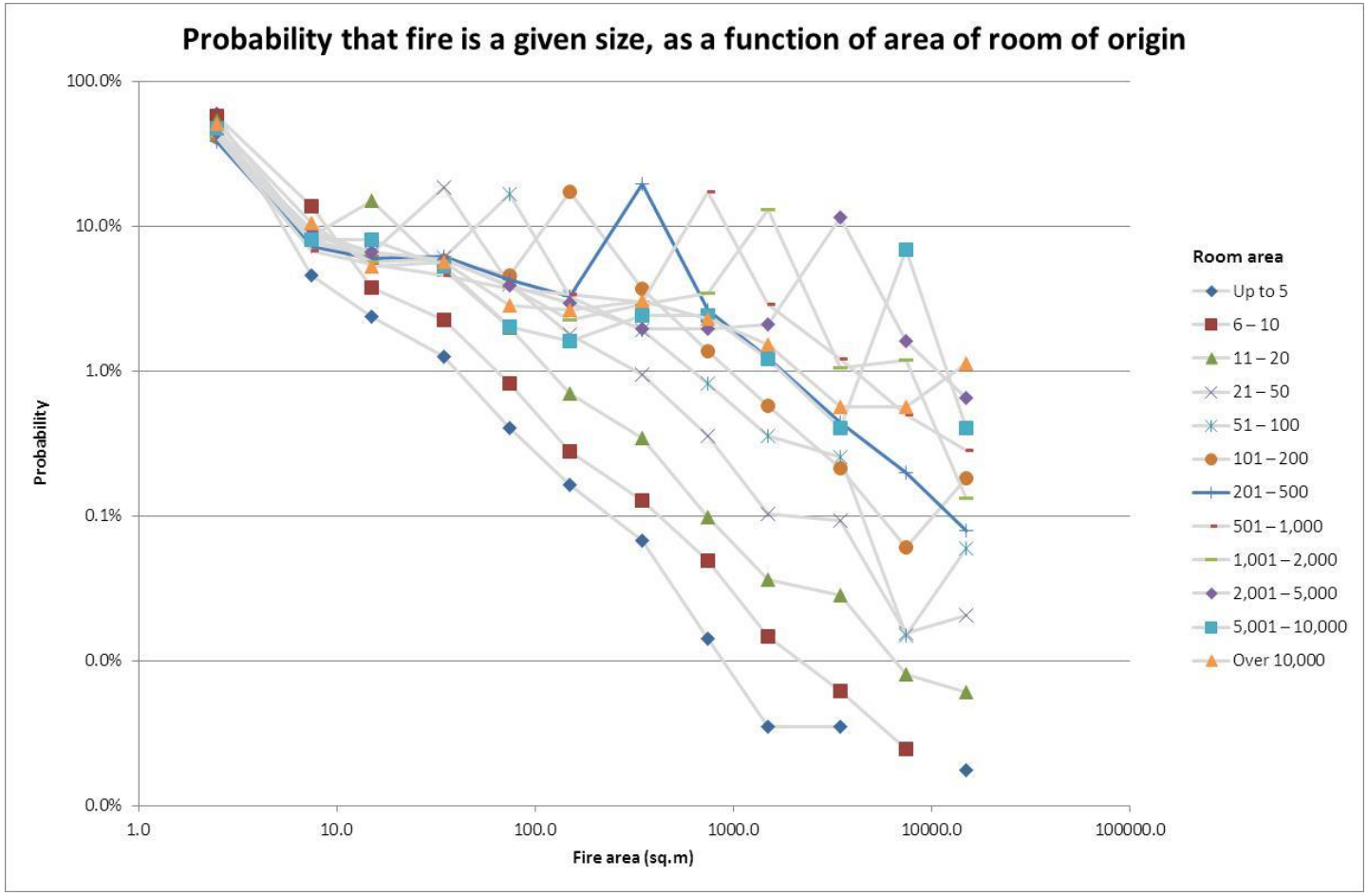


Effect of compartment size on fire area distribution



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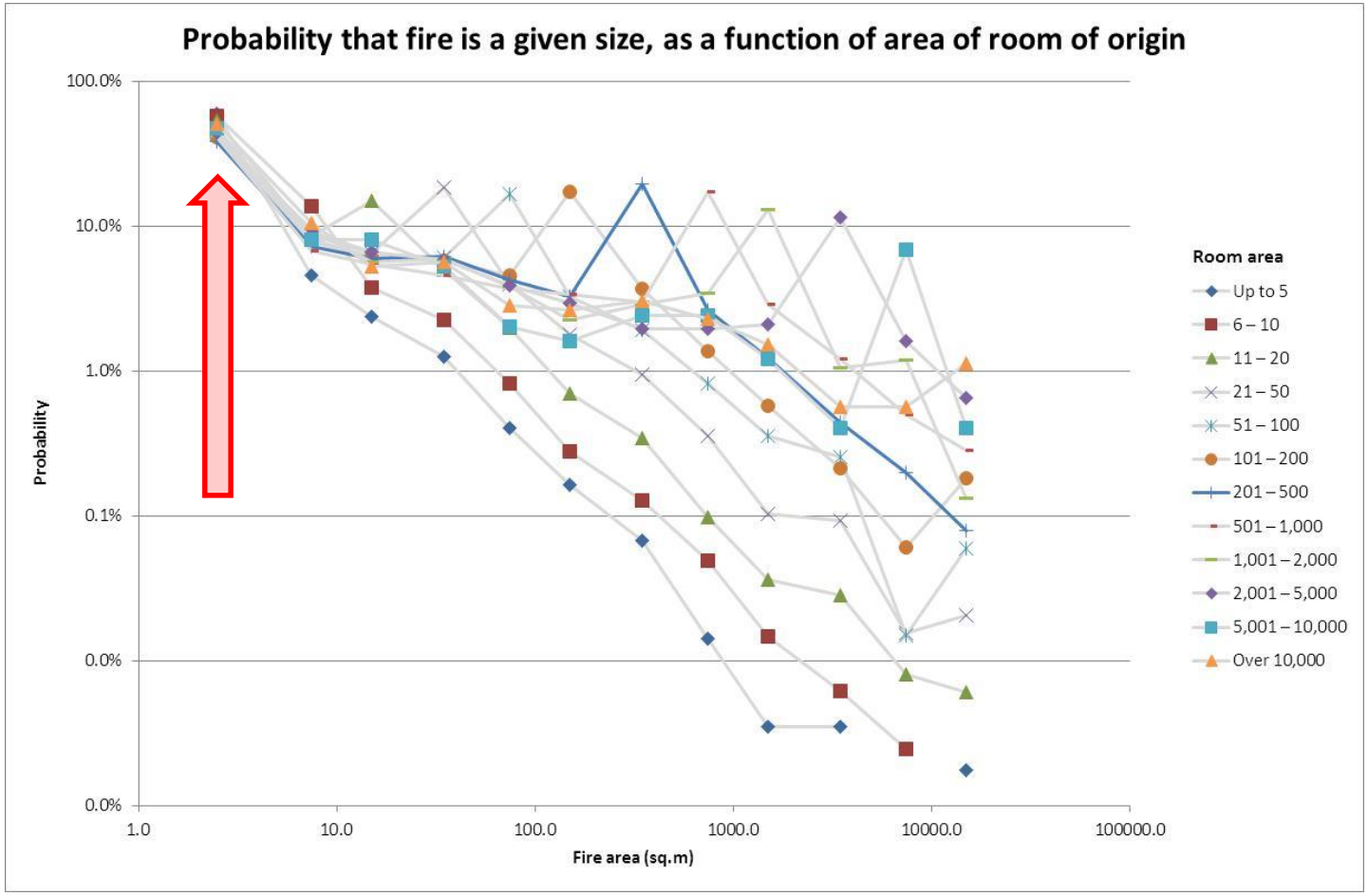

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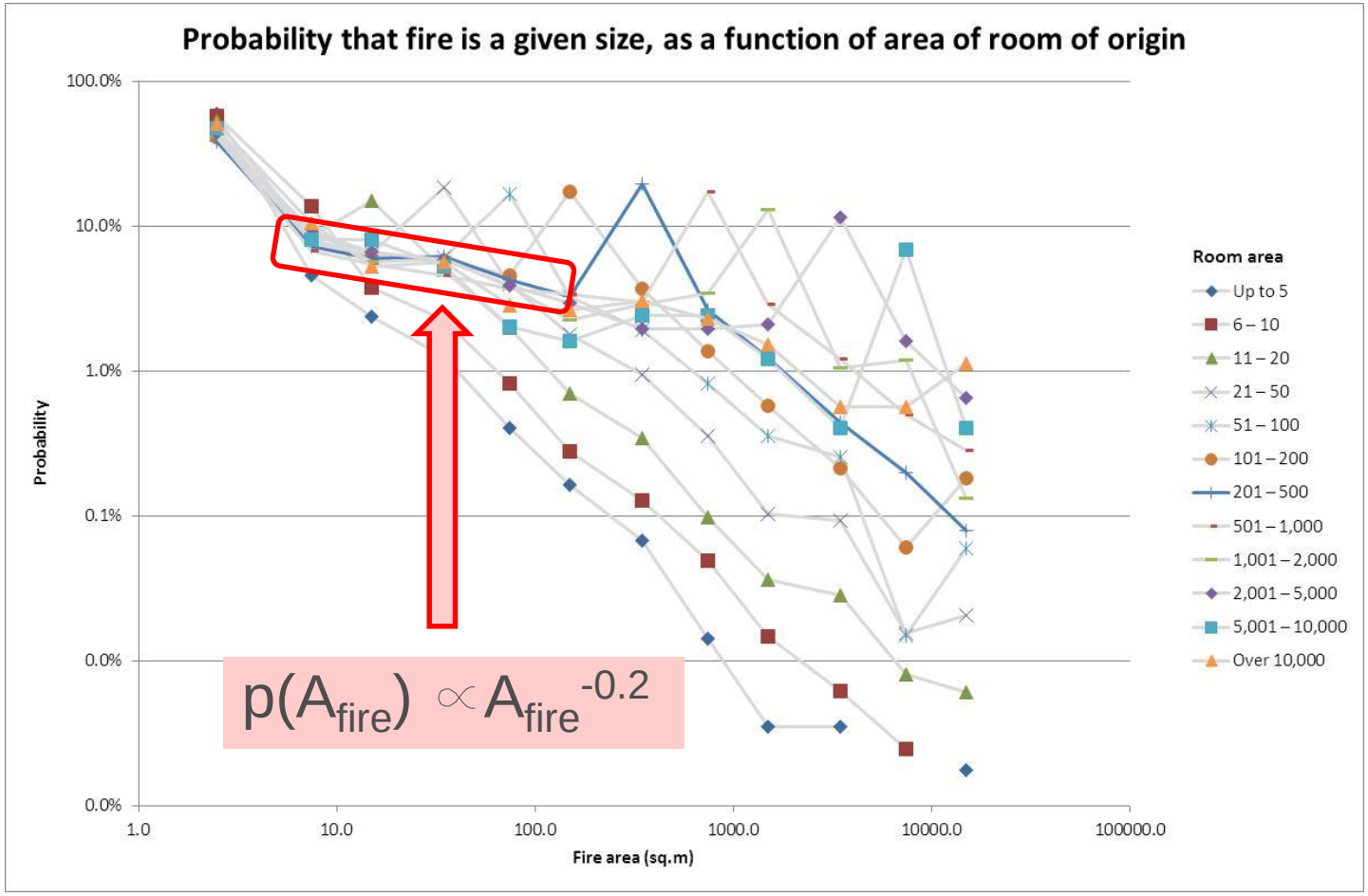

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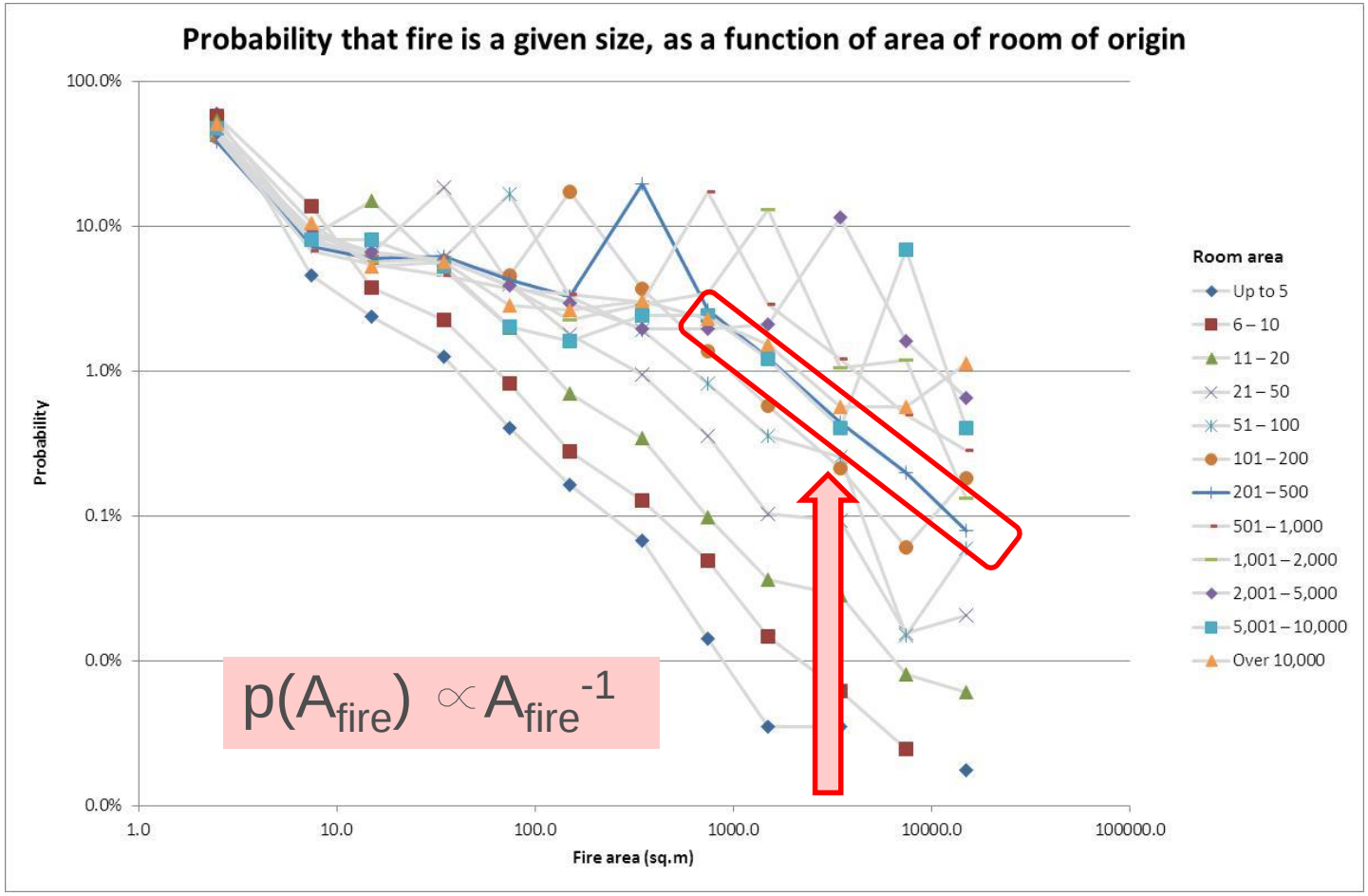
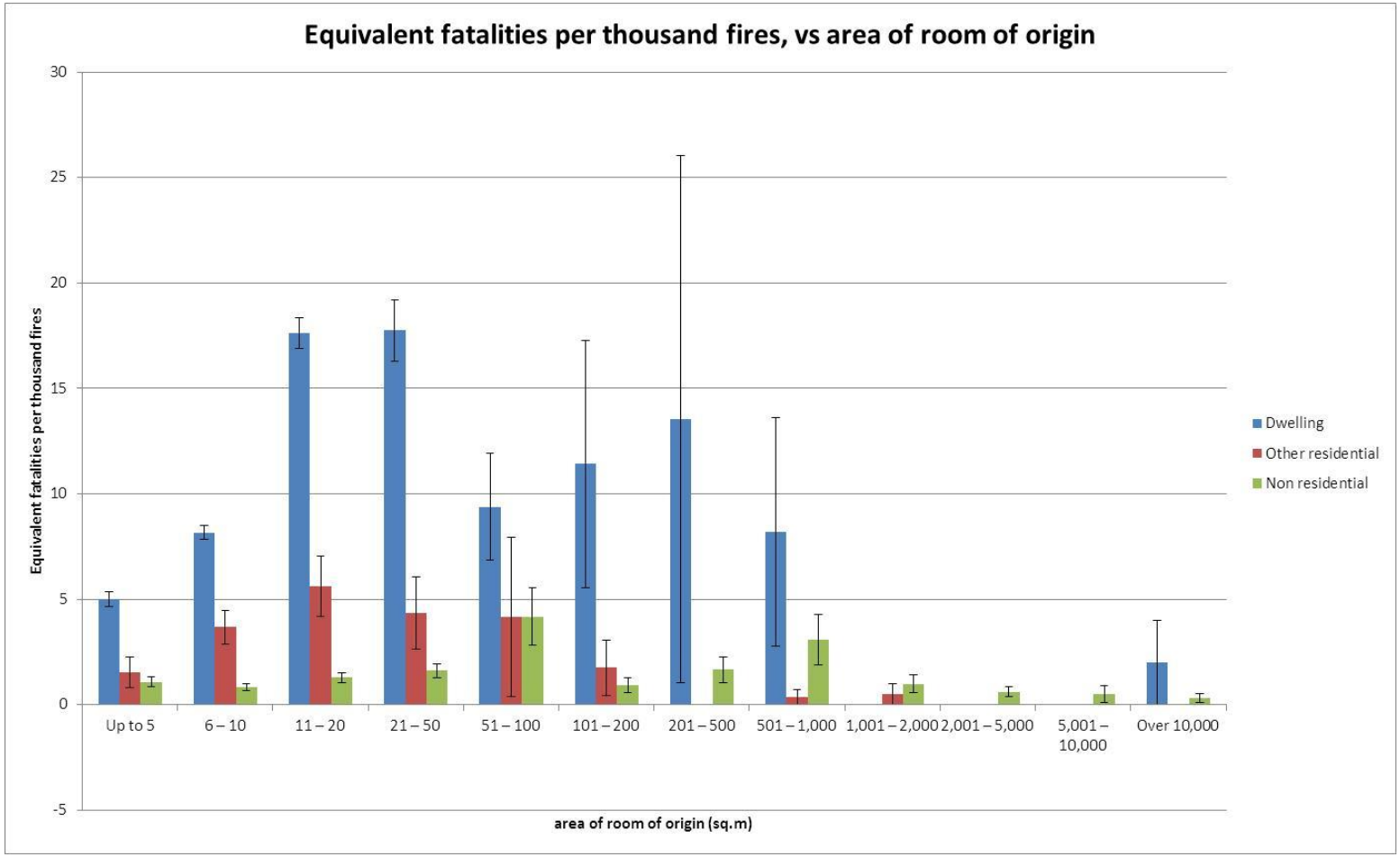


Effect of compartment size on life safety

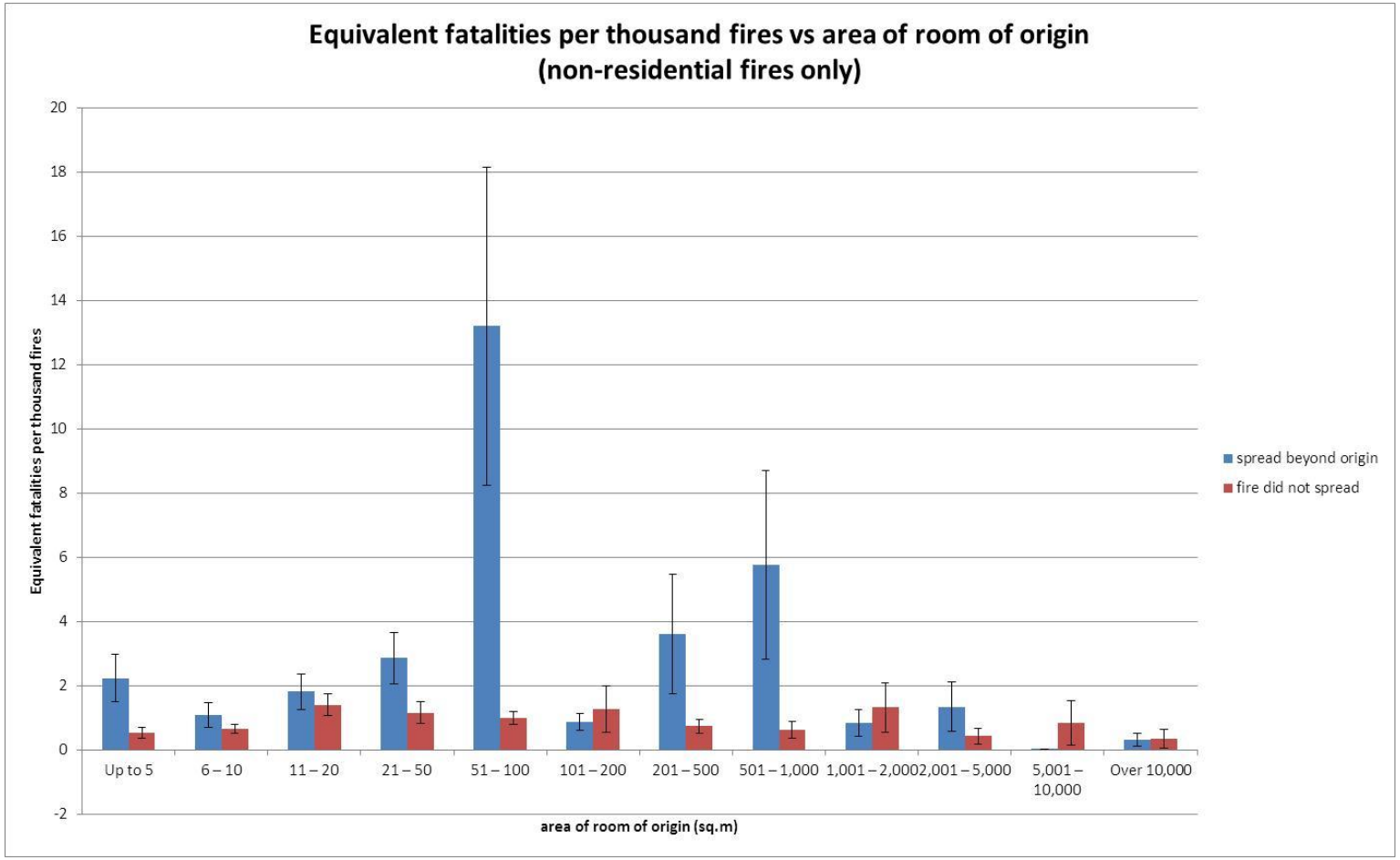
Introduce a concept of "equivalent fatalities":

- Each actual fatality = 1 equivalent fatality
- Each severe injury = 0.1 equivalent fatality
- Each slight injury = 0.01 equivalent fatality
- Each injury treated by first aid = 0.003 equivalent fatality
- Each recommended precautionary check = 0.001 equivalent fatality
- Each person rescued (uninjured) = 0.001 equivalent fatality
- Each unspecified injury = 0.0003 equivalent fatality.

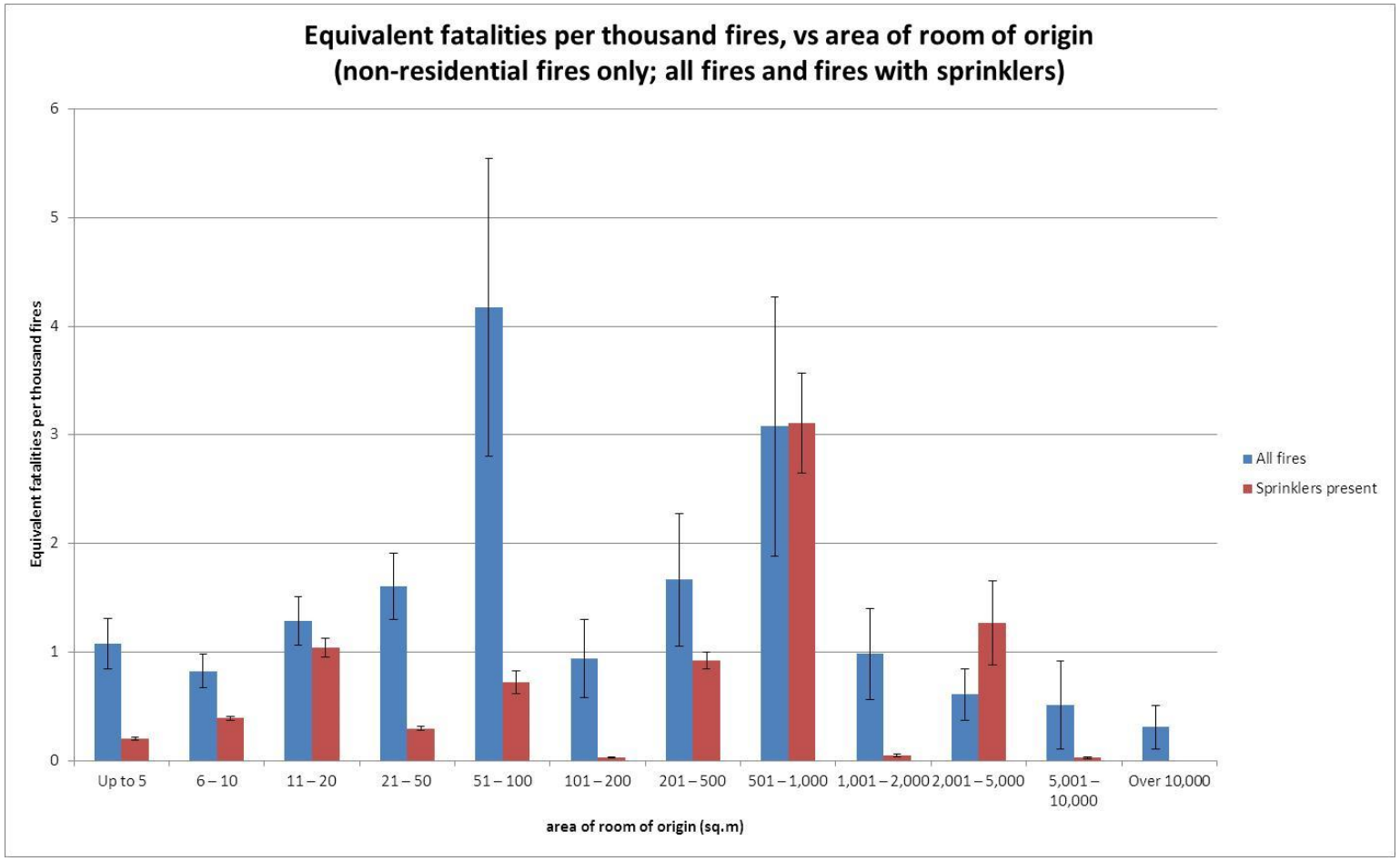
Effect of compartment size on life safety



Effect of compartment size and fire spread on life safety



Effect of compartment size and sprinklers on life safety



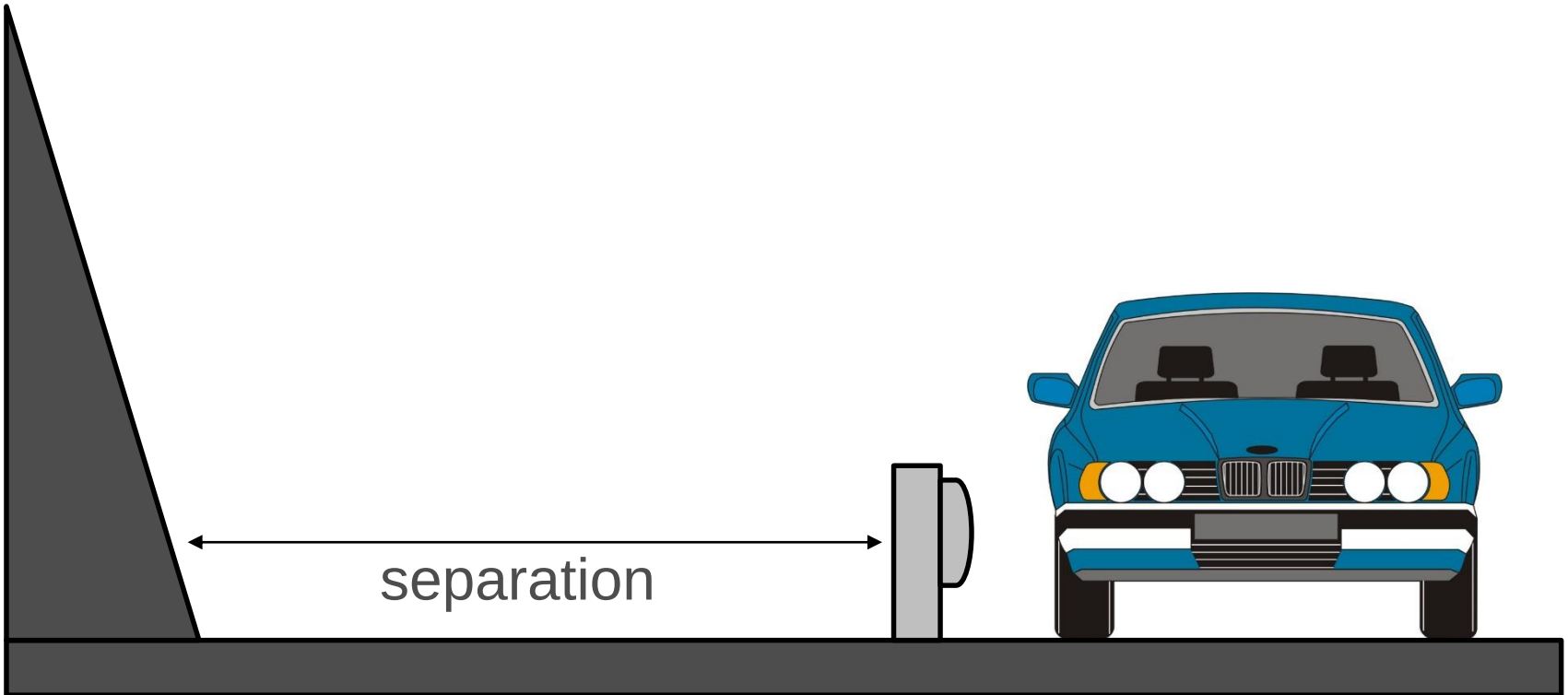
Example 2: Conclusions from fire statistics

- Clear trend for average fire area to increase as area of room of origin increases
- No obvious trend for life risk to increase as area of room of origin increases
- Sprinklers reduce the life risk in non-residential buildings
- In dwellings and other residential buildings, statistics are too sparse to draw any meaningful conclusions directly from the data

Example 3: vehicle fires

The issue: fire spread from external vehicle fires

- Concern over potential for fire spread (by radiant heat transfer)
  - From: burning vehicle(s)
  - To: combustible material close to the side of the road



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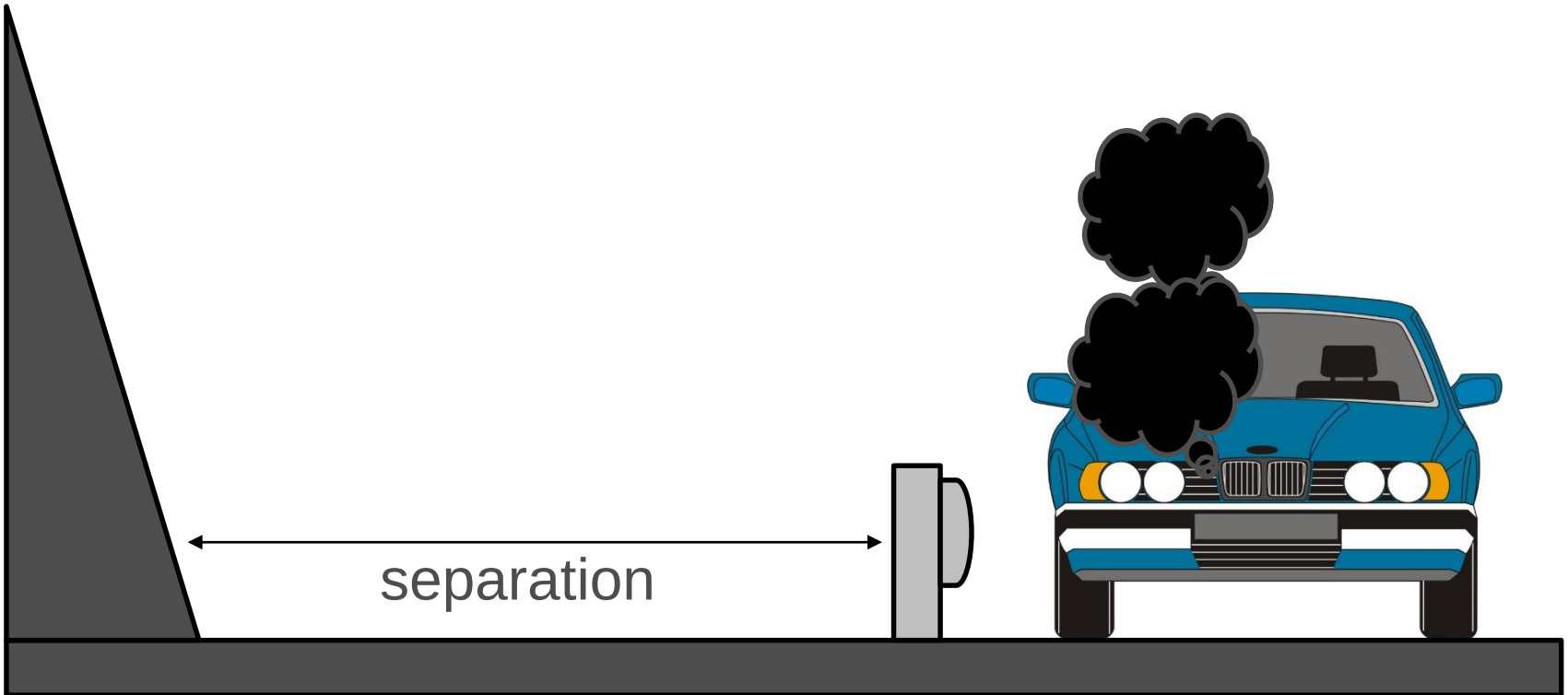

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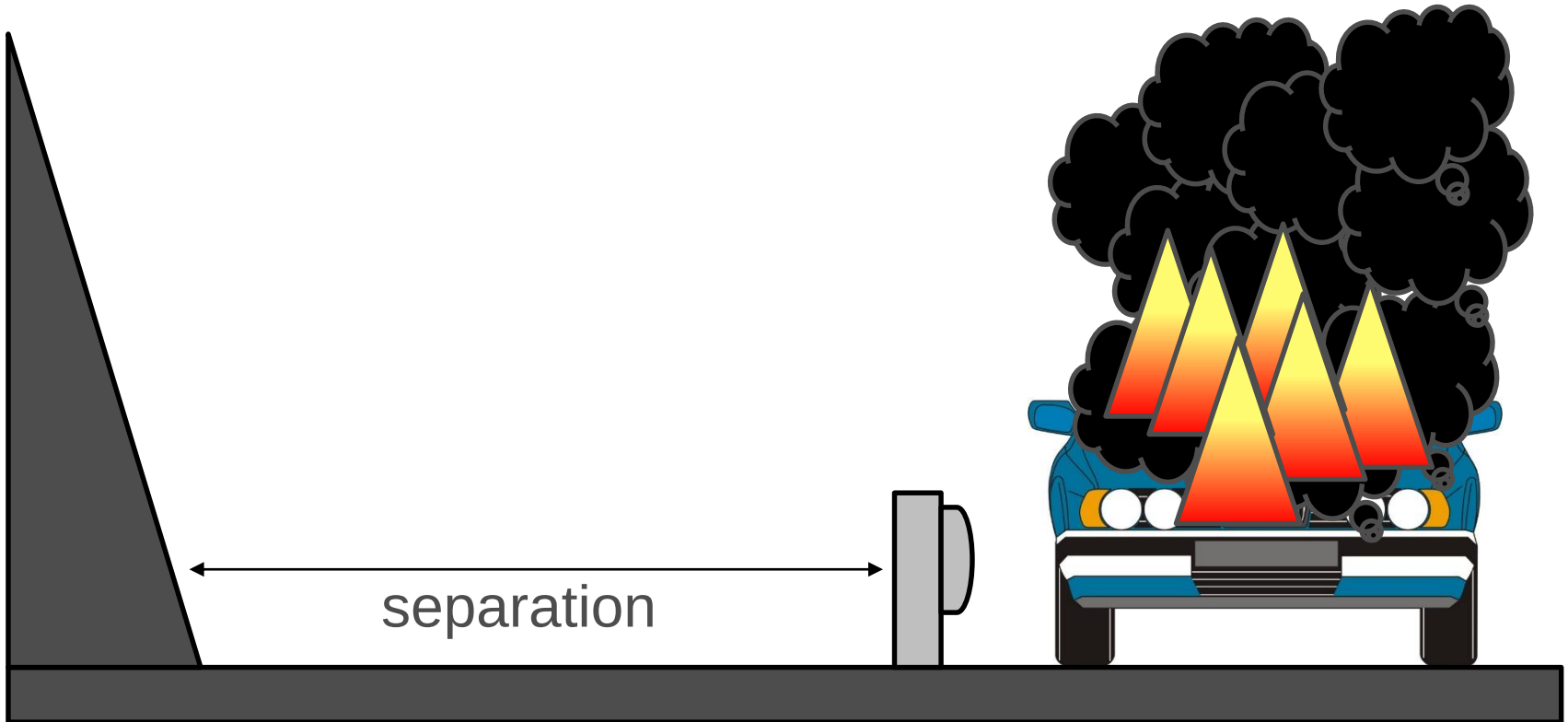

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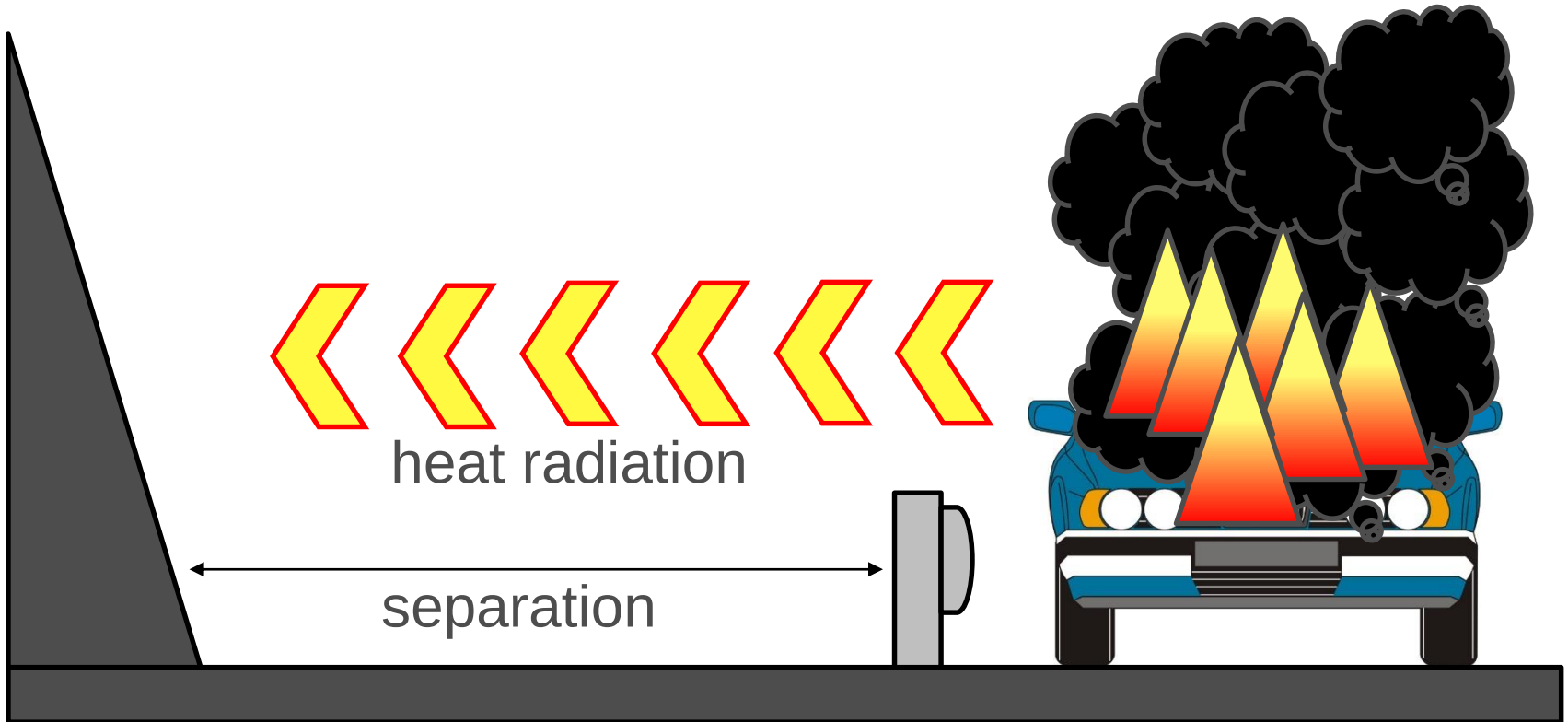

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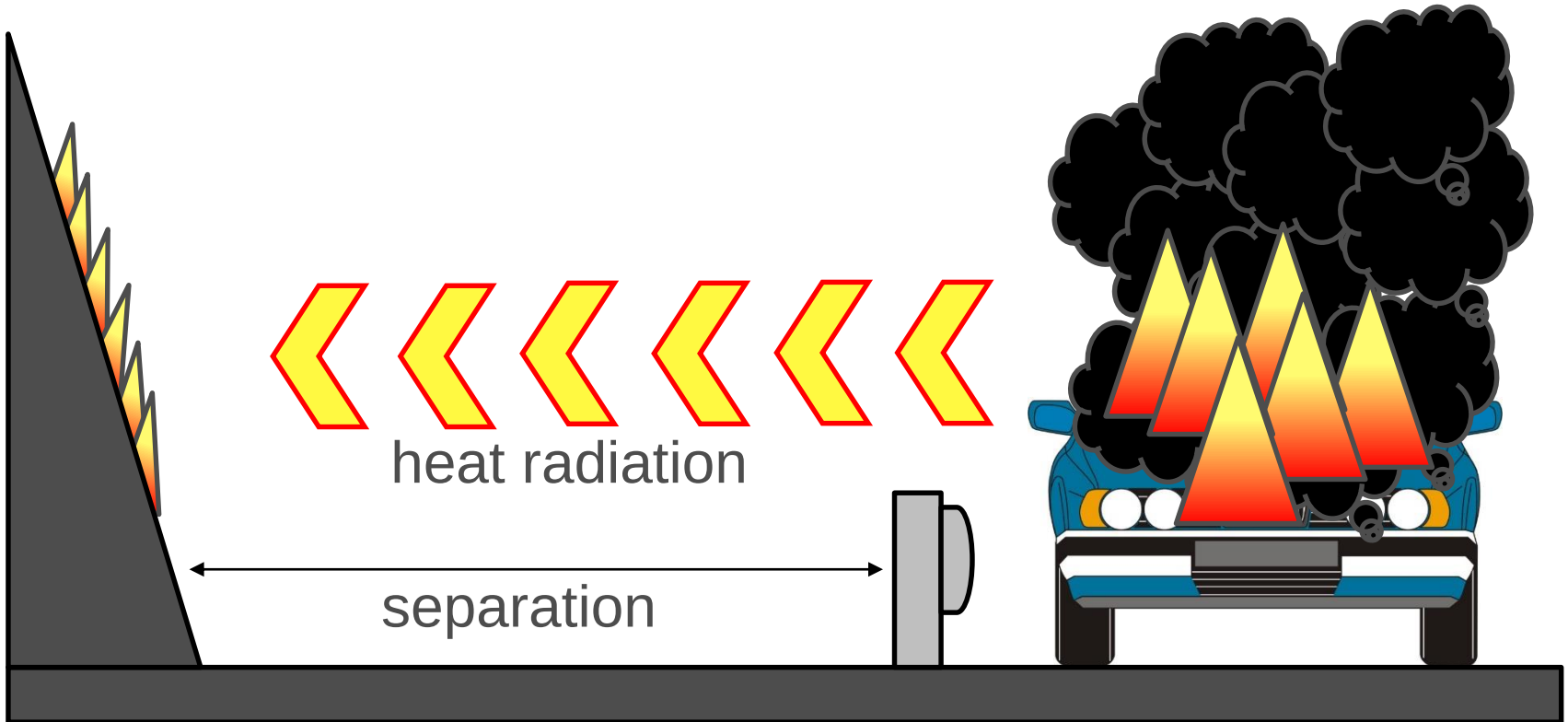


Estimating fire frequency

- Data from trunk roads in 4 different regions (A, B, C, D)
- Data collection period different in each region

- Work out the average interval between fires in each region
- Estimate number of fires per year

Fire frequency data

Region	Average interval	Std. Devn. interval
Region A	103 days	104 days
Region B	13 days	13 days
Regions C & D	18 days	9 days

Region	Interval	Fires per year
Region A	103 days	3.5
Region B	13 days	28.9
Regions C & D	18 days	19.8
Overall (A-D)		52.2

Fires involving different types of vehicles

– If the numbers of fires of different vehicle types are weighted by the frequency of fires in the different regions, the overall proportion of fires involving different vehicles can be estimated

Vehicle type	Region A 3.5 fire/yr	Region B 28.9 fire/yr	Regions C&D 19.8 fire/yr	All regions 52.2 fire/yr
Motorcycle	0	0	1	2.0 (4%)
Car	3	5	1	9.8 (19%)
Bus	0	3	0	3.8 (7%)
Van	3	2	0	4.0 (8%)
HGV	1	7	4	17.2 (33%)
Tanker	0	0	1	2.0 (4%)
Not specified	0	6	3	13.5 (26%)

National (UK) fire statistics on vehicle fires

- It was necessary to go back as far as 1998 to find data that contains details on:
  - the type of road (if applicable) where the fire occurred, and
  - the area of fire damage
- The former is necessary to eliminate the many vehicle fires that do not occur on a road (e.g. in a garage or car park).
- The latter is useful because not all vehicle fires will grow to involve the entire vehicle, which is important in assessing the likely ignition of the target material from radiant heat.

Comparing data from different sources

Vehicle type	Regions A-D (2013-14)	FDR1 data (1998)
Car	9.8 (19%)	104.2 (62%)
Bus / coach	3.8 (7%)	8.1 (5%)
Van	4.0 (8%)	19.3 (12%)
HGV / lorry	17.2 (33%)	35.3 (21%)
Subset: crashes	5.8 (10%)	11.0 (7%)
Total no. fires	52.2 (100%)	166.9 (100%)

- Note: FDR1 data limited to:
  - Accidental fires
  - Engine running
  - Motorways and dual carriageways
  - Same geographical areas as Regions A - D

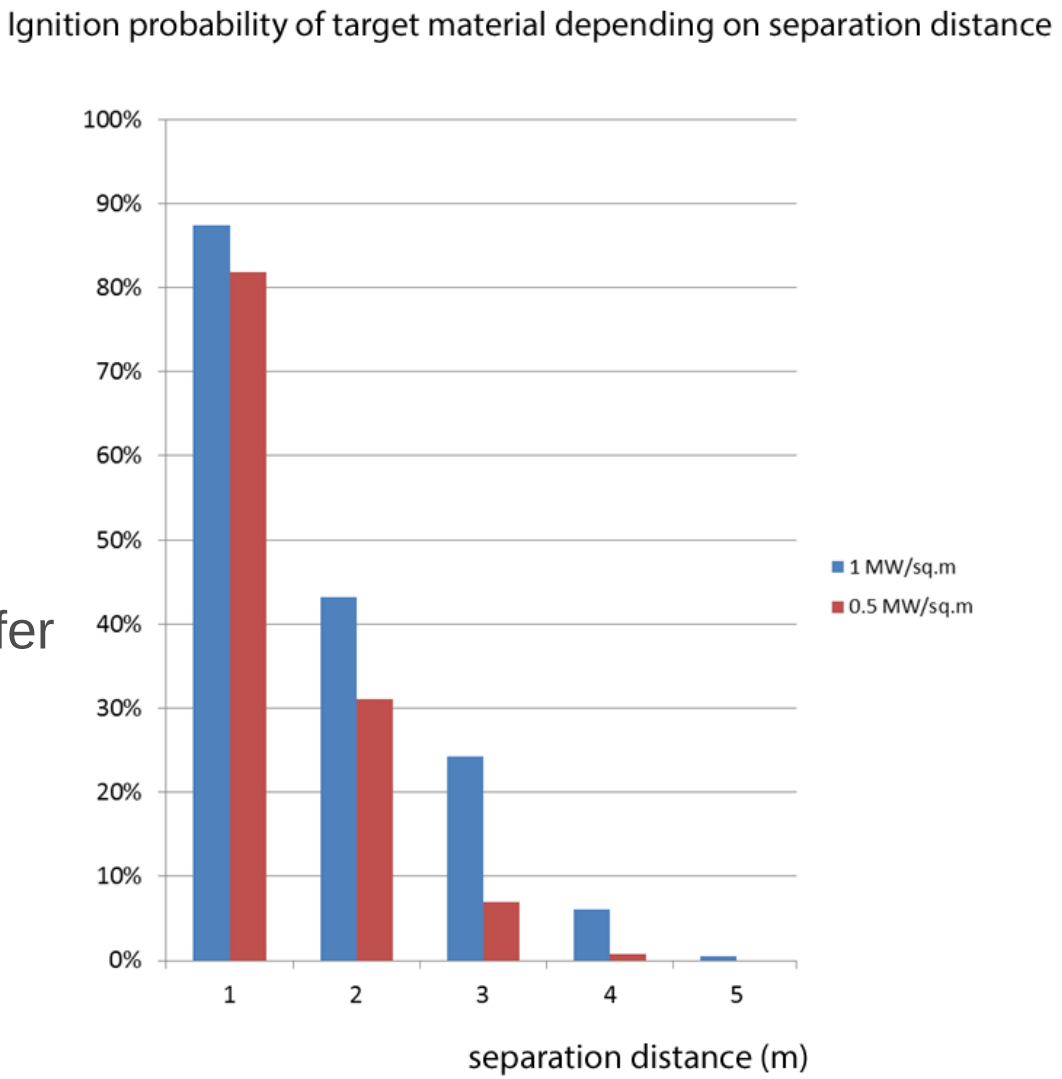
Estimate of heat release rate from vehicle fires

Vehicle type	HRR = 0.5 MW/m^2	HRR = 1.0 MW/m^2
Motorcycle	0.64 MW	1.27 MW
Car	1.36 MW	2.71 MW
Van	1.56 MW	3.12 MW
Bus	1.56 MW	3.12 MW
HGV	1.42 MW	2.84 MW
Tanker	1.46 MW	2.92 MW
Not specified	0.82 MW	1.65 MW

- FDR1 data (1998), all UK, accidental fires with engine running
- HRR estimated from area of fire damage

Example 3 Conclusions: Assessing the risk

- Assuming probability of fire proportional to total no. of vehicles x distance driven
- Estimate 0.3 ~ 1 fire per 10^6 vehicle.km
- From fire size, determine flame geometry
- Calculate radiant heat transfer for different separations
- Does irradiance exceed critical level for ignition?
- Monte Carlo method (since fire size is “random”)



3 Examples: Concluding remarks

- We can use Fire Stats data in a very wide range of different applications
- Often the analysis of the stats is one component (but a vital one) of a wider project
- Clients are Government and Industry
- We rely on DCLG for provision of data from the UK (England) IRS databases