

# ECONOMIC JUSTIFICATION FOR SPRINKLER SYSTEMS



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#### INTRODUCTION

The usual question:

Why would I consider sprinkler protection when it is not required by codes?

The answer:

Because there is a slight difference in the outcome!



source: http://www.glassonweb.com/



source: http://www.firesprinklerassocnewsletters.org/



### CASES IN WHICH SPRINKLER PROTECTION IS USUALLY REQUIRED

There are several cases in which sprinkler protection is usually required, including:

- Large retail spaces;
- Underground car parks;
- High-rise buildings;
- Rack storage;
- High-risk production;
- Large assembly areas...

The common characteristics of these cases are:

- high fire risk life safety and / or property;
- passive fire protection and first-aid firefighting do not suffice;
- rapid fire containment is required for effective firefighting.









### BENEFITS AND COSTS ASSOCIATED WITH SPRINKLER PROTECTION

#### BENEFITS

Real financial benefits:

- Reduction in insurance premiums;
- Tax reduction;
- Grants (in some cases);
- Reduced fire resistance;
- Relaxations in means of escape.

#### Potential financial benefits:

- Reduction in uninsured loss and operations interruption;
- Greater freedom in spatial planning.

#### COSTS

#### Installation costs:

(bulk, incurred during design and construction phases)

- Design;
- Sprinkler heads;
- Pipework and fittings;
- Valve sets;
- Water supply (tank and / or connection to town mains).

#### **Operating costs:**

(incurred periodically over the lifetime of a building)

- Inspection and tests;
- Maintenance.

If a decision is to be made about inclusion of sprinkler protection benefits and costs have to be quantified (financially) with adequate accuracy.



#### **SPRINKLERED AND UNSPRINKLERED FIRE** DAMAGE: DATA FOR PROBABILISTIC ANALYSIS

Table A.7 — Retail premis	ses: frequency	distribution	of area	damage	(in term	s of
	number	r of fires)				

Area damage	Assemb	ly areas	Storag	e areas	Other areas		
$m^2$	Without sprinklers	With <sup>a</sup> sprinklers	Without sprinklers	With <sup>a</sup> sprinklers	Without sprinklers	With <sup>a</sup> sprinklers	
1 and under	4 197	154	1 679	261	4 066	135	
	(48.9)	(31.3)	(67.4)	(26.3)	(43.5)	(26.2)	

Table A.5 — Area damage and percentage of fires for each category of fire spread (pubs, clubs, restaurants – all areas)

Category of fire spread					Sprinklered			Unsprinklered		
				Area dam	age	Percentage of fires	Area damage	Percentage of fires		
				$m^2$			$m^2$			
Confined to item first	Confined to item first ignited					59	1	26		
Spread beyond item by	ut confined	to room of origin	n							
i) contents only				1 15		2	12			
ii) structure involve	ed			4		19	15	45		
Spread beyond room				50		7	101	17		
Average <sup>a</sup>						100	24	100		
<sup>a</sup> Source: UK Fire Statistic										
	(0.8)		(1.0	)		10	J.3)			
500 - 999	29	—	24		-	1	5 -	_		
	(0.4)		(0.5)	)		((	).1)			
1 000 and above 34 – 27					—	5	-	—		
Total number of fires	Cotal number of fires         8 207         224         5 14			14	354 7		194	183		
λ	0.694 7	0.864 4	0.78	30 4	0.8	385 8 0	.893 6 (	0.699 1		
M (m <sup>2</sup> )	1.15	58 3	0.2	285 2 0	.794 2 (	0.214 2				
NOTE Figures within brac	ckets are perce	ntages of fires excee	eding u	pper limits	of da	amage ranges ir	the first colum	n.		
<sup>a</sup> Figures relate to fires in w	which sprinkler	rs operated Source:	Home	Office fire s	tatis	tics for 1979 an	d 1984 to 1987.			

source: PD 7974-7:2003 Part 7: Probabilistic risk assessment



### ECONOMIC TOOLS IN FIRE SAFETY DESIGN: COST BENEFIT ANALYSIS TOOLS



# Minimum total annual cost

$$T_i = P \cdot L_i + I_i + C_i$$

$$B = P \cdot (L_1 - L_2) + (I_1 - I_2)$$

$$C=C_2-C_1$$

Min value of *T* means optimum level of safety.

source:Ramachandran:1998 - Economics of fire protection



### ECONOMIC TOOLS IN FIRE SAFETY DESIGN: SIMPLIFIED COST-BENEFIT ANALYSIS

$$c_{e} = \frac{\overbrace{L_{d1} + L_{i1} + I_{1} - L_{d2} - L_{i2} - I_{2}}^{change in loss and premium}}{\underbrace{C_{p2} - C_{p1}}_{change in FP costs}}$$

- coefficient of economic efficiency [-]

- expected direct loss [€ /year] (value density x extent of fire damage)
- expected indirect loss [€ /year]
- cost of fire protection [€ /year] (installation, maintenance, etc.)
- without fire protection measure (sprinkler system)
- with fire protection measure (sprinkler system)



Ce

 $L_{d}$ 

 $L_{i}$ 

 $C_{\rm p}$ 

1

2

### FIRE PROTECTION ECONOMIC EFFICIENCY EVALUATION MODEL



Input parameters:

- Type of occupancy
- Fire growth rate
- Fuel load
- Type of construction
- FF attendance time
- Size of compartment
- Total area of building
- Building lifespan

- FP installation costs
- FP running costs
- Insurance premiums
- Tax changes



#### **MODEL STRUCTURE – BEHIND THE SCENES**

For each design alternative, an event tree analysis is conducted and the yearly expected fire damage is established by summing the partial outcomes (IDs).

0.65         0.9         0.06         2.5 m²         2.77E-03         3.61E+02         6.92E-03 m²           0.85         0.9         0.9         10 m²         3.249E-03         4.02E+02         2.49E-02 m²           0.75         Yes         0.86         Yes         0.86         Yes         0.86         4.02m²         4.190E-04         5.25E+03         8.00E-02 m²           Yes         0.5         Yes         0.86         Yes         0.86         Yes         0.2         3.10E-05         3.23E+04         4.28E-02 m²           No         0.5         Yes         0.86         Yes         0.2         1.00E-05         3.23E+04         1.30E-02 m²           0.1         0.8         420 m²         6         3.10E-05         3.23E+04         1.30E-02 m²           0.25         0.1         0.8         420 m²         6         5.04E-05         1.39E+02 m²           0.15         No         0.9         0.86         Yes         0.5         5.04E-05         1.39E+04         4.16E-02 m²           0.15         No         0.75         0.86         Yes         0.2         5.04E-05         1.39E+04         4.16E-02 m²           0.1         0.86         Yes	Ignition	Spread beyond 1 <sup>st</sup> item	Fire detection & alarm	Fire extinguishers	Sprinkler protection	Fire compartm.	Fire fighting	Fire damage	ID	Probability	Frequency [years]	Expected yearly damage
0.5         0.5         0.9         10 m²         2         2.77E-03         3.61E+02         6.92E-03 m²           0.65         0.9         10 m²         3         2.49E-03         4.02E+02         2.49E-02 m²           9.68E-03         Yes         0.8         420 m²         4         1.90E-04         5.25E+03         8.00E-02 m²           Yes         0.5         0.8         Yes         0.8         420 m²         4         1.90E-04         5.25E+03         8.00E-02 m²           Yes         0.8         420 m²         4         1.90E-05         2.10E+04         4.28E-02 m²           No         Ves         0.0         900 m²         5         4.76E-05         2.10E+04         4.28E-02 m²           No         Ves         0.2         0.2         3.10E-05         3.23E+04         1.30E-02 m²           0.14         No         1800 m²         7         7.75E-06         1.29E+03         6.59E-03 m²           0.15         No         0.9         0.14         No         1800 m²         1.32E+03         6.59E-03 m²           0.16         No         0.9         0.10 m²         9         5.04E-05         1.98E+04         4.16E-02 m²           No </td <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>a <b>a</b> 2</td> <td></td> <td></td> <td></td> <td>2</td>								a <b>a</b> 2				2
0.85         0.9         10 m²         3         2.49E-03         4.02E+02         2.49E-02 m²           2.66E-03         Yes         0.8         420 m²         4         1.90E-04         5.25E+03         8.00E-02 m²           Yes         0.5         0.66         Yes         0.8         420 m²         4         1.90E-04         5.25E+03         8.00E-02 m²           Yes         0.5         0.66         Yes         0.2         4.76E-05         2.10E+04         4.28E-02 m²           No         Ves         0.1         0.8         420 m²         6         3.10E-05         3.23E+04         1.30E-02 m²           0.14         No         Yes         7.75E-06         1.29E+05         1.39E-02 m²           0.25         2.5 m²         8         2.44E-04         4.10E+03         6.59E-03 m²           0.15         No         10 m²         9         5.9E-04         1.52E+03         6.59E-03 m²           0.15         No         10 m²         0.8         825 m²         1         1.13E-02 m²           0.75         No         0.8         0.25         1.98E+04         1.13E-02 m²           0.76         No         0.8         0.27         2.17E-05				0.5				2.5 m²	2	2.77E-03	3.61E+02	6.92E-03 m <sup>2</sup>
0.85         0.9         10 m²         3         2.49E-03         4.02E+02         2.49E-02 m²           0.75         Yes         No         0.86         Yes         1.90E-04         5.25E+03         8.00E-02 m²           8.68E-03         Yes         0.5         No         0.86         Yes         1.90E-04         5.25E+03         8.00E-02 m²           Yes         No         0.2         0.2         -         -         1.30E-02 m²           No         0.1         0.8         420 m²         6         3.10E-05         3.23E+04         1.30E-02 m²           No         0.14         No         1800 m²         7         7.75E-06         1.29E+05         1.39E-02 m²           No         0.25         0.9         1.01 m²         9         6.59E-04         1.52E+03         6.59E-03 m²           No         0.9         0.9         10 m²         9         6.59E-04         1.52E+03         6.59E-03 m²           No         0.15         No         0.8         825 m²         10         5.04E-05         1.98E+04         4.16E-02 m²           No         0.75         0.8         0.8         825 m²         12         8.20E-06         1.22E+05         6.7				Yes								2
0.75         No         0.86         420 m² 4         1.90E-04         5.25E+03         8.00E-02 m²           8.68E-03         Yes         0.6         Yes         0.86         Yes         0.75         2.10E+04         4.28E-02 m²           Yes         No         900 m² 5         0.75         2.10E+04         4.28E-02 m²           No         0.1         No         900 m² 5         0.210E+04         4.28E-02 m²           No         0.14         No         1800 m² 7         7.75E-06         1.29E+05         1.39E-02 m²           0.25         0.25         0.2         2.5m² 8         2.44E-04         4.10E+03         6.10E-04 m²           0.25         0.9         0.9         10 m² 9         6.59E-04         1.52E+03         6.59E-03 m²           0.15         No         Yes         0.88         825 m² 10         5.04E-05         1.98E+04         4.16E-02 m²           0.75         0.86         Yes         0.88         825 m² 10         5.04E-05         1.98E+04         1.13E-02 m²           0.75         No         0.75         0.86         Yes         0.2         1.32E+03         6.57E-03 m²           0.2         No         0.26         No         9			0.85	-	0.9			10 m²	3	2.49E-03	4.02E+02	2.49E-02 m <sup>2</sup>
No         No<		0.75	Yes	No	Yes		0.0	$420 m^2$		1 005 04	5 05 <b>5</b> 00	$a a = a = m^2$
8.68E-03         Its         0.3         0.3         0.30         Its         0.00         165         0.76E-05         2.10E+04         4.28E-02 m²           Yes         0.2         0.1         0.8         420 m²         6         3.10E-05         3.23E+04         1.30E-02 m²           No         Yes         0.1         0.8         420 m²         6         3.10E-05         3.23E+04         1.30E-02 m²           0.14         No         Yes         0.2         7         7.75E-06         1.29E+05         1.39E-02 m²           0.25         2.5 m²         8         2.44E-04         4.10E+03         6.10E-04 m²           0.15         Yes         0.9         10 m²         9         6.59E-04         1.52E+03         6.59E-03 m²           0.15         No         0.9         0.86         Yes         0.8         825 m²         10         5.04E-05         1.98E+04         4.16E-02 m²           0.75         No         0.86         Yes         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2         0.2		0.75 Voc	-	0.5		0.96	0.8 Voc	420 m	4	1.90E-04	5.25E+03	8.00E-02 m
No         No<	8 68E-03	res		0.5		0.00 Voc	No	$900 \text{ m}^2$	-		0.405.04	4 005 00 m <sup>2</sup>
No         0.1         0.8         420 m² 6         3.10E-05         3.23E+04         1.30E-02 m²           0.1         No         Yes         0.14         No         1800 m² 7         7.75E-06         1.29E+05         1.39E-02 m²           0.25         0.26         0.14         No         1800 m² 7         7.75E-06         1.29E+05         1.39E-02 m²           0.25         0.25         0.9         0.10m² 9         6.59E-04         1.52E+03         6.59E-03 m²           0.15         No         0.9         0.86         Yes         0.50E-05         1.98E+04         4.16E-02 m²           0.75         0.86         Yes         0.2         0.2         5.04E-05         1.98E+04         4.16E-02 m²           0.75         0.86         Yes         0.2         0.2         5.04E-05         1.98E+04         4.16E-02 m²           0.75         0.86         Yes         0.2         0.2         0.2         6.77E-03 m²           0.14         No         3600 m² 13         2.05E-06         4.88E+05         7.38E-03 m²           0.25         0.14         No         3600 m² 13         2.07E-03         4.61E+02         2.17E-03 m²           0.25         0.0 <td< td=""><td>Ves</td><td></td><td></td><td></td><td>No</td><td>103</td><td>0.2</td><td>300 m</td><td>5</td><td>4.70E-05</td><td>2.10E+04</td><td>4.202-02 11</td></td<>	Ves				No	103	0.2	300 m	5	4.70E-05	2.10E+04	4.202-02 11
No         O.3         420 m         O         3.25404         1.30E402 m           0.14         No         1800 m <sup>2</sup> 7         7.75E-06         1.29E+05         1.39E+02 m <sup>2</sup> 0.25         2.5 m <sup>2</sup> 8         2.44E-04         4.10E+03         6.10E-04 m <sup>2</sup> Ves         0.9         10 m <sup>2</sup> 9         6.59E-04         1.52E+03         6.59E-03 m <sup>2</sup> 0.15         No         0.9         0.88         825 m <sup>2</sup> 10         5.04E-05         1.98E+04         4.16E-02 m <sup>2</sup> 0.75         0.86         Yes         0.8         825 m <sup>2</sup> 10         5.04E-05         1.98E+04         4.16E-02 m <sup>2</sup> 0.75         0.86         Yes         0.2         1         1.26E-05         7.94E+04         1.13E-02 m <sup>2</sup> 0.75         0.8         825 m <sup>2</sup> 10         5.04E-05         1.98E+04         4.16E-02 m <sup>2</sup> 0.1         0.8         825 m <sup>2</sup> 12         8.20E-06         1.22E+05         6.77E-03 m <sup>2</sup> 0.1         0.8         3600 m <sup>2</sup> 13         2.05E-06         4.88E+05         7.38E-03 m <sup>2</sup> 0.25         0.14         No         0 m <sup>2</sup>	100				0.1		0.8	$420 \text{ m}^2$	6	2 105 05	2 225 1 04	$1.20 = 0.2 \text{ m}^2$
No         1.39E-02 m²           0.14         No         1800 m²         7         7.75E-06         1.29E+05         1.39E-02 m²           0.25         2.5 m²         8         2.44E-04         4.10E+03         6.10E-04 m²           0.15         Ves         0.9         10 m²         9         6.59E-04         1.52E+03         6.59E-03 m²           0.15         Ves         0.86         Yes         0.8         825 m²         10         5.04E-05         1.98E+04         4.16E-02 m²           0.75         0.86         Yes         0.2         8.20E-06         1.22E+05         6.77E-03 m²           0.1         0.8         825 m²         12         8.20E-06         1.22E+05         6.77E-03 m²           0.1         0.8         825 m²         12         8.20E-06         1.22E+05         6.77E-03 m²           0.1         0.8         825 m²         12         8.20E-06         1.22E+05         6.77E-03 m²           0.1         0.8         0.2         1         2.05E-06         4.88E+05         7.38E-03 m²           0.25         0.14         No         0.00         10 m²         9.91E-01         0.00E+00         0.00E+00           0.25					0.1	No	Yes	420 111	0	5.102-05	3.23E+04	1.30E-02 III
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$						0.14	No	1800 m <sup>2</sup>	7	7.75E-06	1.29E+05	1.39E-02 m <sup>2</sup>
No         0.25         0.9         10 m²         8         2.44E-04         4.10E+03         6.10E-04 m²           No         10 m²         9         6.59E-04         1.52E+03         6.59E-03 m²           0.15         No         0.88         825 m²         10         5.04E-05         1.98E+04         4.16E-02 m²           0.75         0.86         Yes         0.2         11         1.26E-05         7.94E+04         1.13E-02 m²           No         0.75         0.86         Yes         0.2         11         1.26E-05         7.94E+04         1.13E-02 m²           No         0.1         0.88         825 m²         12         8.20E-06         1.22E+05         6.77E-03 m²           No         0.1         0.8         825 m²         12         8.20E-06         1.22E+05         6.77E-03 m²           No         10.4         No         3600 m²         13         2.05E-06         4.88E+05         7.38E-03 m²           0.25         0.24         0.24         0.02         0.02         0.00E+00 m²           0.3913186         0         0         0         0         0.00E+00 m²         0.00E+00 m²							0.2					
No         0.9         10 m² 9         6.59E-04         1.52E+03         6.59E-03 m²           0.15         No         0.86         Yes         0.86         Yes         0.86         Yes         0.86         Yes         0.86         Yes         0.86         Yes         0.75         0.86         Yes         0.22         0.22         0.22         0.22         0.22         0.22         0.25         0.14         0.88         825 m² 12         8.20E-06         1.22E+05         6.77E-03 m²           No         Ves         0.14         No         3600 m² 13         2.05E-06         4.88E+05         7.38E-03 m²           No         Ves         0.14         No         3600 m² 13         2.05E-06         4.88E+05         7.38E-03 m²           No         Ves         0.14         No         3600 m² 13         2.05E-06         4.88E+05         7.38E-03 m²           0.25         0.25         0.26         0 m² 0         9.91E-01         0.00E+00         0.00E+00 m²           0.9913186         0         0         0 m² 0         9.91E-01         0.00E+00         0.00E+00 m²				0.25			0.2	$2.5  \text{m}^2$	8	2 44F-04	4 10E+03	6 10E-04 m <sup>2</sup>
No         0.9         10 m²         9         6.59E-04         1.52E+03         6.59E-03 m²           0.15         No         Yes         0.8         825 m²         10         5.04E-05         1.98E+04         4.16E-02 m²           0.75         0.86         Yes         0.2         11         1.26E-05         7.94E+04         1.13E-02 m²           No         0.1         0.8         825 m²         12         8.20E-06         1.22E+05         6.77E-03 m²           No         Yes         0.1         No         Yes         0.2         8.20E-06         1.22E+05         6.77E-03 m²           No         Yes         0.1         No         Yes         0.2         8.20E-06         1.22E+05         6.77E-03 m²           0.1         No         Yes         0.2         8.20E-06         1.22E+05         6.77E-03 m²           0.2         1m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.25         0.25         0         0         0         0 m²         9.91E-01         0.00E+00         0.00E+00 m²           0.9913186         0         0         0         0         0         0         0.25 m² <td></td> <td></td> <td></td> <td>Yes</td> <td></td> <td></td> <td></td> <td>210 111</td> <td>Ū</td> <td>2.112 01</td> <td>4.102100</td> <td>0.102 04</td>				Yes				210 111	Ū	2.112 01	4.102100	0.102 04
No         Yes         0.8         825 m²         10         5.04E-05         1.98E+04         4.16E-02 m²           0.75         0.86         Yes         0.2         1         1.26E-05         7.94E+04         1.13E-02 m²           No         0.1         0.88         825 m²         12         8.20E-06         1.22E+05         6.77E-03 m²           0.1         0.8         825 m²         13         2.05E-06         4.88E+05         7.38E-03 m²           No         Ves         0.2         1 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.2         1 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.25         0.2         1 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.9913186         0.00         0 m²         0         9.91E-01         0.00E+00         0.00E+00 m²			No		0.9			10 m <sup>2</sup>	9	6.59E-04	1.52E+03	6.59E-03 m <sup>2</sup>
No         0.8         825 m²         10         5.04E-05         1.98E+04         4.16E-02 m²           0.75         0.86         Yes         0.2         1         1.26E-05         7.94E+04         1.13E-02 m²           No         0.1         0.86         Yes         0.2         1         8.20E-06         1.22E+05         6.77E-03 m²           No         Yes         0.14         No         3600 m²         13         2.05E-06         4.88E+05         7.38E-03 m²           0.14         No         3600 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.25         0.2         1 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.9913186         0         0         0         0         0         0.00E+00 m²			0.15		Yes					-		
No         0.75         0.86         Yes         900 m²         11         1.26E-05         7.94E+04         1.13E-02 m²           No         0.2         0.2         0.2         0.2         0.1         0.88         825 m²         12         8.20E-06         1.22E+05         6.77E-03 m²           No         Yes         0.14         No         3600 m²         13         2.05E-06         4.88E+05         7.38E-03 m²           0.2         1 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.25         0.2         1 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.9913186         0         0         0         0         0         0         0.00E+00         0.00E+00 m²				No			0.8	825 m <sup>2</sup>	10	5.04E-05	1.98E+04	4.16E-02 m <sup>2</sup>
No         Yes         No         900 m²         11         1.26E-05         7.94E+04         1.13E-02 m²           0.1         0.2         0.8         825 m²         12         8.20E-06         1.22E+05         6.77E-03 m²           No         Yes         0.14         No         3600 m²         13         2.05E-06         4.88E+05         7.38E-03 m²           No         O.2         1 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.25         0.25         0 m²         0 m²         9.91E-01         0.00E+00         0.00E+00 m²           0.9913186         0         0         0         0         0         0.25 m²         0.25 m²				0.75		0.86	Yes			-		
No         0.2         0.2         0.8         825 m²         12         8.20E-06         1.22E+05         6.77E-03 m²           No         Yes         0.14         No         3600 m²         13         2.05E-06         4.88E+05         7.38E-03 m²           No         0.2         1 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.25         0.05         0 m²         0         9.91E-01         0.00E+00         0.00E+00 m²           0.9913186         0         0         0         0         0         0.25 m²         0.00E+00         0.00E+00 m²						Yes	No	900 m <sup>2</sup>	11	1.26E-05	7.94E+04	1.13E-02 m <sup>2</sup>
No         0.1         0.8         825 m² 12         8.20E-06         1.22E+05         6.77E-03 m²           No         Yes         0.14         No         3600 m² 13         2.05E-06         4.88E+05         7.38E-03 m²           No         0.2         1 m² 1         2.17E-03         4.61E+02         2.17E-03 m²           No         0.25         0 m² 0         9.91E-01         0.00E+00         0.00E+00 m²           0.9913186         0 m²         0         0         0.25 m²         0.00E+00 m²					No		0.2					
No         Yes           0.14         No         3600 m² 13         2.05E-06         4.88E+05         7.38E-03 m²           No         0.2         1 m² 1         2.17E-03         4.61E+02         2.17E-03 m²           0.25         0.25         0 m² 0         9.91E-01         0.00E+00         0.00E+00 m²           0.9913186         0         0         0         0         0         0.025 m²					0.1		0.8	825 m <sup>2</sup>	12	8.20E-06	1.22E+05	6.77E-03 m <sup>2</sup>
No         0.14         No         3600 m²         13         2.05E-06         4.88E+05         7.38E-03 m²           No         0.25         1 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           No         0.25         0 m²         0 m²         9.91E-01         0.00E+00         0.00E+00 m²           0.9913186         0         0         0         0         0.00E+00         0.00E+00 m²						No	Yes					
No         0.2         1 m²         1         2.17E-03         4.61E+02         2.17E-03 m²           0.25         0 m²         0 m²         0         9.91E-01         0.00E+00         0.00E+00 m²           0.9913186         0         0         0         0         0.02E+00         0.00E+00         0.00E+00 m²						0.14	No	3600 m <sup>2</sup>	13	2.05E-06	4.88E+05	7.38E-03 m <sup>2</sup>
No         1 m² 1         2.17E-03         4.61E+02         2.17E-03 m²           No         0 m² 0         9.91E-01         0.00E+00 m²         0.00E+00 m²           0.9913186							0.2					2
0.25         0 m²         0         9.91E-01         0.00E+00 m²           0.9913186		No						1 m²	1	2.17E-03	4.61E+02	2.17E-03 m <sup>2</sup>
NO         0 m <sup>-</sup> 0         9.91E-01         0.00E+00         0.00E+00 m <sup>-</sup> 0.9913186	NI-	0.25						c 2		0.045.05		· · · · · · · · · · · · · · · · · · ·
	INO							0 m²	0	9.91E-01	0.00E+00	0.00E+00 m <sup>2</sup>
	0.9913100							То	tal ve	arly expected	fire damage:	0.26 m <sup>2</sup>



### EXAMPLE OF MODEL APPLICATION: SCENARIO SPECIFICATION

The model building is a single-storey shopping centre with a total floor area of 3600 m<sup>2</sup>. It is divided into four retail units, each with a floor area of 900 m<sup>2</sup>.

The impact of the following fire protection measures will be assessed:

- Fire detection and alarm system;
- Portable fire extinguishers;
- Sprinkler system;
- Fire partitioning.

Yielding 16 potential combinations from no protection up to all measures included.





### EXAMPLE OF MODEL APPLICATION: RESULST – EXPECTED FIRE SEVERITY

	7 -	Design	Presence of fire protection measure				Expected yearly	- 7.00E.06		
year-1]	,	alternative	AFD	PFEX	SPRK	COMP	Gamage S <sub>d,y</sub> [m <sup>2</sup> ]	[%]		ear <sup>1</sup> ]
[m².	6 -	0	No	No	No	No	6,20	ref.	- 6,00E-06	a V
$S_{d,y}$		1	Yes	No	No	No	5,04	18,7	-	$p_{\rm fd}$
age	5 -	2	No	Yes	No	No	4,66	24,9	- 5,00E-06	ality
lame		4	No	No	No	Yes	4,03	35,1	-	e fat
ire o	4 -	- 9	No	Yes	No	Yes	3,02	51,3	4,00E-06	of fire
t of f		5	Yes	Yes	No	No	2,76	55,5	-	llity o
xten	3 -	- 7	Yes	No	No	Yes	2,52	59,4	3,00E-06	bab
e e		12	Yes	Yes	No	Yes	1,42	77,2	-	Pro
ecte	2 -	_ 3	No	No	Yes	No	0,67	89,2	1 2,00E-06	
ЩЩ		6	Yes	No	Yes	No	0,55	91,1	-	
	1 -	8	No	Yes	Yes	No	0,50	91,9	1,00E-06	
		10	No	No	Yes	Yes	0,45	92,7	-	
	0 -	14	No	Yes	Yes	Yes	0,34	94,5	1 0.00E+00	
	-	13	Yes	Yes	Yes	No	0,31	95,0	-,	
		11	Yes	No	Yes	Yes	0,30	95,2		
		15	Yes	Yes	Yes	Yes	0,17	97,2		

FDA – Fire Detection and Alarm, PFEX – Portable Fire Extinguishers, SPRK – sprinkler system, COMP – fire partitioning



### EXAMPLE OF MODEL APPLICATION: RESULTS – PROTECTION EQUIVALENCY



A comparison of expected yearly expected damage (equivalency measure) of two design alternatives: Alternative 1- Fire detection and alarm, Portable fire extinguishers, Fire compartmentation Alternative 2 – Sprinkler protection



#### EXAMPLE OF MODEL APPLICATION: INVESTIGATING SENSITIVITY TO FIRE OCCURENCE PROBABILITY

- Two occupancy types: retail and industrial;
- In example cases occupancy type affected fire occurrence probability;
- Two sources were used PD7974-7 (adjusted for reduction in fire occurrence 1970s to 2012) and recent statistics review – both area dependent;
- Other parameters are as per table below:

Fire growth rate Fast - Fire protection Installation Operat	ing
Fire load Medium - measure (Eur) (Eur / ye	ear)
Building       Standard       Fire detection and       tot. area*10       5% of installation         construction       concrete       alarm system       tot. area*10       installation	of tion
Fire service attendance time5 - 15 mins-Portable fire extinguisherstot. area*0.6tot. area	a*0.3
Max. compartment not exceeding size 1/2 of total area m <sup>2</sup> Sprinkler protection tot. area*30 +150000 tot. area	a*2
Total area 1000 - 10000 m <sup>2</sup> Fire tot croa*0.2 5% c	of
Expected lifespan 50 years compartmentation tot. area 0.5 installat	tion



#### EXAMPLE OF MODEL APPLICATION: INVESTIGATING SENSITIVITY TO FIRE OCCURENCE PROBABILITY







#### EXAMPLE OF MODEL APPLICATION: INVESTIGATING SENSITIVITY TO FIRE OCCURENCE PROBABILITY







#### **CONCLUDING REMARKS**

- In reality, it may difficult to provide solid economic justification for sprinkler protection when not required by codes or insurers, especially at early design stages when certain details are not known – compartmentation, means of escape, insurance premiums, taxation.
- This may preclude considering a design alternative with sprinkler protection which would usually allow for a reduction in fire resistance, means of escape, more freedom in spatial planning, i.e. cost reduction.
- Fire occurrence probability is a very important parameter other parts of these types of model usually just modify how a fire will develop given the set of fire protection measures present in a design.
- Example cases presented illustrate the significance of the differences in probabilities which may lead to an erroneous assumption that sprinkler protection is not economically feasible.



#### **CONCLUDING REMARKS**

- Once further building and systems specifications become available more detailed input will increase the accuracy of evaluation.
- It is important that the stakeholders are informed about the expected extent of damage/loss for various design alternatives in absolute terms, e.g. in Eur per year of loss they may expect over the lifetime of the building.
- The above should also account for indirect loss (included in the examples) and business disruption, which will not only cause financial loss but may also lead to loss of market share due to downtime dependency on extent of damage.
- Presented type of modelling can be used for identifying design alternatives that meet performance objectives set by the stakeholders.
- The example case presented indicates difficulties/impracticalities in reducing fire damage for unsprinklered design alternatives to sprinkler-protected levels; significant compartment size required.



## Thank you for your attention! Questions?

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