

FIRE RISK ANALYSIS

Risk assessment for the estimation of the disaster „fire“ for (historical) timber constructions



Tallinn, 2005 09 13
Hon.-Prof. Dr.techn. Hans Hartl

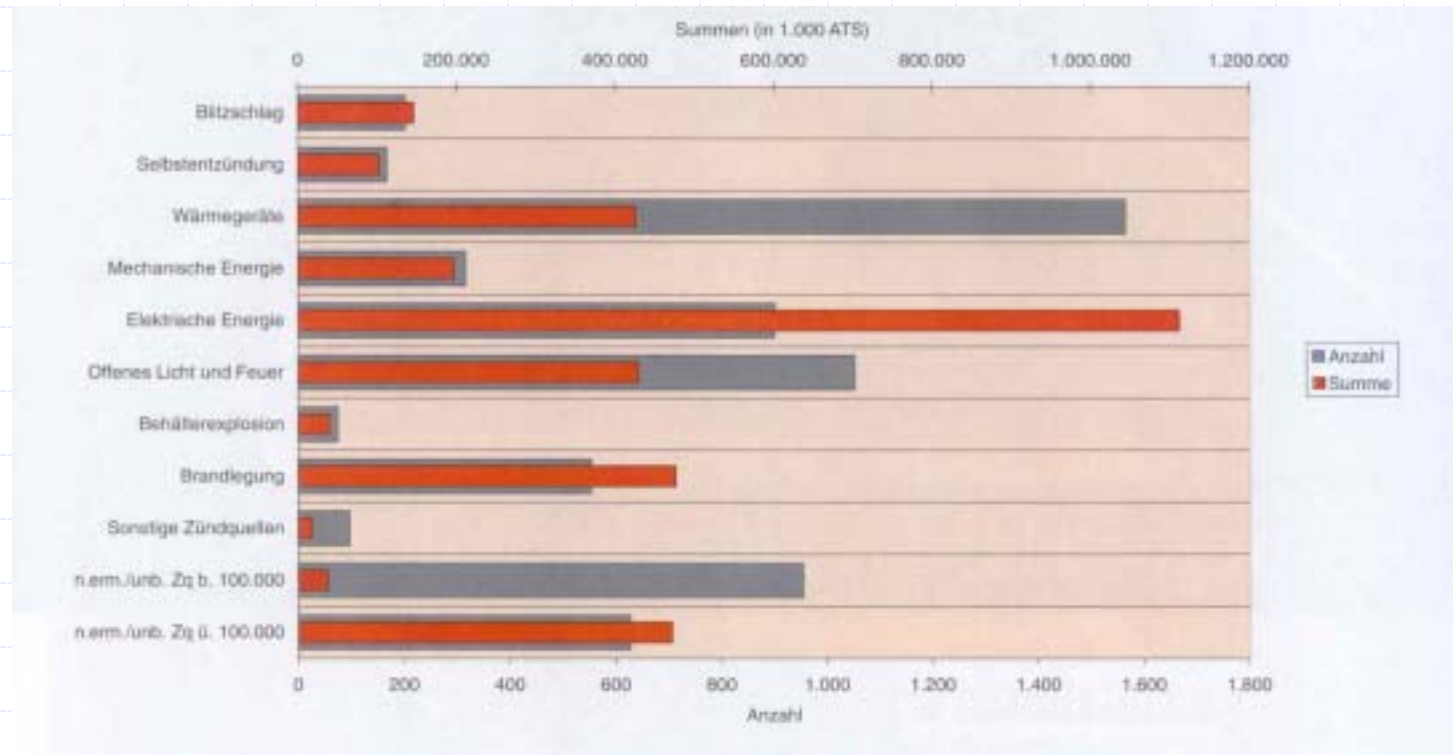


Fire risk

- ◆ Statistical approaches
- ◆ Risk analysis

“Fire risk” and statistical approaches

◆ Austrian statistical approaches



“Fire risk” and statistical approaches

◆ Example from CH

Nutzung (nach VKF-Nutzungscode)		Schadenbelastung [%]		
		VKF-Kantone 1989 – 1998	Kanton Zürich 1989 – 1998	Kanton Bern 1986 – 1995
10	Gebäude mit öffentlichem Charakter	0,123	0,084	
40	Verkehrswesen	0,137	0,027	
10/40	Öffentlich genutzte Gebäude			0,080
20	Wohngebäude	0,151	0,103	
90	Nebengebäude	0,193	0,151	
20/90	Wohnen			0,147
30	Land- und Forstwirtschaft	0,462	0,425	0,528
50	Handel	0,209	0,139	
60/70	Industrie und Gewerbe	0,376	0,263	
80	Gastgewerbe	0,574	0,193	
50/60/70/80	Gewerbe und Industrie			0,299
	alle Nutzungen	0,206	0,130	0,205

“Fire risk” and statistical approaches

◆ Example from CH:

- Use
- Age
- Structural design and construction

Number of „Deaths“ depending on the construction material is not relevant !

Assessment of the fire performance

◆ Reaction to fire

- SBI Test
- CWFT list

◆ Fire resistance performance based on

- EN 1991-1-2
- Fire parts of material oriented EC`s

Assessment of the fire performance

- ◆ Nominal temperature-time curves
 - Standard temperature-time curve
 - External fire curve
 - Hydrocarbon curve
- ◆ Natural fire models

FiRE-TECH:

Fire Risk Evaluation

To European Cultural Heritage

Austria - UIBK
Belgium - UGent
France - CSTB
Germany - iBMB
Greece - AUTH
Hungary – EMI
Italy - IUAV
Netherlands - TNO
Portugal - IST
Sweden - FSN
United Kingdom - WFR

Aim

◆ Methods developed in FiRE-TECH for fire risk evaluation

IST Cost / Effectiveness Excel Sheet

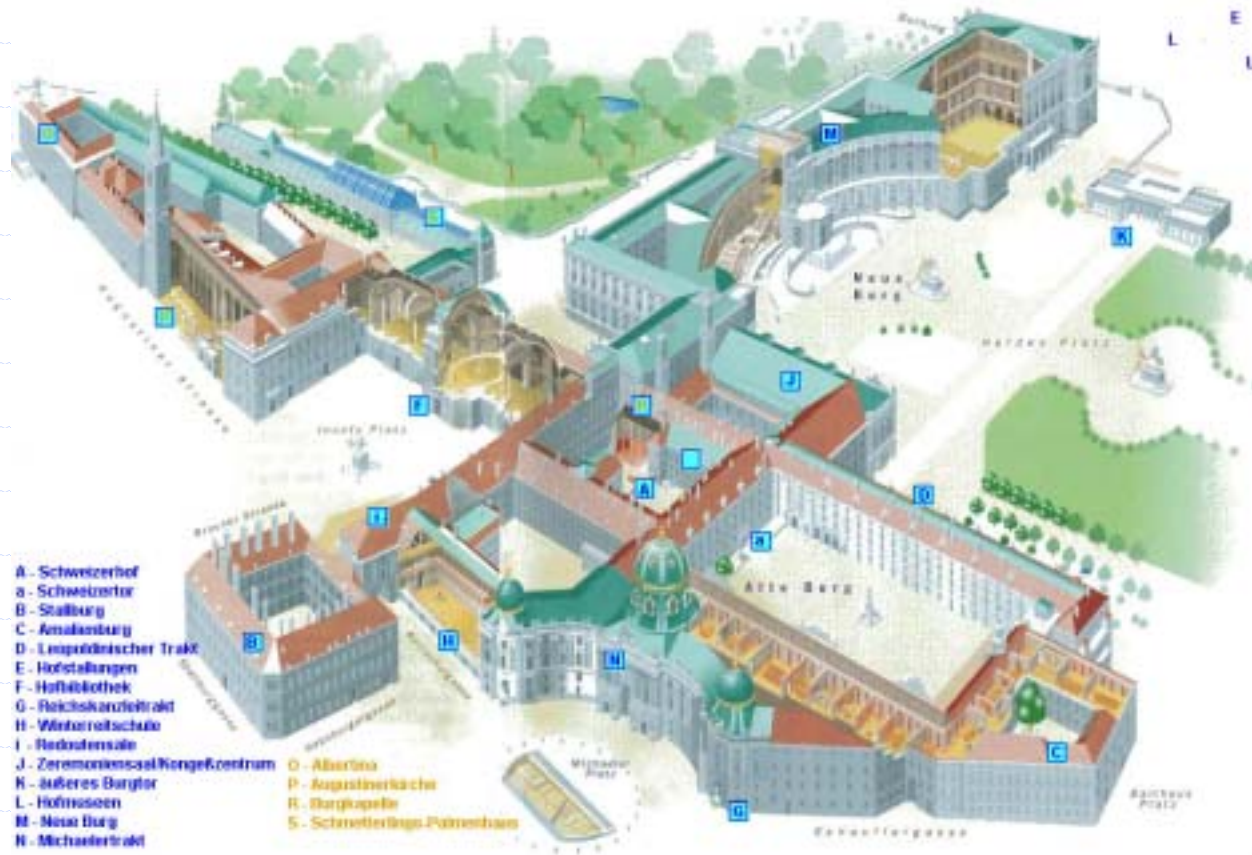
CST ALADIN Fortran Programme

FSN Event Tree Method

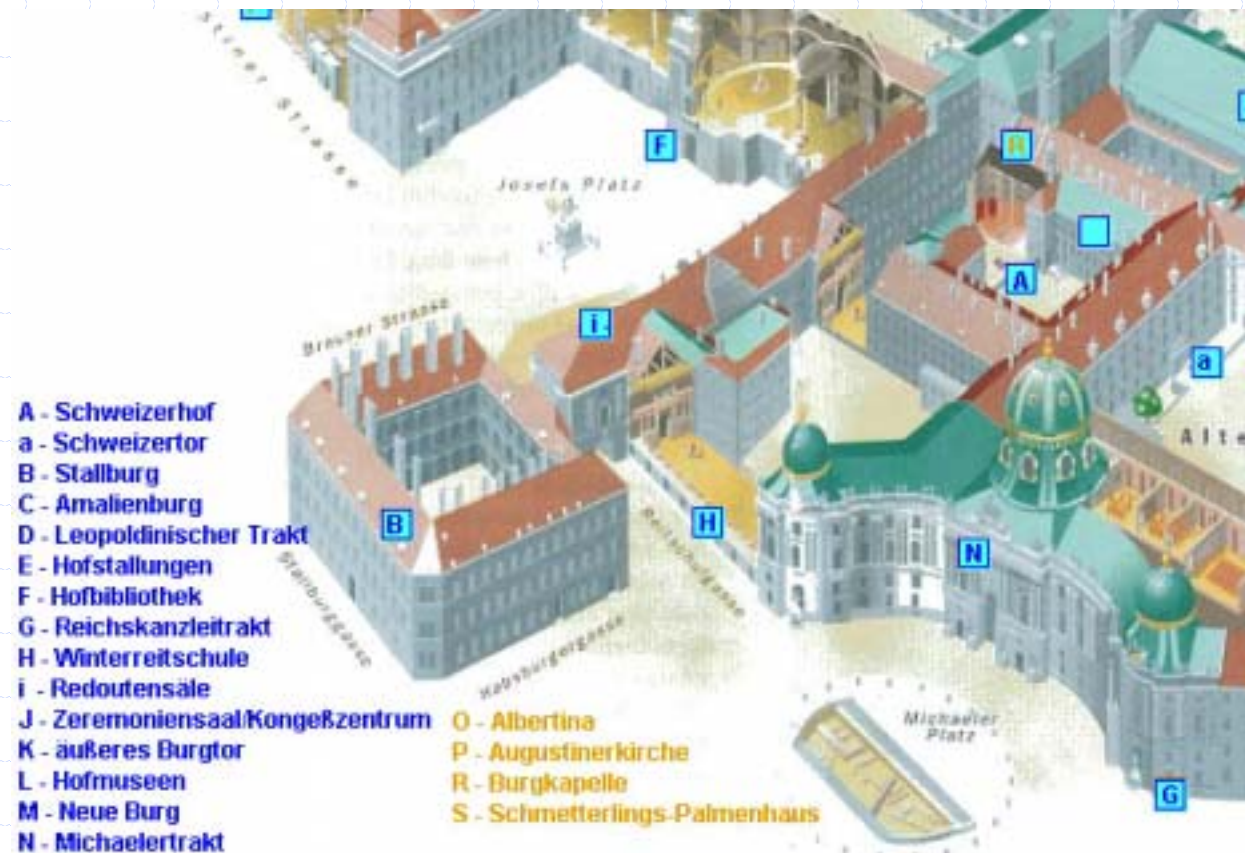
◆ Influence of timber structures upon fire risk

◆ Identification of measures with big influence upon fire risk

Case study: Imperial Castle Vienna



Case study: Imperial Castle Vienna

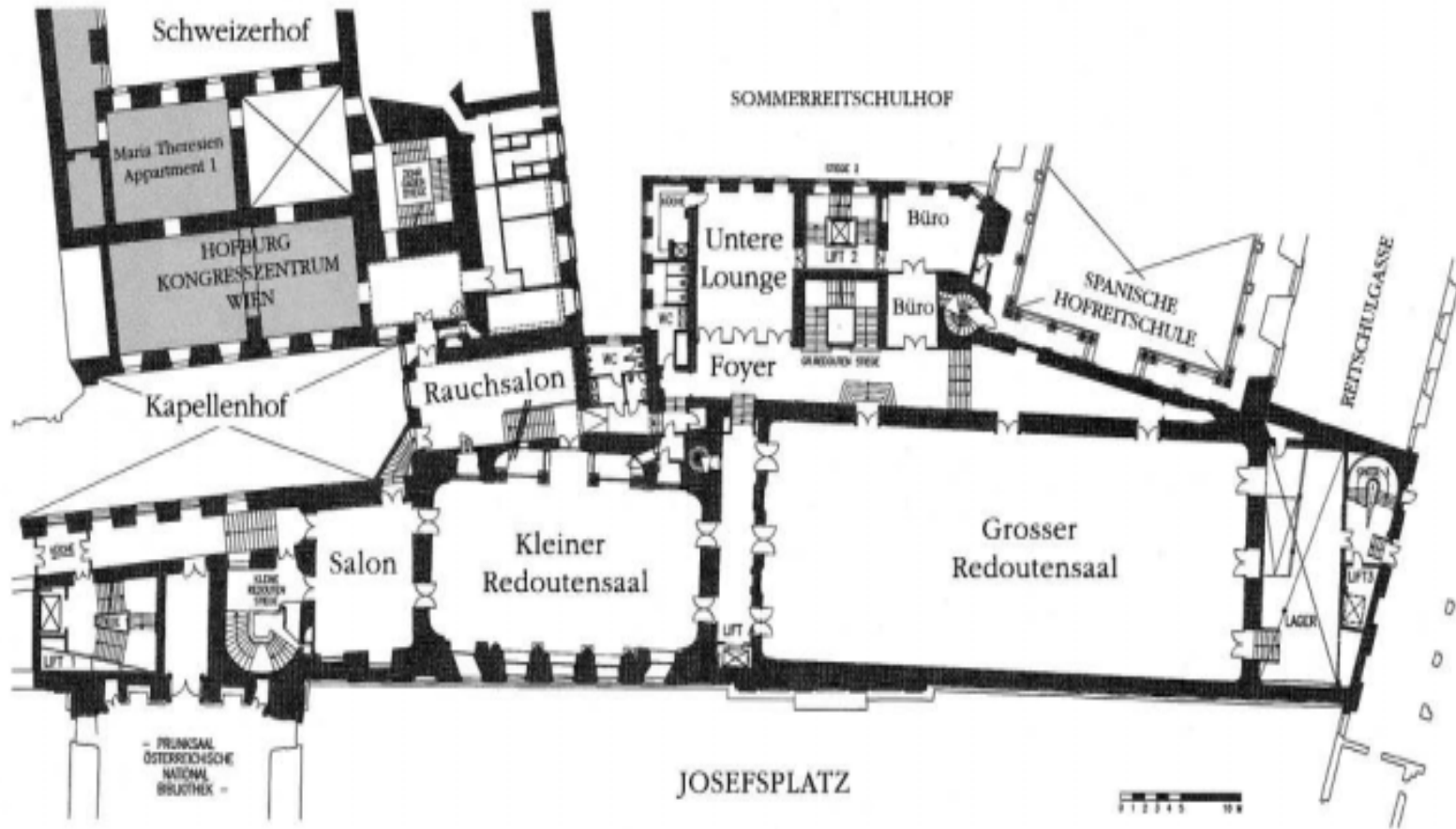


Case study: Imperial Castle Vienna





Case study: Imperial Castle Vienna



The big fire in the Redoutensäle

26. November 1992, during the night

56 Mio. Euro damage



Case study: risk analysis

Alternative 0: state of building before destruction by the big fire in the year 1992.

Alternative 1: assumption of the state of the building before the fire, but assumed, that the wooden roof was replaced by a steel construction.

Alternative 2: state of the building before the fire, under the assumption that active measures and installations for the early detection and fire fighting were installed.

IST Cost/Effectiveness Excel Sheet

PO - Fire Safety					
OB1 - Protect the occupants	OB2 - Protect the firemen	OB3 - Protect the building	OB4 - Protect contents	OB5 - Safeguard continuity of activity	OB6 - Protect the environment
ST1 - Reduce the probability of fire start	ST2 - Limit fire development/propagation	ST3 - Facilitate egress	ST4 - Facilitate fire fighting and rescue	ST5 - Limit the effects of fire products	
M1 - M19 Measures					

- M1 - Reaction to fire
- M2 - Fire resistance of structure
- M3 - Fire resistance of partitions
- M4 - Size of fire compartments
- M5 - Characteristics and location of openings on the facades
- M6 - Distance between buildings
- M7 - Geometry of egress paths
- M8 - Access for the firemen
- M9 - Means for fire detection
- M10 - Means for fire suppression
- M11 - Smoke control
- M12 - Emergency and alarm signs
- M13 - On site firemen
- M14 - Fire brigade
- M15 - Maintenance of fire safety systems
- M16 - Education for fire safety
- M17 - Emergency planning + training
- M18 - Salvage operation management
- M19 - Periodic inspection of the building

Preference / importance	Scores
None	0
Very little	1
Weak	3
Medium	5
Strong	7
Absolute	9

Table 4.2 – SAATY Scale for Setting the Scores

IST Cost / Effectiveness Excel Sheet

		PC - Reduce fire risk																
	Risk	T																
OC1 - Protect the occupants	2	0.229																
OC2 - Protect the public	3	0.072																
OC3 - Protect the building	4	0.195																
OC4 - Protect contents	5	0.195																
OC5 - Salvage of continuity of activity	6	0.322	OC1 - Protect the occupants	OC2 - Protect the fireman	OC3 - Protect the building	OC4 - Protect contents	OC5 - Salvage of continuity of activity	OC6 - Protect the environment										
OC6 - Protect the environment	7	0.195	2	3	4	5	6	7										
ST1 - Reduce the probability of fire start	8	0.229	8.221	0.388	0.390	8.221	0.589	0.217										
ST2 - Limit fire development	9	0.272	8.779	0.323	0.390	8.221	0.242	0.298										
ST3 - Facilitate egress	10	0.002	8.221	0.388	0.890	0.077	0.125	0.890										
ST4 - Facilitate fire-fighting and rescue	11	0.242	8.820	0.203	0.210	8.221	0.589	0.208	ST1 - Reduce the probability of fire start	ST2 - Limit fire development	ST3 - Facilitate egress	ST4 - Facilitate fire-fighting and rescue	ST5 - Limit the effects of fire products					
ST5 - Limit the effects of fire products	12	0.162	8.221	0.203	0.907	8.221	0.242	0.890	8	9	10	11	12					
MF1 - Reaction to fire	13	0.121	0.008	0.388	0.820	0.028	0.185	0.824	0.222	0.387	0.894	0.288	0.087					
MF2 - Fire resistance of structures	14	0.044	0.890	0.384	0.887	0.388	0.008	0.889	0.890	0.248	0.895	0.287	0.049					
MF3 - Fire resistance of partitions	15	0.062	0.894	0.388	0.871	0.812	0.008	0.002	0.890	0.287	0.894	0.287	0.067					
MF4 - Fire at the compartment	16	0.007	0.008	0.384	0.887	0.387	0.005	0.887	0.890	0.248	0.847	0.248	0.049					
MF5 - Characteristics and location of openings in walls	17	0.248	0.067	0.384	0.890	0.388	0.005	0.068	0.890	0.287	0.890	0.248	0.029					
MF6 - Distance between buildings	18	0.022	0.002	0.382	0.884	0.384	0.002	0.886	0.890	0.248	0.890	0.329	0.180					
MF7 - Geometry of egress paths	19	0.389	0.008	0.881	0.882	0.383	0.002	0.884	0.890	0.288	0.894	0.248	0.008					
MF8 - Access for the firemen	20	0.026	0.008	0.383	0.887	0.388	0.008	0.008	0.890	0.248	0.825	0.287	0.008					
MF9 - Means for fire detection	21	0.062	0.894	0.388	0.871	0.812	0.008	0.002	0.890	0.287	0.894	0.287	0.067					
MF10 - Means for fire suppression	22	0.066	0.894	0.388	0.042	0.810	0.008	0.002	0.890	0.287	0.895	0.287	0.067					
MF11 - Smoke control	23	0.067	0.890	0.385	0.088	0.088	0.007	0.088	0.890	0.248	0.894	0.287	0.067					
MF12 - Emergency and exit sign	24	0.022	0.008	0.383	0.882	0.385	0.008	0.008	0.890	0.288	0.894	0.010	0.088					
MF13 - On site firemen	25	0.088	0.894	0.388	0.002	0.810	0.008	0.002	0.890	0.287	0.895	0.287	0.067					
MF14 - Fire brigade	26	0.042	0.007	0.384	0.888	0.388	0.005	0.008	0.890	0.287	0.820	0.287	0.029					
MF15 - Maintenance of fire safety systems	27	0.007	0.008	0.384	0.887	0.387	0.005	0.887	0.890	0.248	0.847	0.248	0.049					
MF16 - Education for fire safety	28	0.009	0.821	0.881	0.822	0.810	0.008	0.310	0.829	0.820	0.388	0.029						
MF17 - Emergency lighting - training	29	0.059	0.810	0.385	0.088	0.088	0.007	0.002	0.890	0.287	0.894	0.287	0.088					
MF18 - Service operation management	30	0.188	0.008	0.382	0.882	0.384	0.002	0.890	0.890	0.288	0.890	0.288	0.067					
MF19 - Fire drills	31	0.088	0.821	0.881	0.822	0.810	0.008	0.310	0.829	0.820	0.388	0.029						

IST Cost / Effectiveness Excel Sheet

The image displays three screenshots of an Excel spreadsheet. The top screenshot shows a table with columns for 'Implementation Grade', 'Alternative 0', 'Alternative 1', and 'Alternative 2'. The middle screenshot shows a large table with many rows and columns, likely representing detailed data for each measure. The bottom screenshot shows a smaller table with columns for 'Implementation Grade', 'Alternative 0', 'Alternative 1', and 'Alternative 2'.

Implementation Grade	Alternative 0	Alternative 1	Alternative 2
G1 - Reaction to fire	0.60	0.60	0.60
G2 - Fire resistance of structure	0.44	0.70	0.44
G3 - Fire resistance of partitions	0.12	0.12	0.12
G4 - Size of fire compartments	0.40	0.40	0.40
G5 - Characteristics and location of openings on the facades	0.88	0.88	0.88
G6 - Distance between buildings	0.25	0.25	0.25
G7 - Geometry of egress paths	0.55	0.68	0.55
G8 - Access for the firemen	0.40	0.40	0.40
G9 - Means for fire detection	0.40	0.40	1.00
G10 - Means for fire suppression	0.20	0.20	1.00
G11 - Smoke control	0.00	0.00	0.00
G12 - Emergency and alarm signs	0.60	0.60	1.00
G13 - On site firemen	1.00	1.00	1.00
G14 - Fire brigade	0.68	0.68	0.68
G15 - Maintenance of fire safety systems	0.62	0.62	1.00
G16 - Education for fire safety	0.80	0.80	1.00
G17 - Emergency planning + training	0.80	0.80	1.00
G18 - Salvage operation management	0.40	0.40	0.40
G19 - Periodic inspection of the building	0.70	0.70	1.00

IST Cost / Effectiveness Excel Sheet

The image displays three screenshots of an Excel spreadsheet. The top screenshot shows a wide table with many columns, likely representing various cost and effectiveness metrics. The middle screenshot shows a table with a red column on the right, possibly indicating a specific category or status. The bottom screenshot shows a table with multiple columns and rows, some highlighted in yellow and green, suggesting a detailed breakdown of data.

◆ Effectiveness Index:

- 0 – no measures available
- 1 – all measures available and fully completed
- ◆ no objective result but relative value,
- ◆ comparison useful

$$E(PO) = \sum_{i=1}^6 \sum_{j=1}^5 \sum_{k=1}^{19} OB(i) \cdot ST(ji) \cdot M(kj) \cdot G(k)$$

IST Cost / Effectiveness Excel Sheet

Item	Unit	Quantity	Unit Price	Total Price	...
...

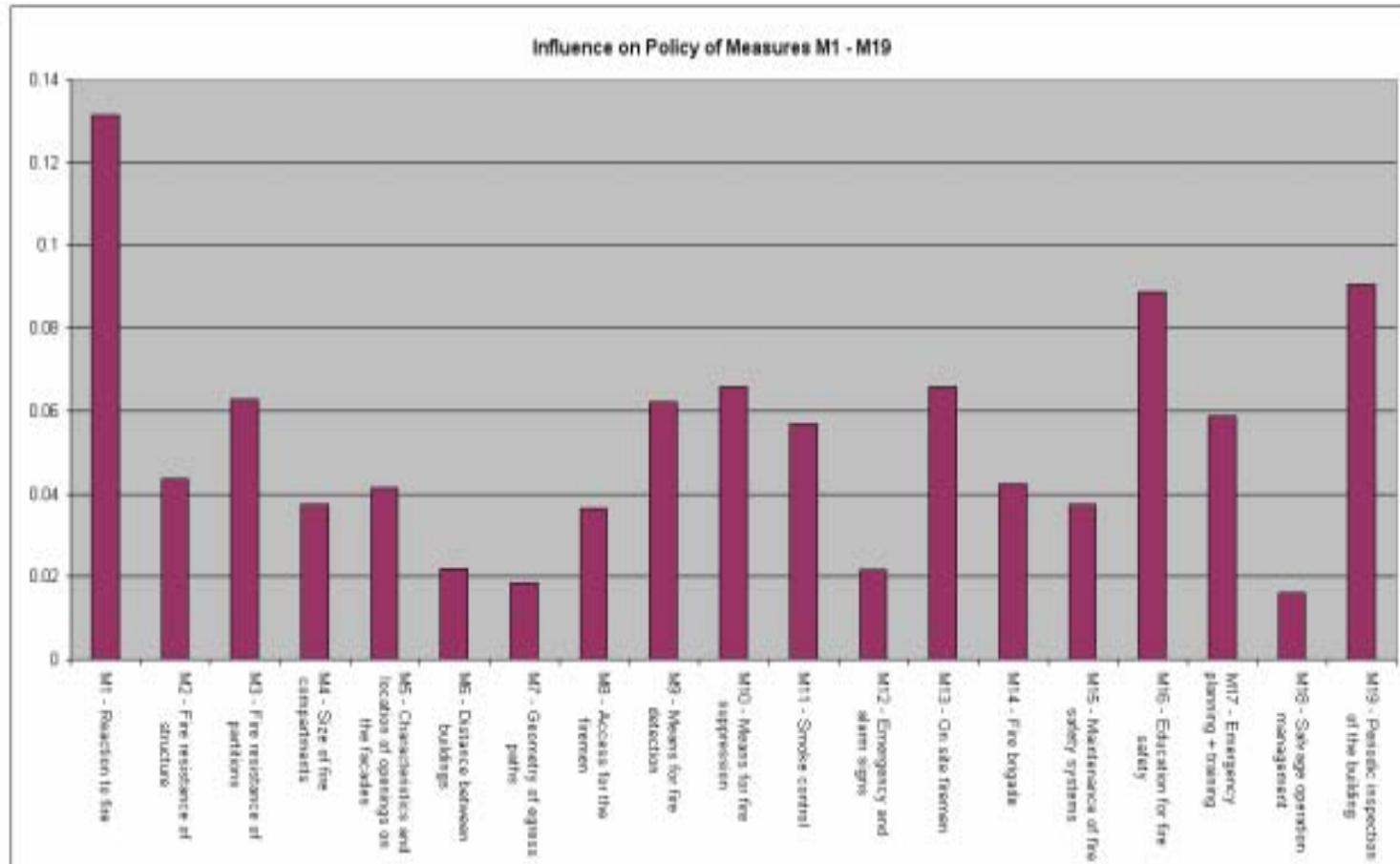
Item	Unit	Quantity	Unit Price	Total Price	...
...

Item	Unit	Quantity	Unit Price	Total Price	...
...

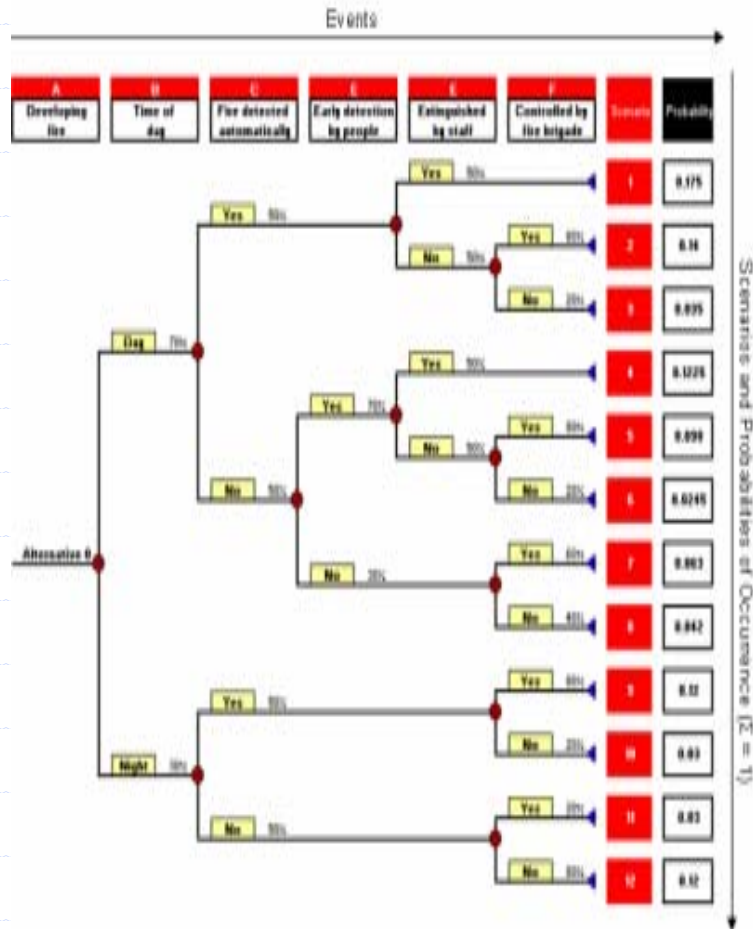
◆ Effectiveness/Cost Ratio:

$$\frac{E(PO)_1 - E(PO)_0}{\left(\sum_{k=1}^{19} C_k \right)_1}$$

CSTB Aladin

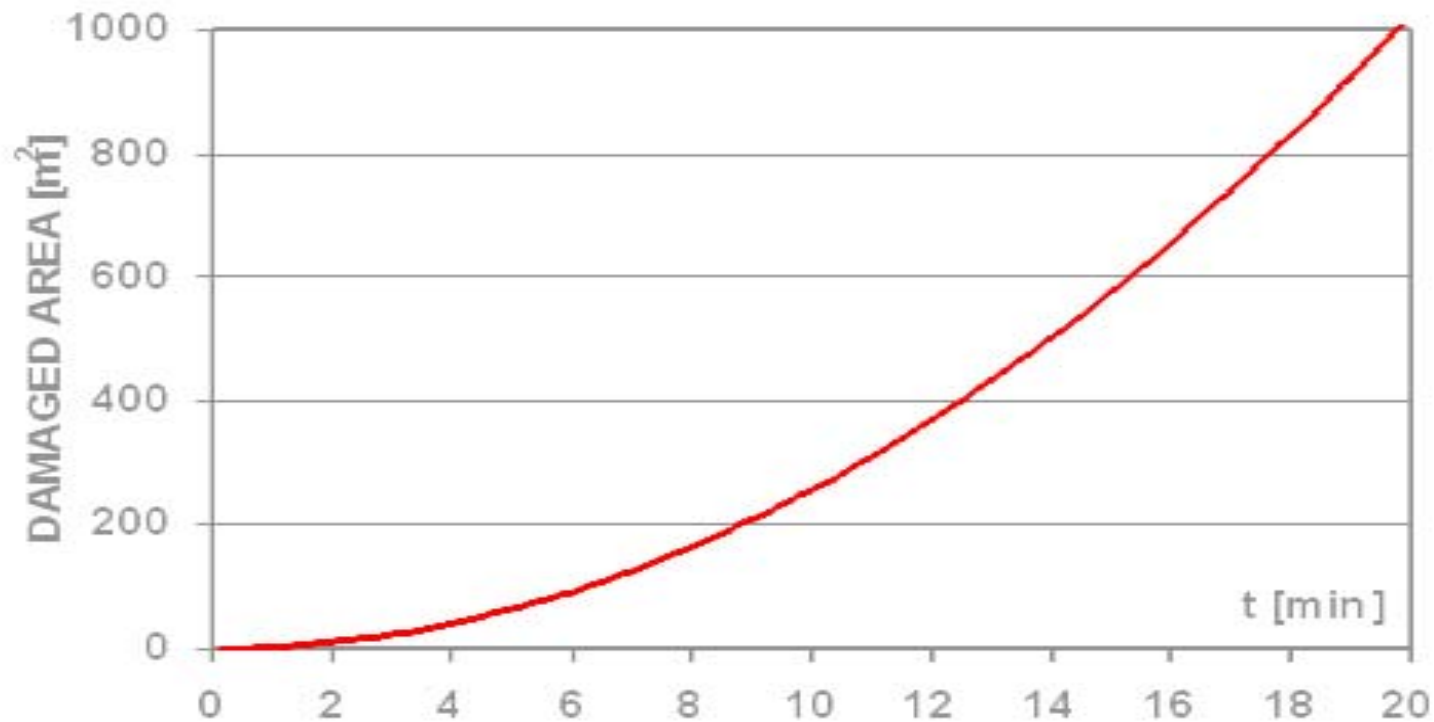


FSN Event tree method



- ◆ - Events and temporal sequence
- ◆ - Terms for sequence of the single events
- ◆ - Probabilities for success or failure

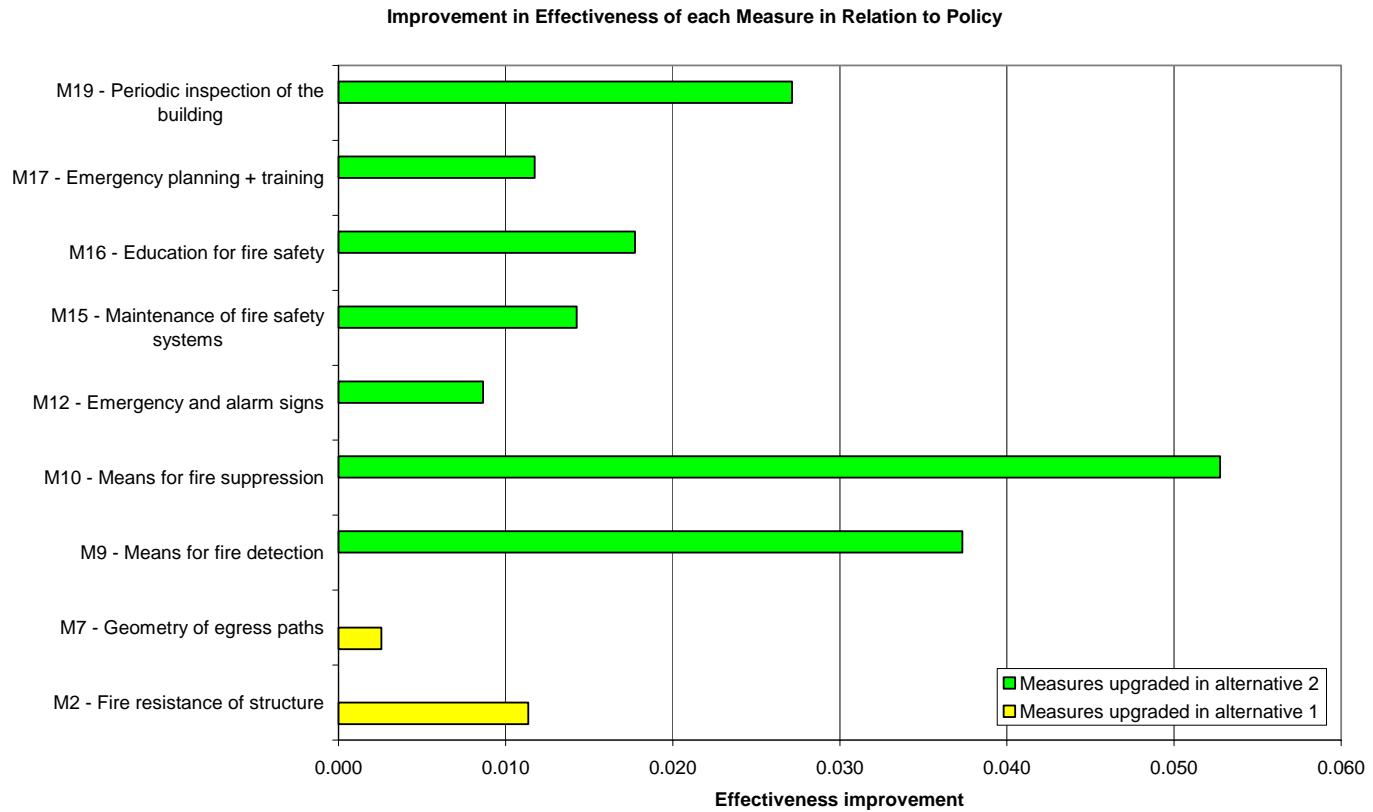
FSN Event tree method



Results

Method	Result	Alternative 0	Alternative 1	Alternative 2
IST Cost/Effectiveness Excel Sheet	Effectiveness Index	0.54	0.56	0.71
	Cost/Effectiveness Index	-	34.9	15.6
	Effectiveness/Cost Ratio	-	0.01	0.07
FSN Event Tree Method	Average risk of damage (burnt area) [m²]	635	635	120
	Probability of total Damage [%]	30.7	30.7	4.4

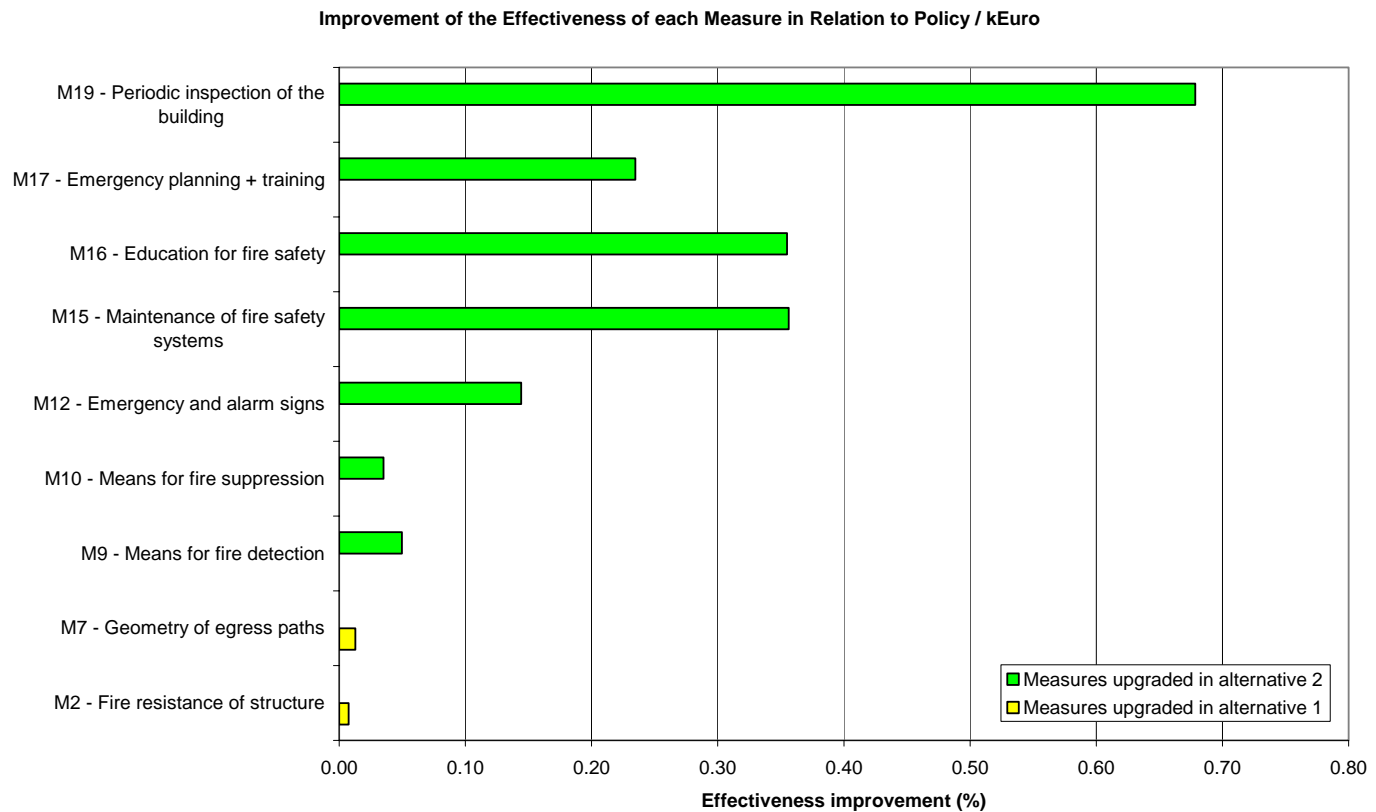
Results



Results

Method	Result	Alternative 0	Alternative 1	Alternative 2
IST Cost/Effectiveness Excel Sheet	Effectiveness Index	0.54	0.56	0.71
	Cost/Effectiveness Index	-	34.9	15.6
	Effectiveness/Cost Ratio	-	0.01	0.07
FSN Event Tree Method	Average risk of damage (burnt area) [m ²]	635	635	120
	Probability of total Damage [%]	30.7	30.7	4.4

Results



Realistic reflection on the fire behaviour of buildings

- ◆ Request for fire safety in buildings is well defined
- ◆ European fire safety standards reflect present state of the art
- ◆ Lot of projects been carried out
- ◆ Coordination of research work needed
- ◆ **Timber structures achieve high safety levels**



**Thank you very much for
your attention !**