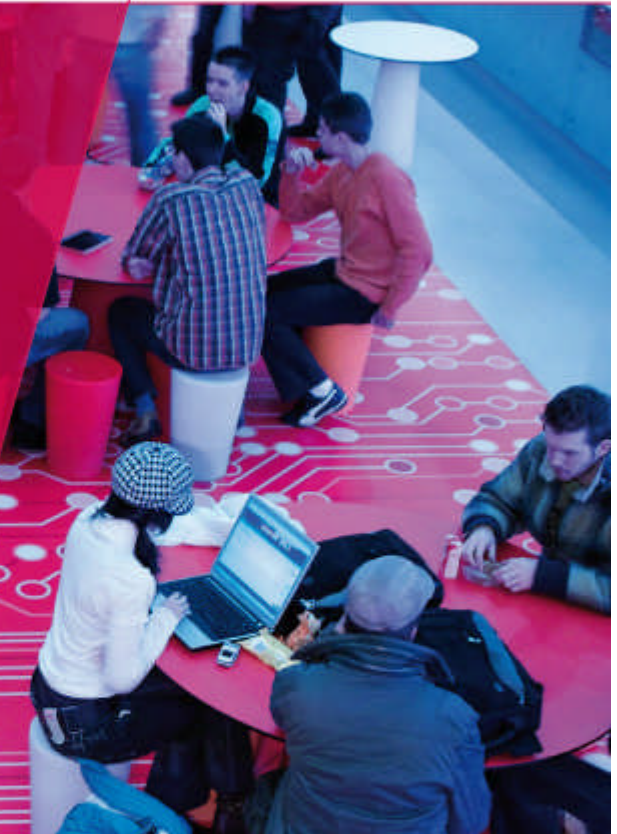


Prevention and suppression

Dealing with uncertainties in a time dependent balance (workshop)

Prof. Ruud van Herpen, TU/e / Saxion



 Nieman

TU  **e** Technische Universiteit
Eindhoven
University of Technology

Where innovation starts

Ruud van Herpen



Eindhoven University of technology:
Fellow Fire Safety Engineering (Building & Architecture – unit BPS) – 0,2 fte

Saxion University of applied sciences:
Professor Fire safety in buildings – 0,1 fte

Nieman consulting engineers:
Technical director – 0,7 fte

 Nieman

Workshop contents

Objectives for fire safety

Prevention:

Fire development and LOD's
Project specific characteristics
Uncertainties

Suppression:

Strategies
Operational time
Uncertainties

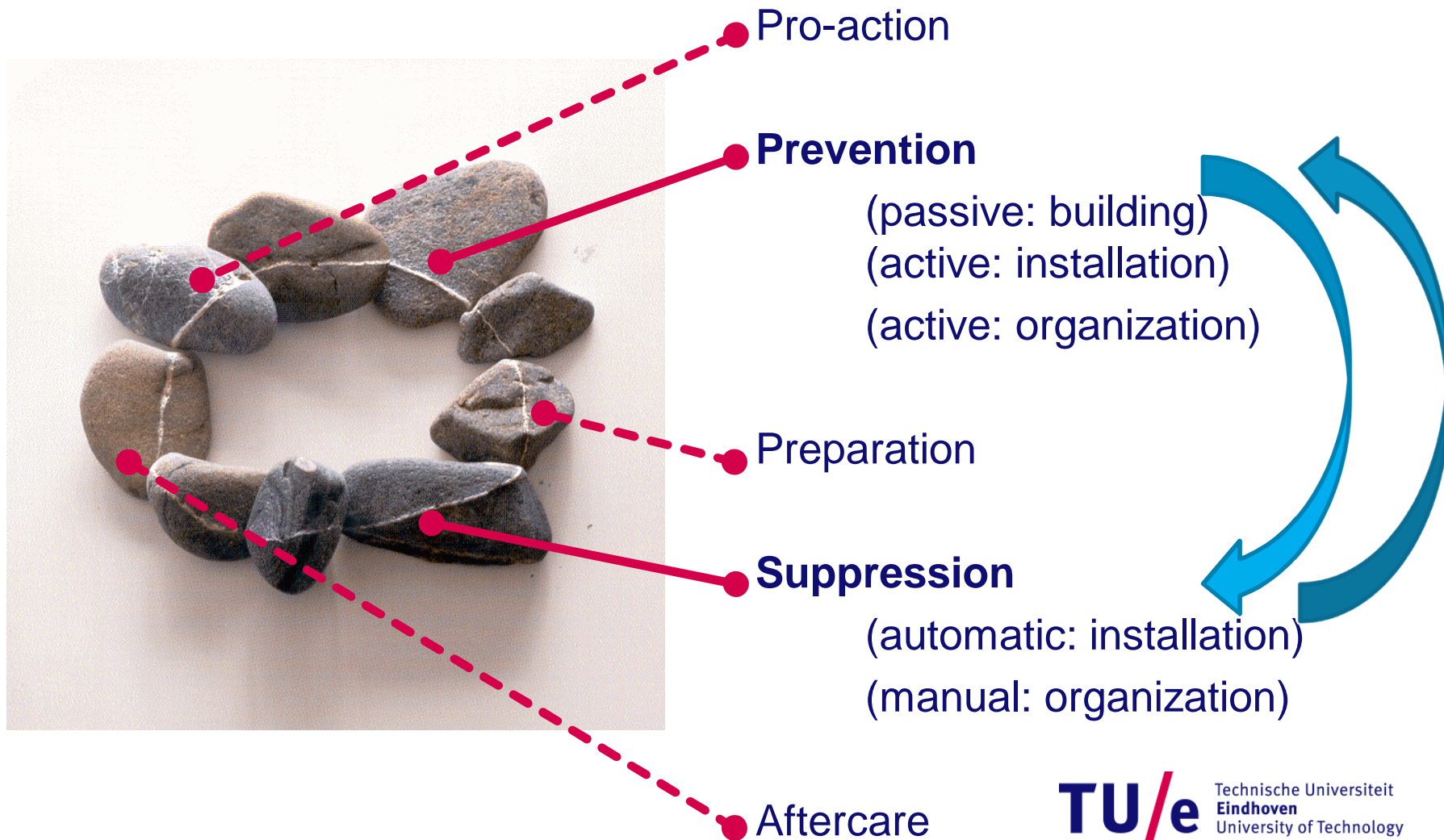
Performance based suppression

By linking suppression and prevention

Link?

- preventive measures
in the building code
- suppression strategy
of the fire brigade

Safety chain





**Building code and firesuppression code:
Safety goals**

OBJECTIVES FOR FIRE SAFETY

Objectives for fire safety

Public objectives:

Preventing deaths from fire

- Personal safety of building occupants, fire fighters, ...

Preventing fire damage to third parties

- Neighbouring plots

Private objectives:

Sustainability, resilience,

Damage control,

Business continuity,

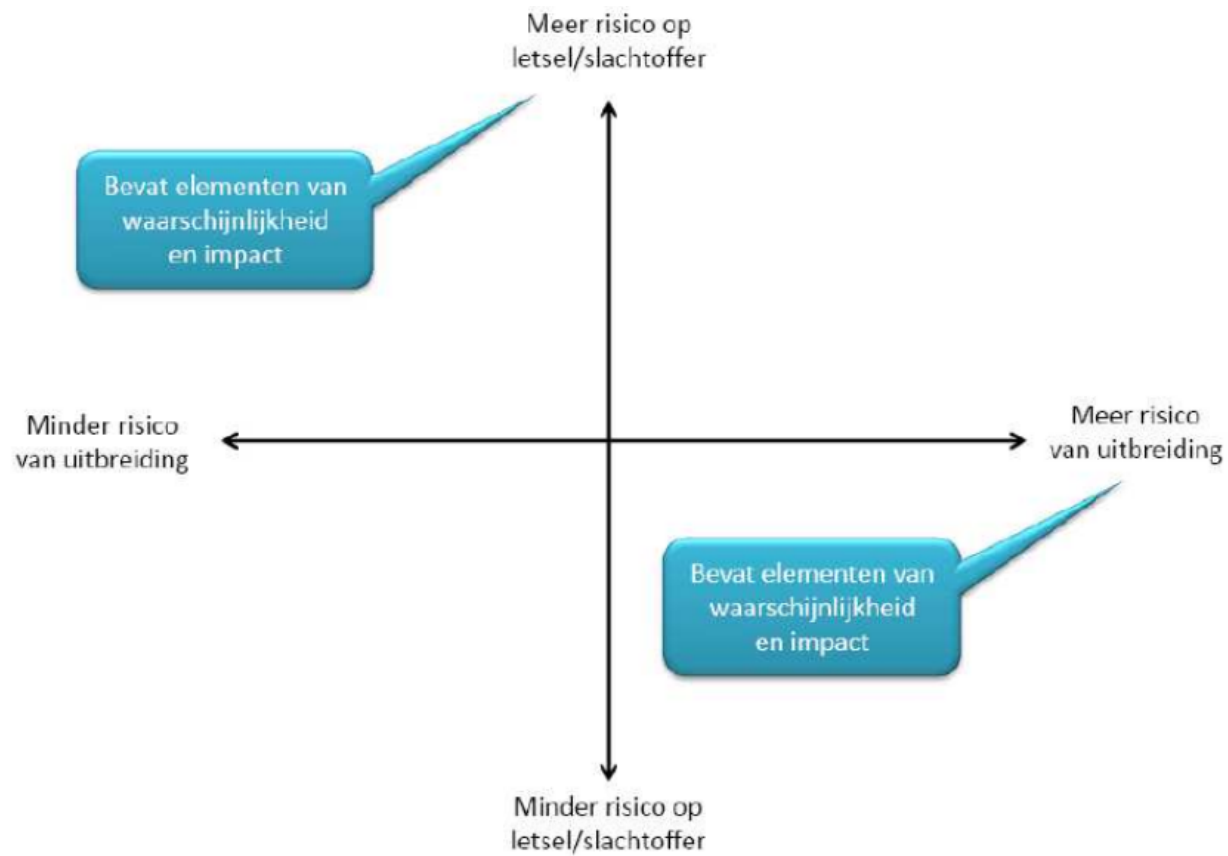
Protection environment,

...?



Objectives for fire safety

Two main public objectives



Objectives: rules or risk

Safety of third party properties

Objective:

Preventing fire spread to neighbouring plots

Rule based (building code):

Distance to property borders, radiationflux, fire resistance of separation constructions and load bearing elements, etc...

Risk based:

The failureprobability and failureconsequences of the objective

Objectives: rules or risk

Safety of building occupants

Objective:

Reaching a safe haven without health-damage

Rule based (building code):

Walking-distances, flow- and storagecapacities of building occupants, number and dimensions of escaperoutes, safety-level of escaperoutes, fire resistance of escaperoutes, etc....

Risk based:

The failureprobability and failureconsequences of the objective

Objectives: rules or risk

Rules / regulations:

Simple assessment

Generic measures

Undefined safety level

(no tailormade firesafety concept,
changing boundary conditions have no
consequences)

Acceptable risk:

Complex assessment

Projects specific measures

Uniform safety level

(projectspecific characteristics and boundary
conditions: fuel – building – building occupants)





Fire development and LOD's for building safety

PREVENTION

Objectives and LOD's

Risk objectives of the building code (Dutch building decree):

- Safe environment (neighbouring plots)
- Safe building (structure)
- Safe compartmentation (max. spread of fire and smoke)
- Safe escape route (building occupants)
- Safe attack route (suppression and assistance)

Acceptable failure risk or failure probability per objective?

Objectives and LOD's

Risk objectives of the building code (Dutch building decree):

Safe environment (neighbouring plots)

Safe building (structure)



LOD

Safe compartmentation (max. spread of fire and smoke)



LOD

Safe escape route (building occupants)

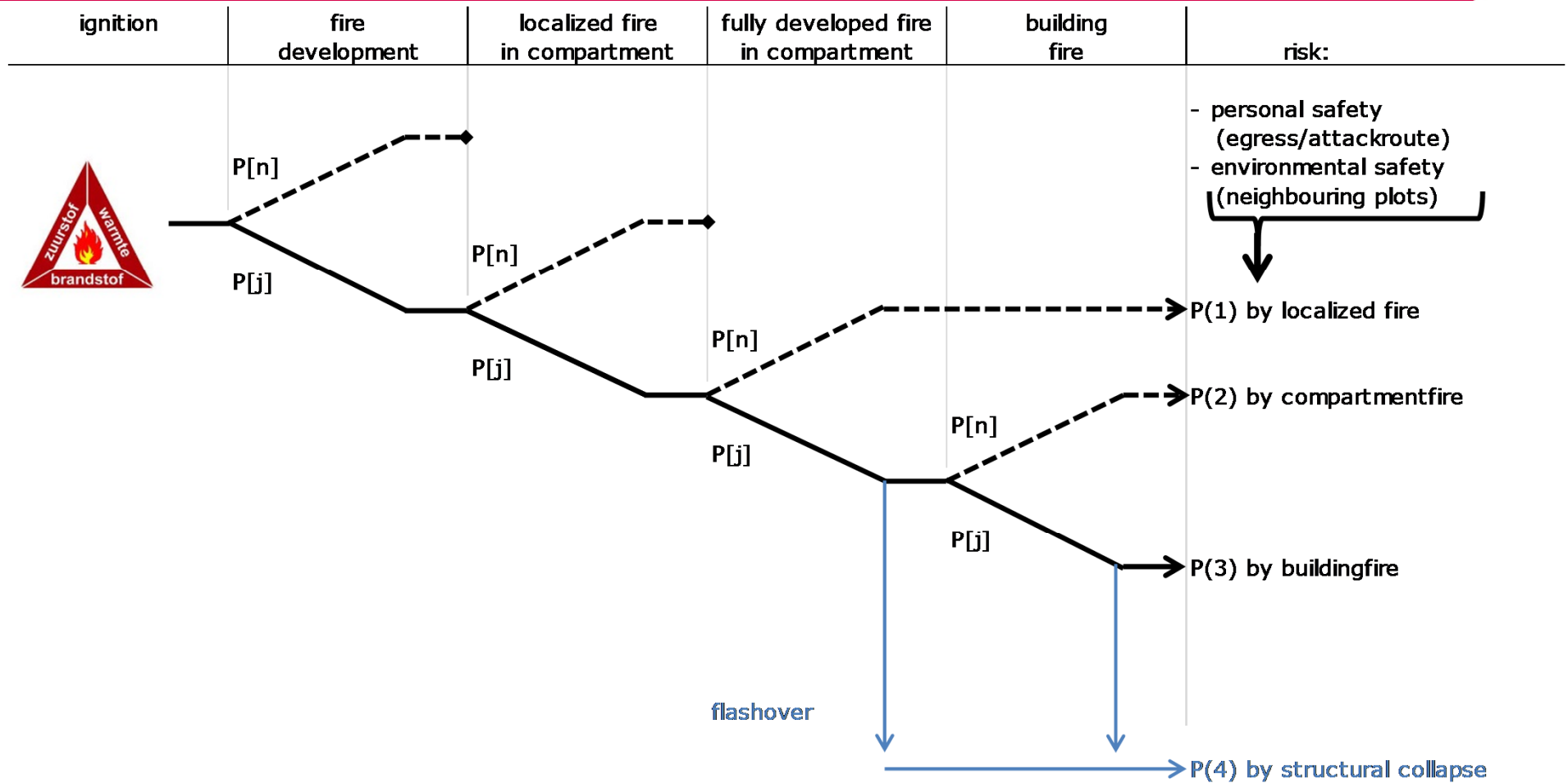
Safe attack route (suppression and assistance)

Are fire safe buildings possible:

Without escape routes?

Without attack routes?

Objectives and LOD's



Project-specific characteristics

Natural fire

Taking into account project-specific characteristics:

Fuel



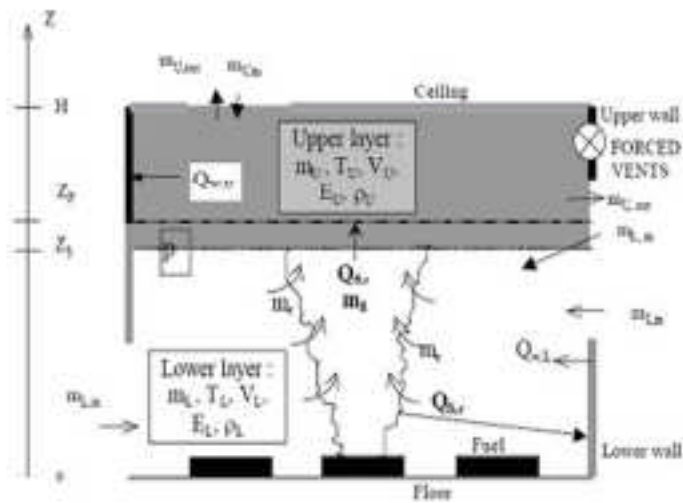
Building



Project-specific characteristics

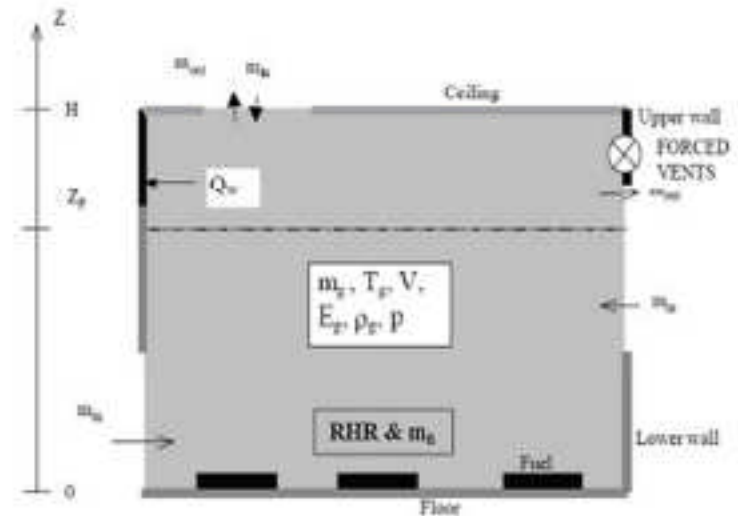
Natural fire

Pre flashover: two zones



flashover

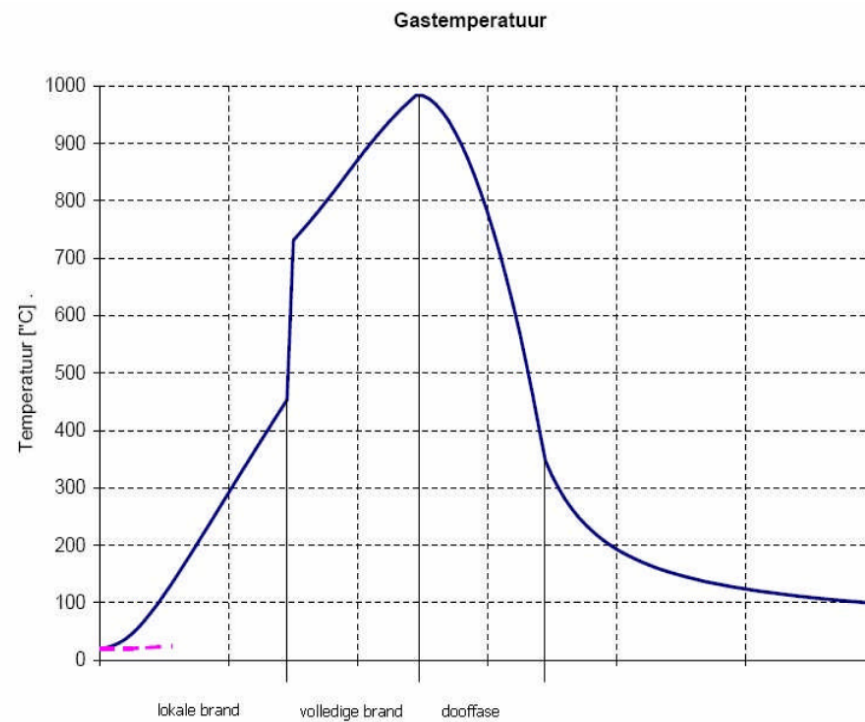
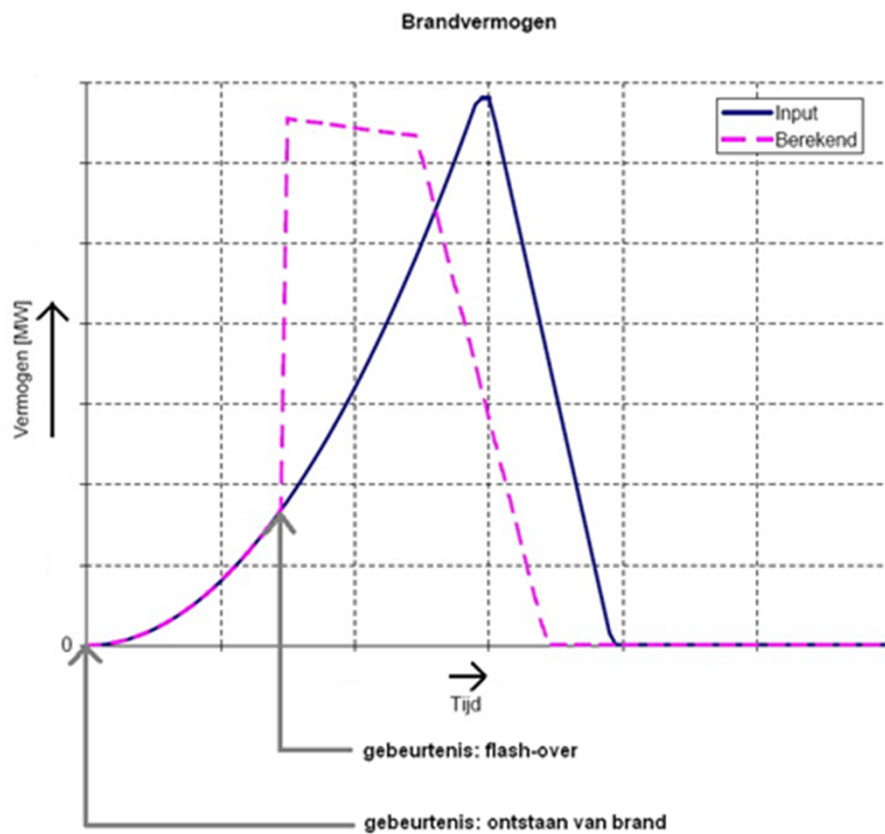
Post flashover: one mixed zone



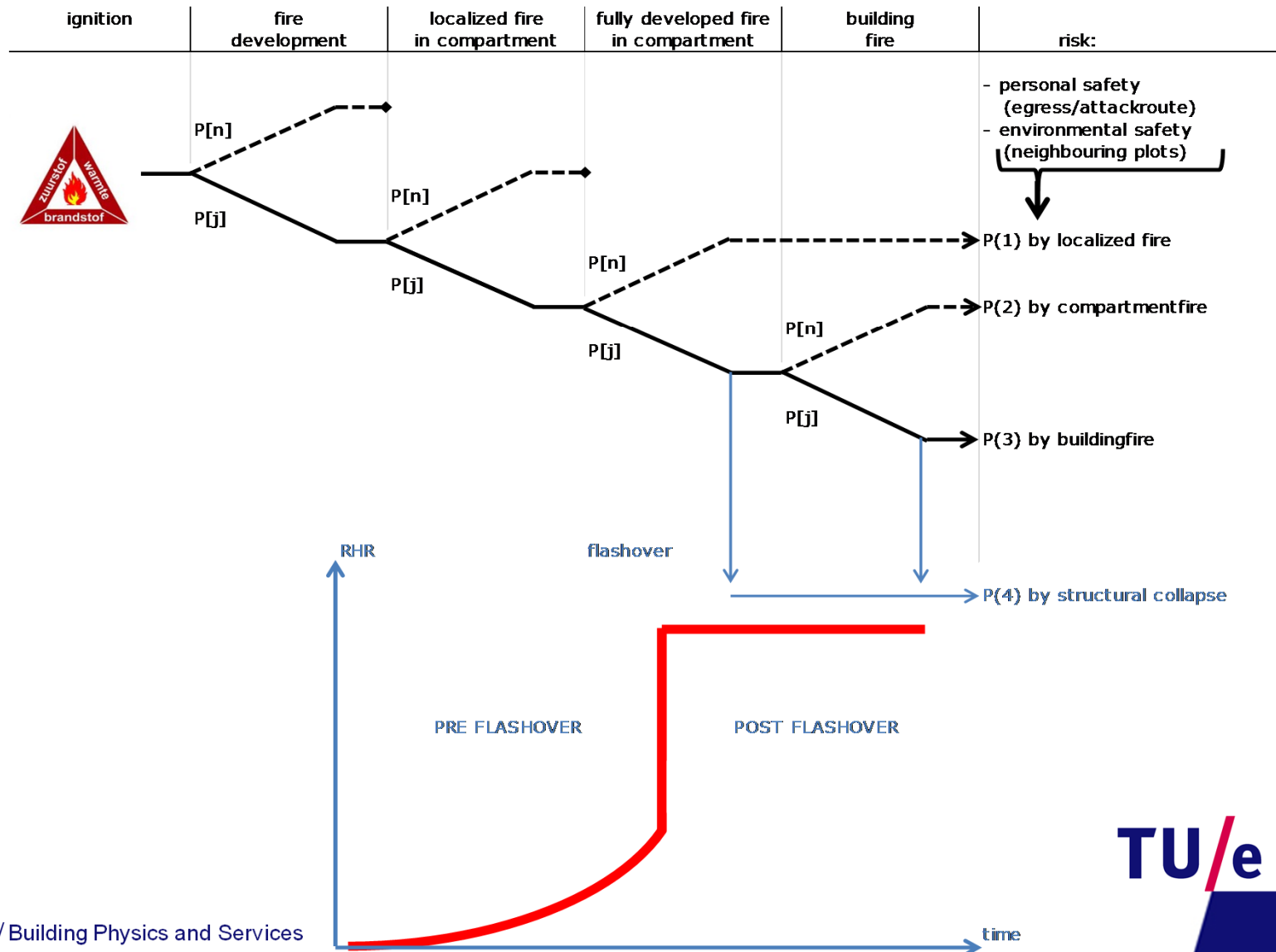
Flashover conditions

Project-specific characteristics

Natural fire



Project-specific characteristics



Critical incident: Flashover

Objectives of the building code (POST-F.O.):

- Safe environment (neighbouring plots)
- Safe building (structure)
- Safe compartmentation (max. spread of fire and smoke)
- Safe escape route (building occupants)
- Safe attack route (suppression and assistance)

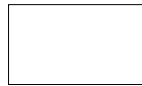
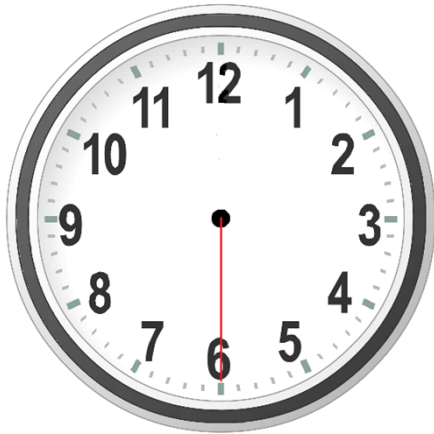
Objectives of the building code (PRE-F.O.):

- Safe escape route in compartment (building occupants)

Pre-F.O. Fire:

No WBDBO assessment needed?

Critical incident: Flashover



**minutes to
flashover?**



Critical incident: Flashover

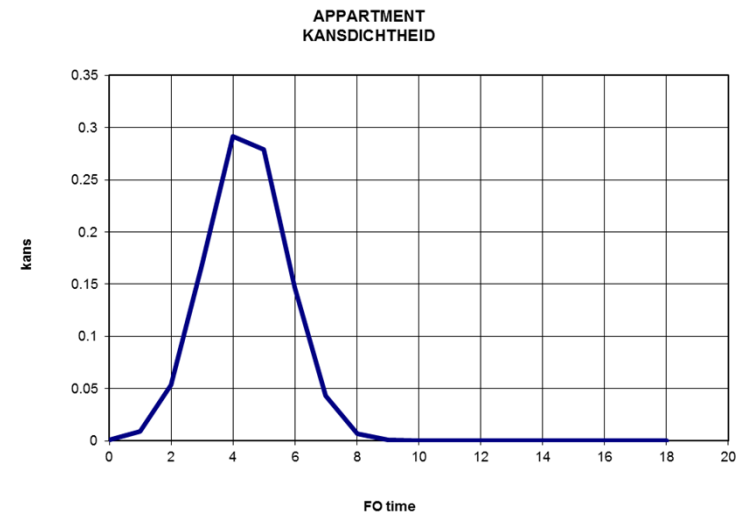
Your Votes:

FLASHOVER TIME (experts opinion)

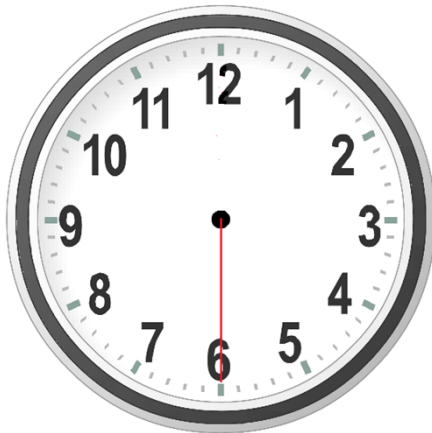
case apartment 100 m2
 aantal stemmers 40 250 kW/m2
 fast development
 3 m (height)

FO-time	aantal	gemiddelde	variantie
1	0	0	-3.43 0.00
2	1	0.05	-2.43 5.88
3	10	0.75	-1.43 2.03
4	11	1.1	-0.43 0.18
5	12	1.5	0.57 0.33
6	2	0.3	1.58 2.48
7	3	0.525	2.58 6.63
8	1	0.2	3.58 12.78
9	0	0	4.58 0.00
10	0	0	5.58 0.00
11	0	0	6.58 0.00
12	0	0	7.58 0.00
13	0	0	8.58 0.00
14	0	0	9.58 0.00
15	0	0	10.58 0.00
16	0	0	11.58 0.00
17	0	0	12.58 0.00
18	0	0	13.58 0.00

40	4.425	1.684132	1.297741
	gemiddelde	variantie	standaardafwijking



Critical incident: Flashover



**minutes to
flashover?**



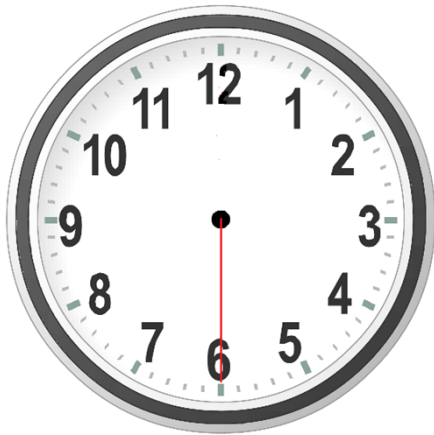
Critical incident: Flashover

Your Votes:

The supermarket has a sprinklersystem:
F.O. time > 60 min.

Without sprinkler F.O. time \ll 60 min.!

Critical incident: Flashover



minutes to
flashover?



Critical incident: Flashover

Your Votes:

FLASHOVER TIME (EXPERTS OPINION)

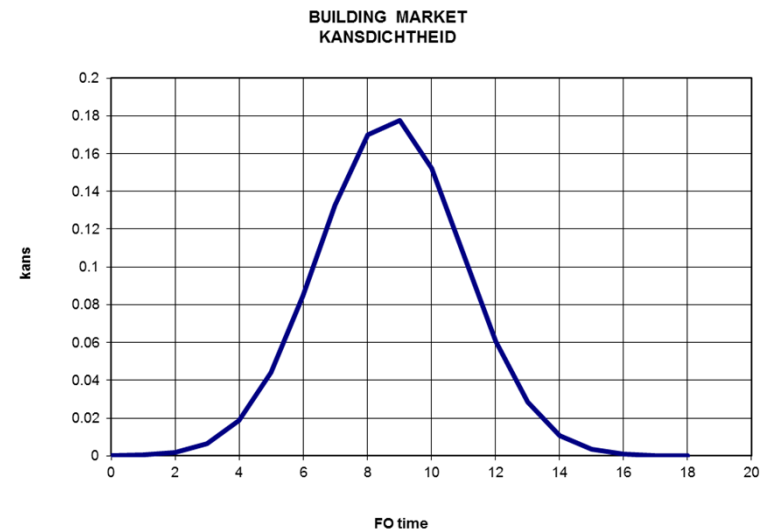
case
aantal stemmers

building market
40

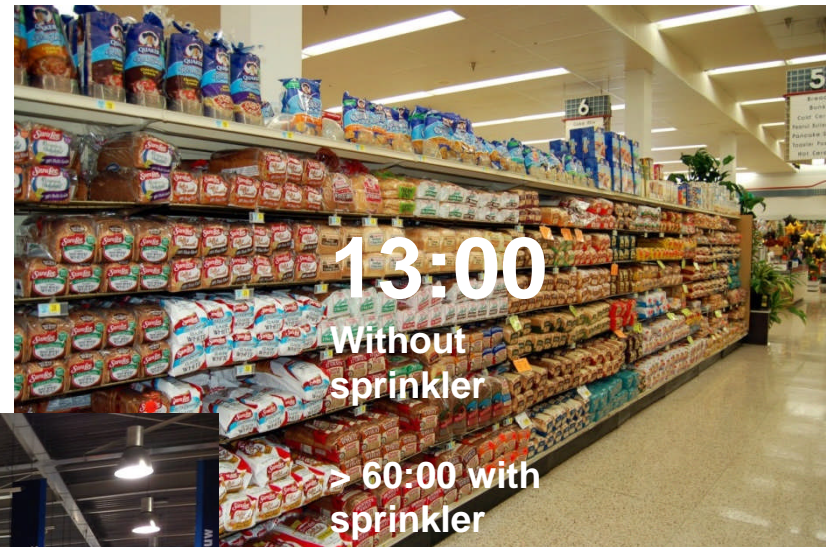
2000 m2
500 kW/m2
ultrafast development
7 m (height)

FO-time	aantal	gemiddelde		variantie
1	0	0	-7.73	0.00
2	0	0	-6.73	0.00
3	0	0	-5.73	0.00
4	0	0	-4.73	0.00
5	2	0.25	-3.73	13.88
6	3	0.45	-2.73	7.43
7	3	0.525	-1.73	2.98
8	11	2.2	-0.73	0.53
9	7	1.575	0.28	0.08
10	11	2.75	1.28	1.63
11	1	0.275	2.28	5.18
12	0	0	3.28	0.00
13	1	0.325	4.28	18.28
14	0	0	5.28	0.00
15	1	0.375	6.28	39.38
16	0	0	7.28	0.00
17	0	0	8.28	0.00
18	0	0	9.28	0.00
MJ				

40	8.725	4.962813	2.227737
	gemiddelde	variantie	standaardafwijking



Critical incident: Flashover



Critical incident: Flashover

BUILDING		FIRE (FUEL)					
Acomp	Hcomp	ultra fast		fast		medium	
		250	500	250	500	250	500
[m ²]	[m]	[kW/m ²]	[kW/m ²]	[kW/m ²]	[kW/m ²]	[kW/m ²]	[kW/m ²]
100	3	0:02:05	0:01:59	0:03:30	0:03:21	0:06:13	0:06:15
	5	0:02:34	0:02:27	0:04:16	0:04:28	0:07:42	0:09:10
	10	0:03:11	0:03:36	0:05:46	0:07:18	0:11:03	0:14:01
	15	0:03:43	0:03:56	0:06:48	0:08:17	0:12:59	0:16:50
500	3	0:03:40	0:04:11	0:06:22	0:07:52	0:11:40	0:14:57
	5	0:04:29	0:05:19	0:07:48	0:09:46	0:14:23	0:18:57
	10	0:05:45	0:06:59	0:10:38	0:13:02	0:19:45	0:25:04
	15	0:06:34	0:08:18	0:12:08	0:15:45	0:23:15	0:30:28
1000	3	0:04:45	0:05:31	0:08:25	0:10:16	0:19:39	0:19:39
	5	0:05:49	0:06:56	0:10:18	0:12:54	0:19:32	0:24:42
	10	0:07:32	0:09:05	0:14:03	0:17:04	0:25:22	0:32:53
	15	0:08:31	0:10:44	0:15:53	0:20:24	0:30:29	0:39:24
2000	3	0:06:17	0:07:04	0:11:18	0:13:17	0:21:41	0:32:54
	5	0:07:39	0:09:05	0:13:46	0:17:04	0:25:55	0:32:54
	10	0:09:55	0:11:53	0:18:43	0:22:30	0:36:04	0:43:23
	15	0:11:07	0:13:58	0:20:54	0:26:32	0:40:13	0:51:17

Apartment

Supermarket

Buildingmarket



Suppression strategy, operational time and uncertainties

SUPPRESSION

Suppression in addition to prevention

Prevention:

Building act → Building code

Suppression:

Firesuppression act → Firesuppression code

- Availability of suppression/assistance by fire brigade
- Suppression strategies:....?

NL: act and code?

**Wet op de veiligheidsregio's
Besluit veiligheidsregio's**



NL Firesuppression Code

Nr.	Occupancy	Type of building	Norm opkomsttijd	Norm ontdekkings- en meldingstijd	Norm inzettijd
1	Building users self-reliant	Winkelfunctie met gesloten constructie	5	15	7
		Onderwijsfunctie	8	15	7
		Winkelfunctie	8	15	7
		Kantoorfunctie	8	15	7
		Overige gebruiksfunctie	10	15	7
		Overige bijeenkomstfunctie	10	15	7
		Sportfunctie	10	15	7
		Industriefunctie	10	15	7
2	Building users self-reliant, sleeping function	Logiesfunctie	8	1	7
3	Building users non self-reliant, sleeping function	Celfunctie	5	1	7
		Gezondheidszorgfunctie	8	1	7
		Bijeenkomstfunctie kinderopvang	8	1	7
4	Residential	Woonfunctie boven winkel	5	15	7
		Woonfunctie portiek	6	15	7
		Woonfunctie wonen met zorg	6	1 of 15	7
		Overige woonfunctie	8	15	7

NL Suppression times

Deterministic → Stochastic (assumption)

Time interval	Normative 80% fractile [min]	Average 50% fractile [min]	Standaard deviation [min]
Meldtijd (detection & alarm)	15 1	10 1	6,0 0,0
Opkomsttijd (fire brigade transfer)	5 6 8 10	2 3 5 7	3,6 3,6 3,6 3,6
Inzettijd (pre-action)	7	5	2,4

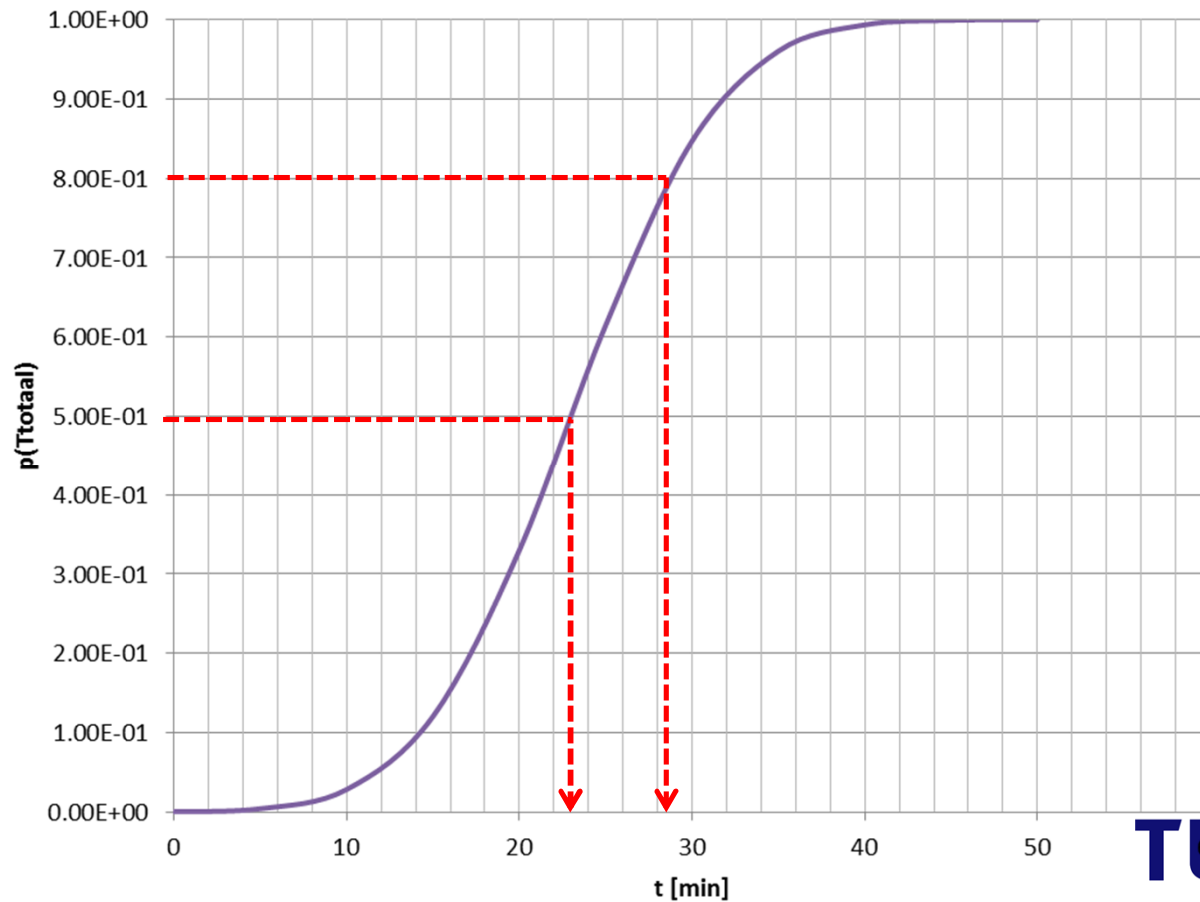
NL Suppression times

Operational time (pre suppression time)

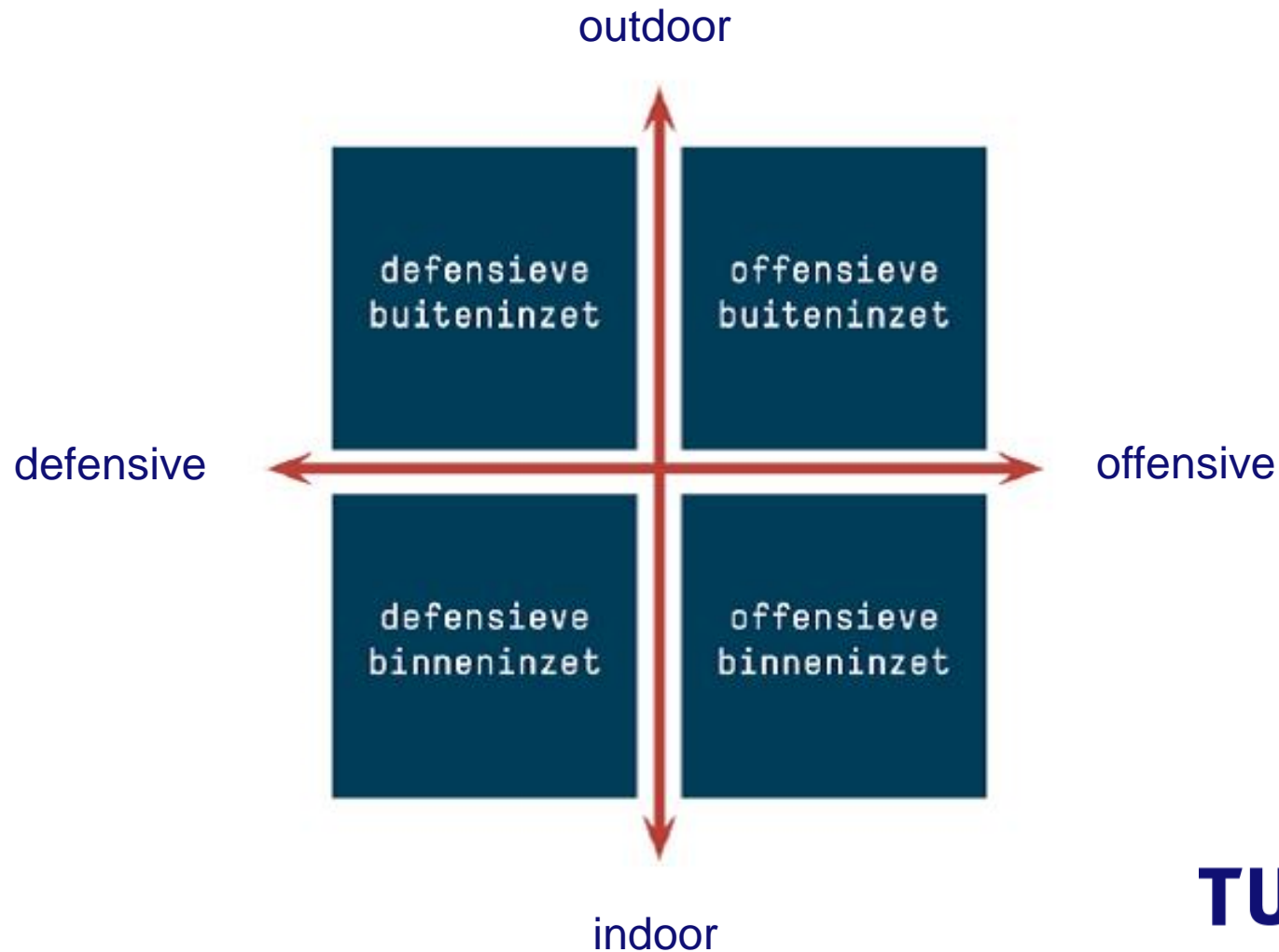
Combination	Inzettijd normative [min]	Meldtijd normative [min]	Opkomsttijd normative [min]	Operational time 80% fractile [min]
A	7	15	5	23,2
B	7	15	6	24,2
C	7	15	8	26,2
D	7	15	10	28,2
E	7	1	5	11,6
F	7	1	6	12,6
G	7	1	8	14,6
H	7	1	10	16,6

Operational suppression time

Operational time – normal distribution



Suppression strategies



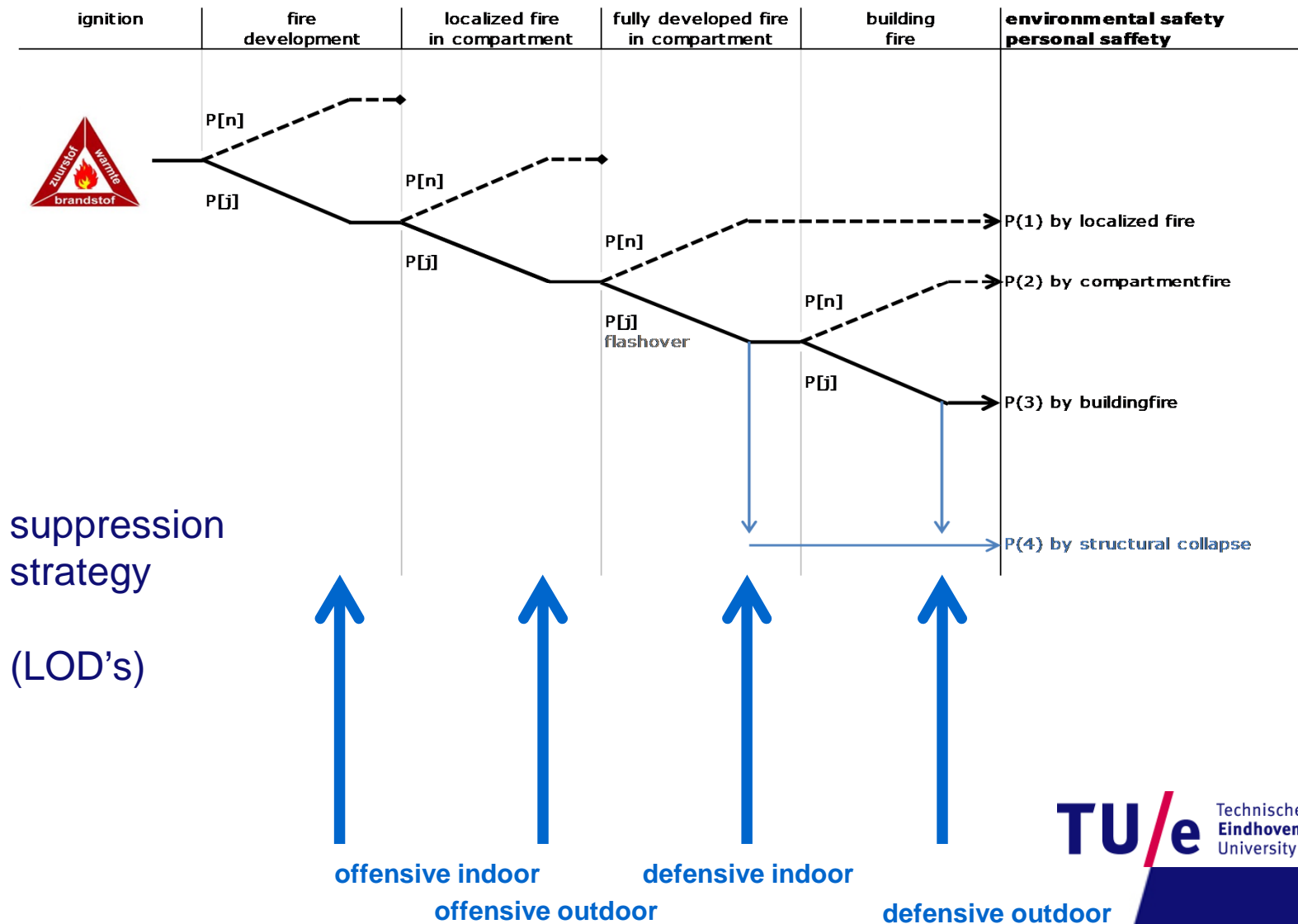
Suppression strategies

Suppression strategy depends on:

- Operational time
- Primary/secondary water supply
- Object / type of building
- Fire development
- Building users
- Environment
-??



Suppression strategies





Suppression strategy linked to building and preventive measures

PERFORMANCE BASED SUPPRESSION

Suppression strategies

Offensive indoor attack:

- Localized fire, controlled by
 - Automatic fire suppression
 - Heat- and smoke-outlet system
 - Localized fire load
- Only possible in large compartments



Suppression strategies

Defensive indoor attack:

- Compartment fire, controlled by
 - Fire resistant separation constructions
 - Fire resistant load bearing constructions
- Suits best with the Dutch Building code



Suppression strategies

Offensive outdoor attack:

- Localized fire
 - Untenable indoor conditions (inside compartment)
- Compartment fire
 - Untenable indoor conditions (outside compartment)
- Relatively new strategy



Suppression strategies

Defensive outdoor attack:

- Burn-down scenario

- Environmental protection



Suppression strategies

Suppression strategies:

- a. Offensive indoor
- b. Defensive indoor
- c. Offensive outdoor
- d. Defensive outdoor

Order of suppression strategies?

(c) → b → a → d

Suppression strategies AST-RST

Relation with natural fire development

Flashover time compared to operational time (AST – RST)

Case	Flashover time [min]	Operational time [min]	AST – RST [min]	Suppression strategy
Standaard woonfunctie 100 m ² , H=3 m	7	23	4	Defensieve binneninzet
Veel voorkomende kantoorfunctie 1000 m ² , H=3 m	7	26	1	Defensieve binneninzet
Veel voorkomende winkelfunctie 1000 m ² , H=5 m	16	26	10	Defensieve binneninzet
Willekeurige industriefunctie 2000 m ² , H=10 m	13	26	7	Defensieve binneninzet
	23	28	15	Defensieve binneninzet

Assumption: compartments EIW > 20 min.

Suppression strategies AST-RST

Consequences for operational time / attendance time

AST-RST > 0:

- acceptable situation

AST-RST < 0:

- shorten attendance time; or
- add preventive measures; or
- change suppression strategy

Suppression strategies AST-RST

When the real attendance time exceeds the acceptable attendance time (firesuppression code):

The situation is acceptable if there are no consequences for the suppression strategy

The situation is not acceptable if there are consequences for the suppression strategy

→ Change boundary conditions to remove the consequences for the suppression strategy

Try it yourself

Toolbox firesuppression

Spreadsheet developed for VR Noord Holland-Noord

Suggestions for improvement:
r.a.p.v.herpen@tue.nl

Thank you

