FEMTC 2020
Fire and Evacuation Modeling Technical Conference
September 9th-11th, Online Event

Guidi&Partners

INTELLIGENT EGRESS IN A HISTORICAL BUILDING

M. Pugnalin, G. Guidi, M. Capobelli, L.Caira

11 September '20

M. Eng. Matteo Pugnalin
matteo.pugnalin@guidiandpartners.com

PROJECT GOAL

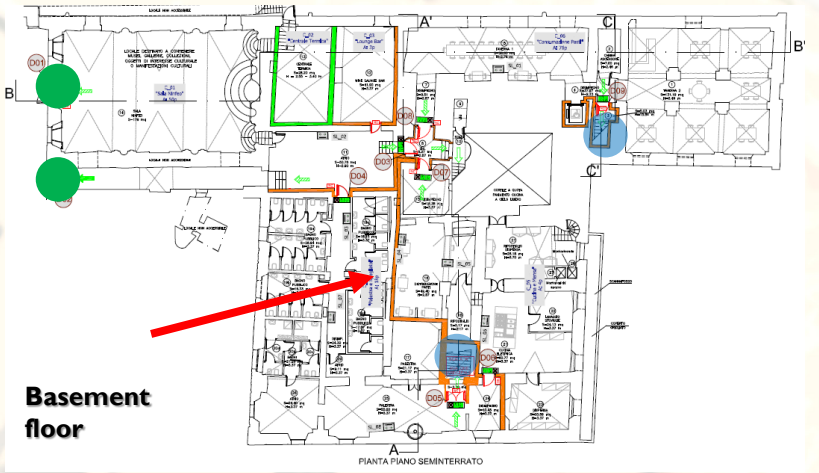
Re-use of an Italian historical building, XVI Century villa, as a University Post Graduate business school.

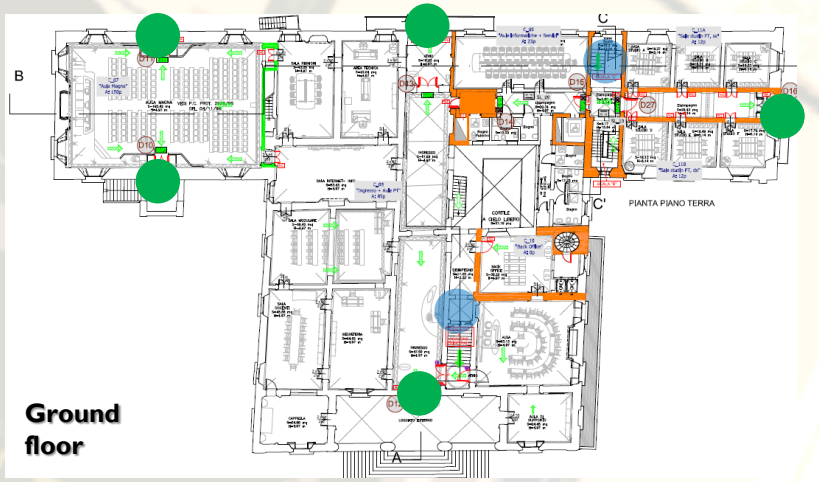
Necessity to adequate existing building to Fire Prevention rules.

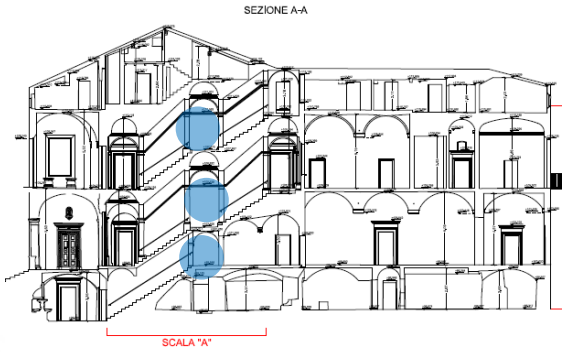
PROJECT DESCRIPTION

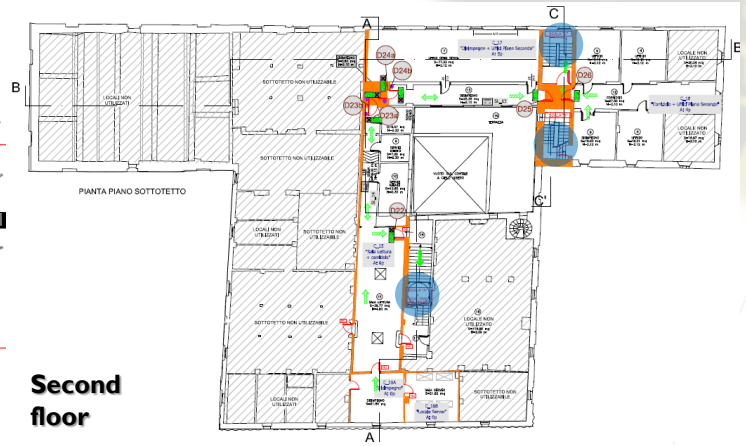
Building Description

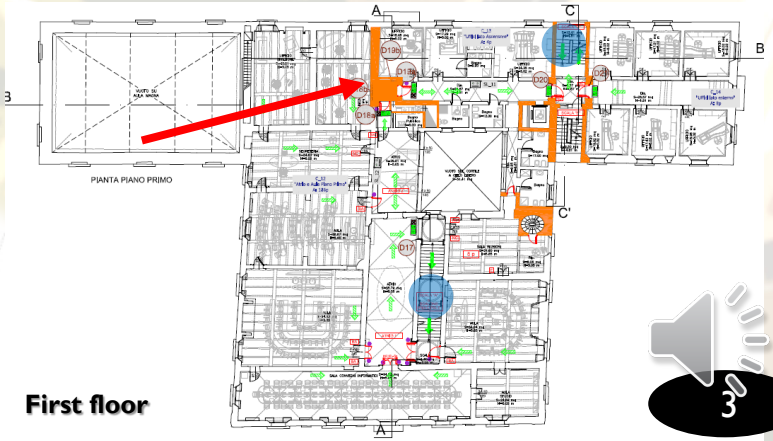
- **4 floors building height** (1 basement floor and 3 above ground floors)
- **7 final exit doors**
- **3 emergency staircases**
- **Internal fire compartments**











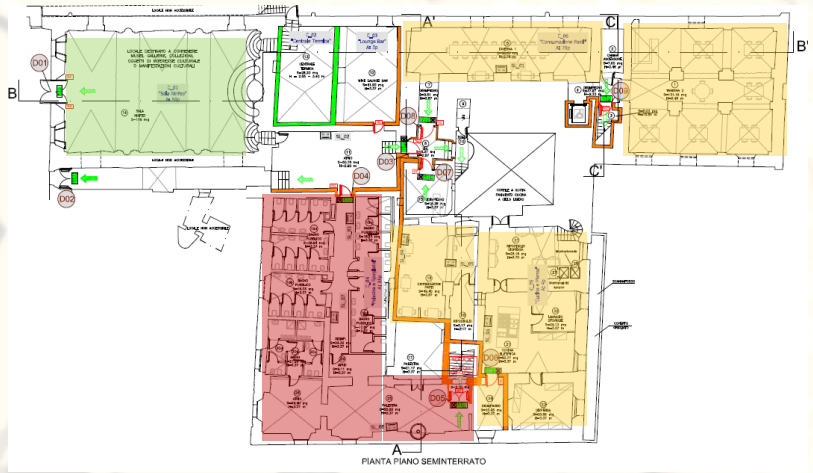
PROJECT DESCRIPTION

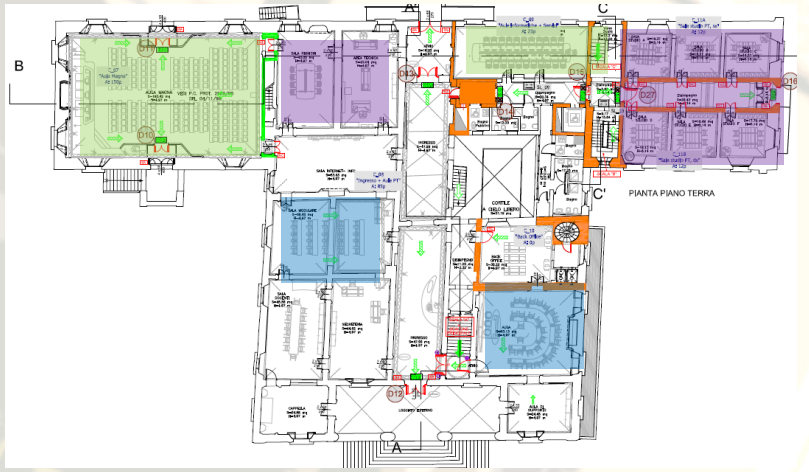
Activity Description

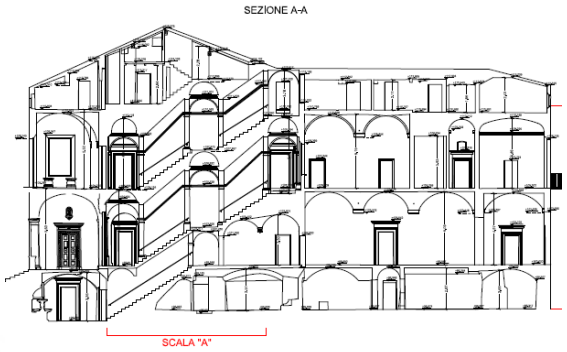
International school for post graduate students
(from all around the world)

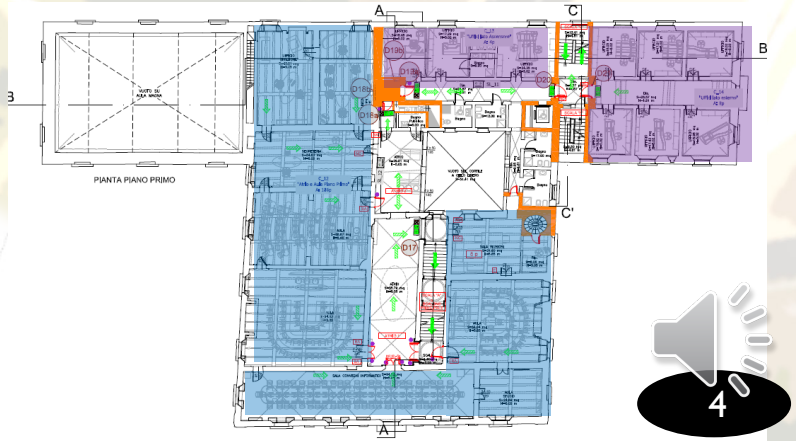
Services:

- **Classrooms;**
- **Study halls;**
- **Kitchen and Dining halls;**
- **Gym;**
- **Administrative offices;**
- **Meeting rooms;**







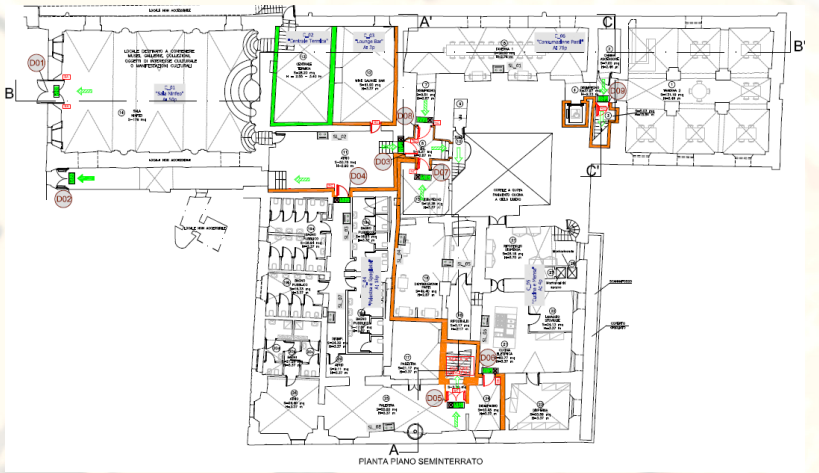


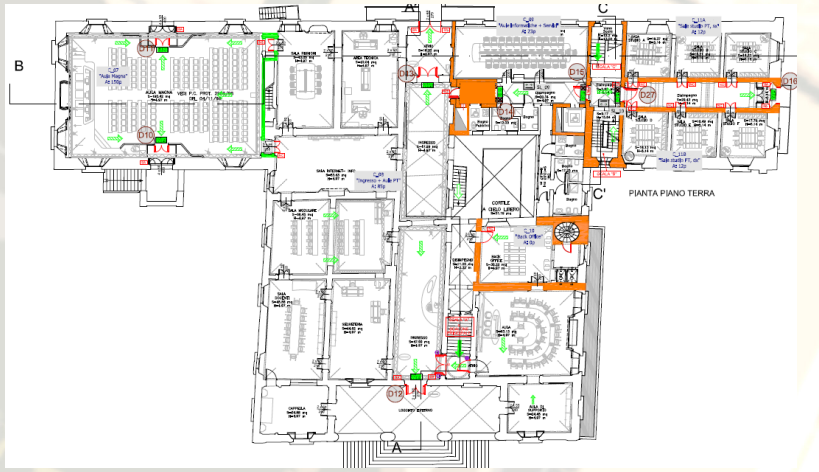
PROJECT DESCRIPTION

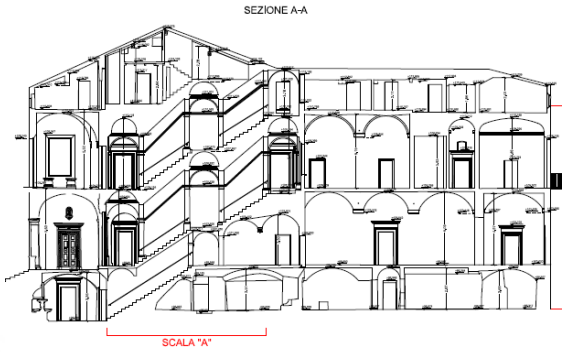
Activity Description

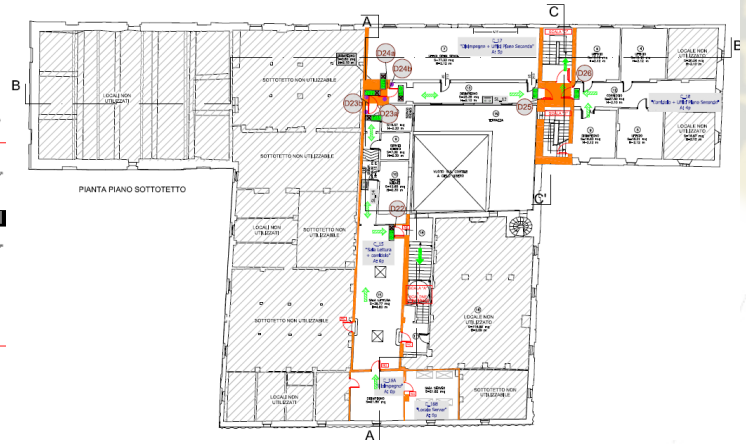
Fire protection systems:

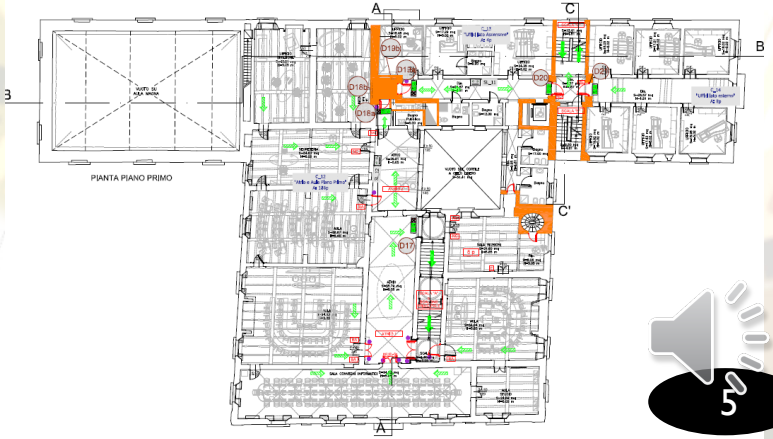
- **Fire Detection System extended to the whole building;**
- **Internal hose reel network;**
- **Vocal Alarm system (EVAC).**











Occupants Description

- Occupants can be considered as **"Awake"** (no dormitory is present) and **"Familiar"** (courses have at least 6 months duration);
  - **"A"** classification according to ISO Standard[1].
- About **250 people** are considered to be present at the same time.
- **Foreign students** shall be considered in the fire safety strategy.

[1] ISO/TR 16738:2009 *"Fire-safety engineering – Technical information on methods for evaluating behaviour and movement of people"*

CRITICAL POINTS

Prescriptive Rules requirements[2][3]:

- Request to provide all emergency staircases in fire separated compartments

or

- Request to have an external emergency staircase

Problems:

Historical restrictions do not permit

to transform existing main staircase into a fire protected one, neither to provide an external emergency staircase.

[2] D.M. 26 agosto 1992 *"Norme di prevenzione incendi per l'edilizia scolastica."*

[3] Lettera Circolare DCPREV prot. n. 3181 del 15/3/2016 *"Linea guida per la valutazione, in deroga, dei progetti di edifici sottoposti a tutela ai sensi del d.lgs. 22 gennaio 2004, n. 42, aperti al pubblico, destinati a contenere attività dell'allegato 1 al D.P.R. 1 agosto 2011"*

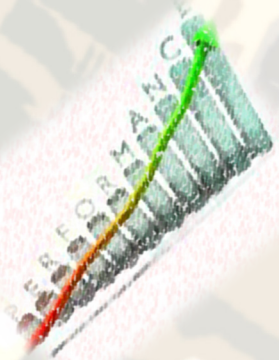
CRITICAL POINTS

…from

Prescriptive Method

…to

Performance Based Design Approach



NEW FIRE SAFETY STRATEGY

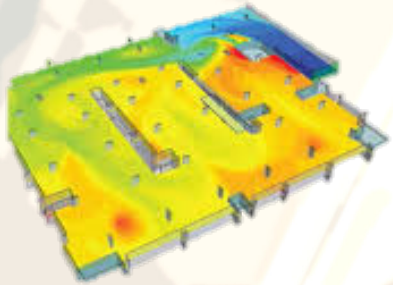
Intelligent Active Dynamic Signage System (IADSS)

Furniture's material

New Fire Rating Door

Egress time evaluation

CFD Analysis



Development of Safety Procedure (management level)

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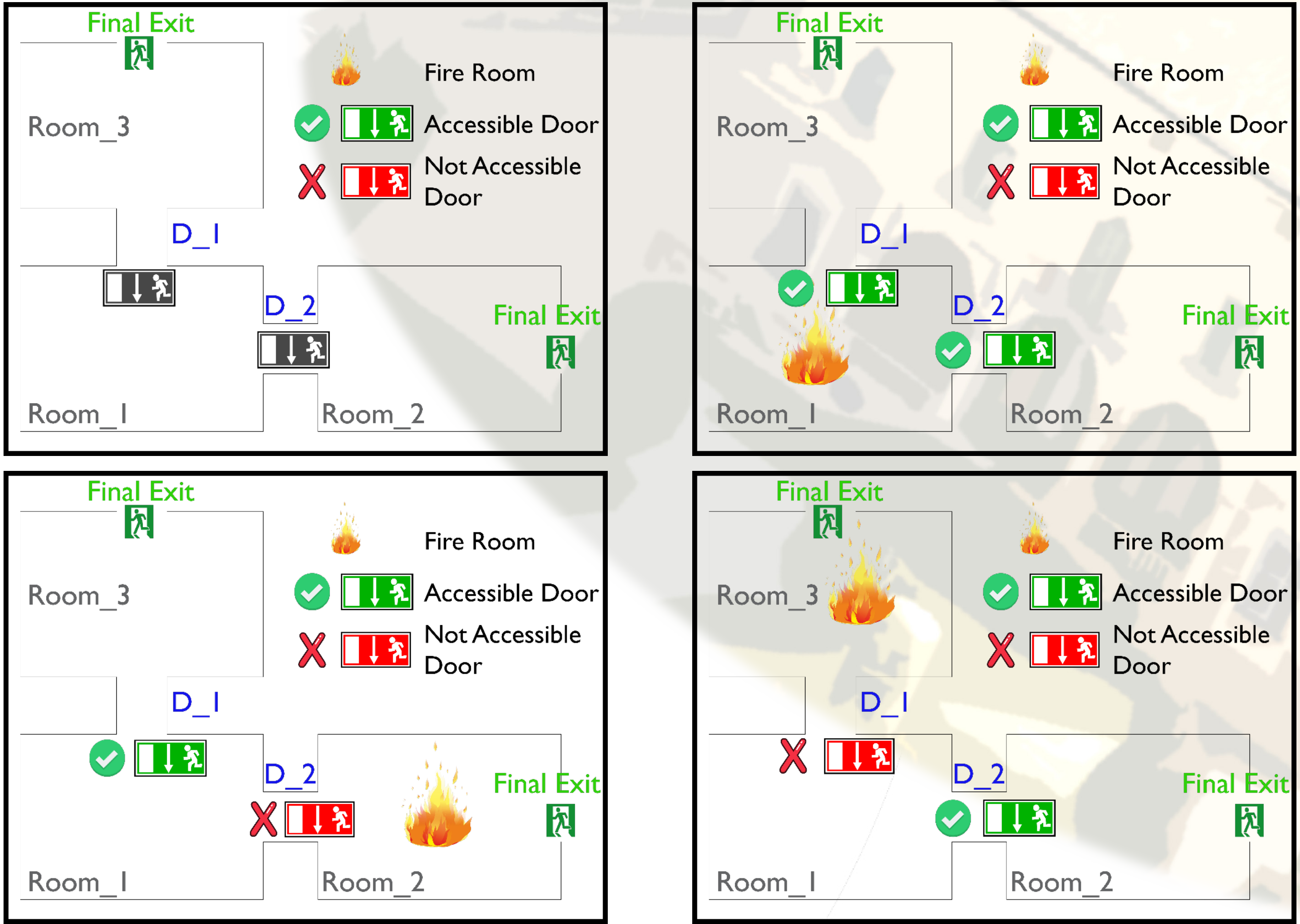
Intelligent Active Dynamic Signage System (IADSS)

FIRE SAFETY STRATEGY

FIRE SCENARIO

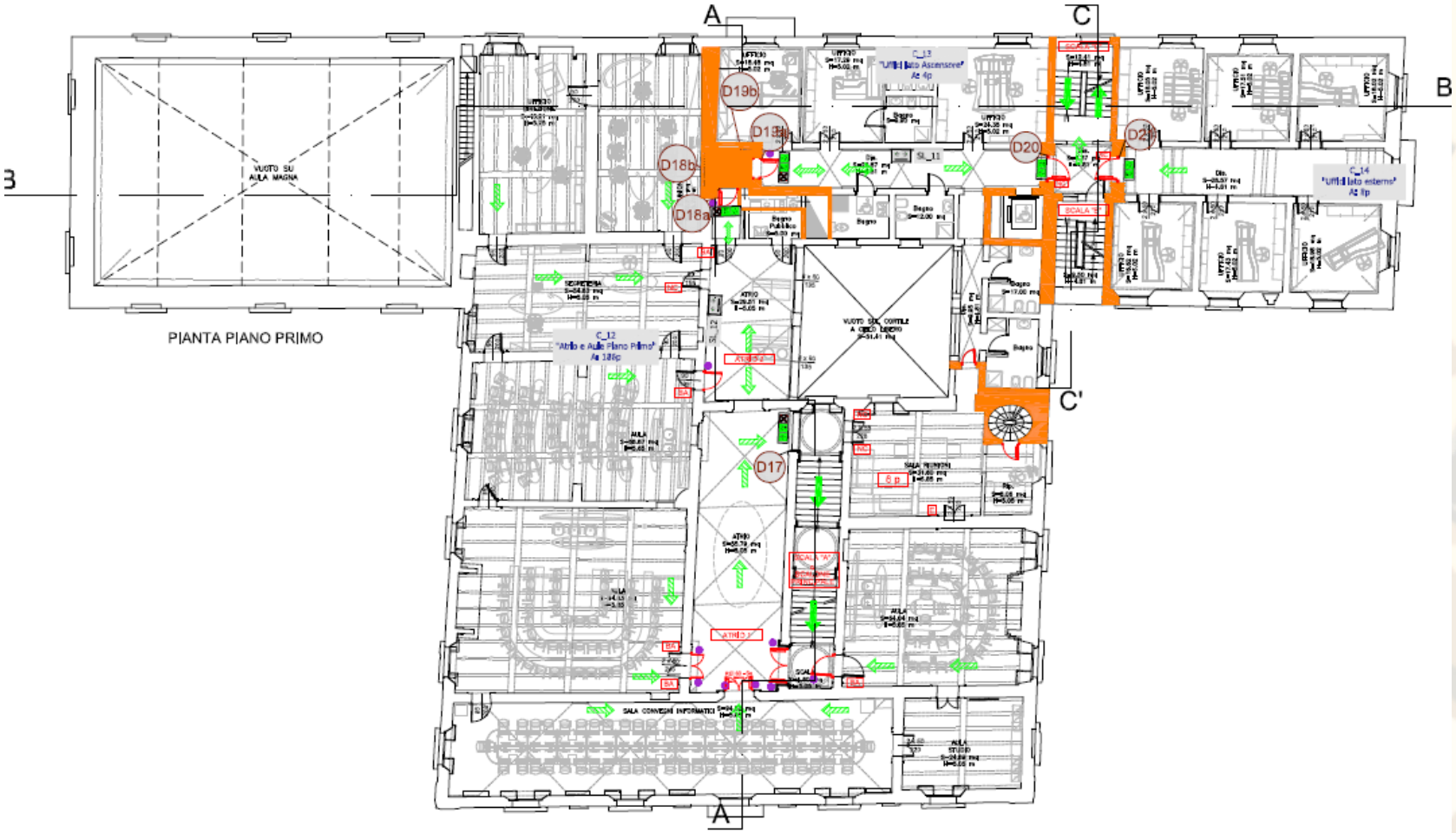


FIRE SAFETY STRATEGY

Intelligent Active Dynamic Signage System (IADSS)

Egress routes are identified and dynamic signage position are located.

Depend on compartment on fire Emergency signages are set up.



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Intelligent Active Dynamic Signage System (IADSS)

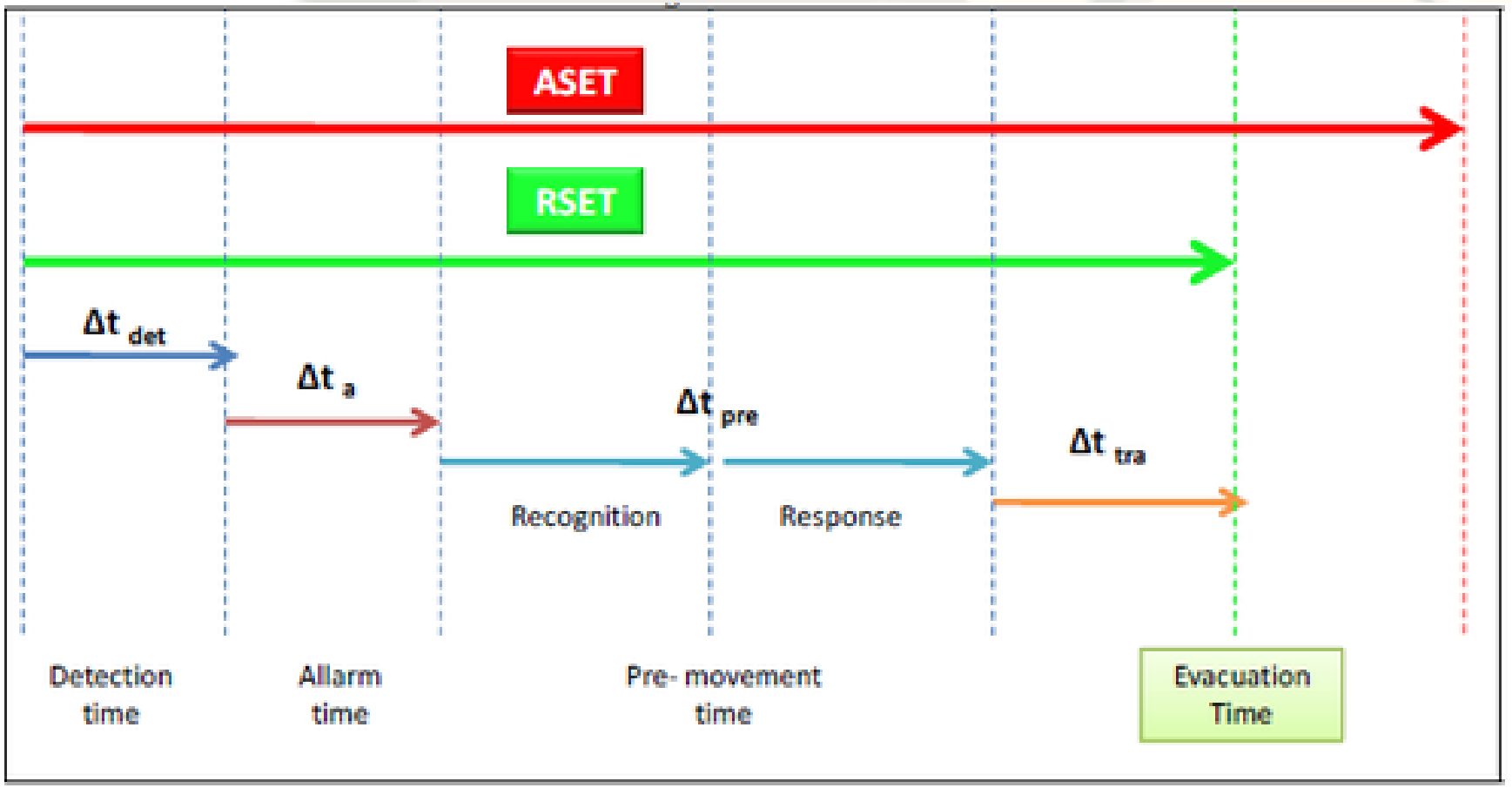
FIRE SAFETY STRATEGY

SYSTEM ACTIVATION MATRIX

Compar. Fire Scenrio	C_01	C_02	C_03	C_04	C_05	C_06	C_07	C_08	C_09	C_10	C_11A	C_11B	C
Door signal	Emergency Signal Status												
D_01	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_02	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_03	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	
D_04	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_05	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	
D_06	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	
D_07	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	
D_08	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	
D_09	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_11	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_13	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_14	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	
D_15	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	
D_16	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_17	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	
D_18a	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	
D_18b	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_19a	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
D_19b	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	
D_20	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

Egress time evaluation

In order to evaluate the egress time, the Required Safety Egress Time (RSET) is calculated according to ISO[1] and BS[4] Standards;



[4] BS-PD 7974-6:2006 *"Application of fire safety engineering principles to the design of buildings. Human factors. Life safety strategies. Occupant evacuation, behaviour and condition (Sub-system 6)."*

Egress time evaluation

Particular focus on travel time considering effects of IADSS.

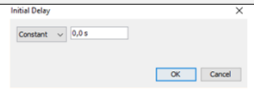
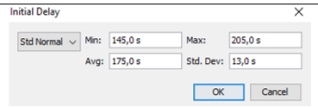
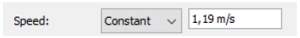
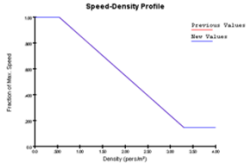
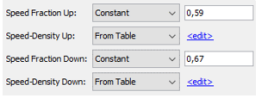
HORIZONTAL TRAVEL SPEED				
Area	A=	85,00	[m^2]	Note *Travel Speed*
People	p=	185	[p]	
People Density	D=	2,18	[p/m^2]	D > 3,8 --> 0
k factor	k=	1,40		0,54 ≤ D ≤ 3,8 --> S = k - akD
a factor	a=	0,266		D < 0,54 --> 1,19 m/s
Egress speed	S=	0,59	[m/s]	
MAXIMUM FLOW RATES				
Density	D=	2,35	[p/m^2]	Note *Flow Rate*
Egress Speed	S=	0,52	[m/s]	F_S = SD
Specific flow	F_S=	0,99	[p/m s]	D > 1,9 --> F_S = 1,9S D > 3,77 --> F_S = 0
TIME FOR PASSAGE				
Egress door widht	L=	0,80	[m]	Note *Time Passage*
Specific Flow	F_S=	0,99	[p/m s]	
People	p=	185	[p]	
Flow per time	F_c=	47,42	[p/min]	T_p = p / F_c
Time for passage	T_p=	3,90	[min]	
		235	[sec]	

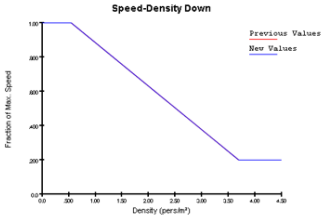
FIRE SAFETY STRATEGY

Pathfinder Simulation

In order to check Evacuation Time, egress simulation was performed, using Pathfinder

Set software using ISO TR 16738 data and formula

Parameter	Standard Reference	Pathfinder input data
Egress data		
t_{start} **(fire room)**	t = 0 s (according to AHJ)	
t_{pre}	**ISO TR 16738** 1° percentile: 60 s 99° percentile: 120 s Normal distribution	
t_{tra}	**ISO TR 16738** horizontal travel speed S_o = 1,19 m/s.	
	ISO TR 16738 $S = k - akD$ con ➢ S = travel speed (m/s); ➢ D = people density (p/m²) with [0,54 ≤ D ≤ 3,8]; ➢ k = 1,4; ➢ a = 0,266	
	ISO TR 16738 Vertical travel speed: ➢ $S_{v,d}$ = 0,8 m/s = 0,67 S_o; ➢ $S_{v,u}$ = 0,7 m/s = 0,59 S_o.	

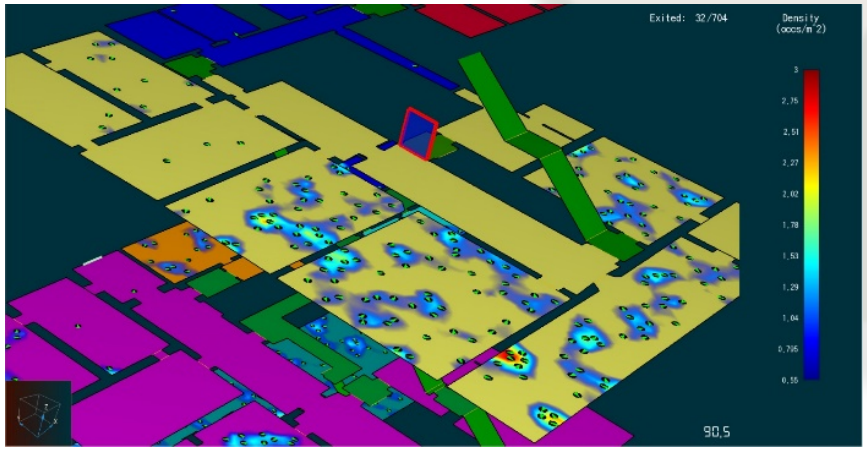
Standard Reference	Pathfinder input data
ISO TR 16738 $S = k - akD$ con ➢ S = travel speed (m/s); ➢ D = people density (p/m²) with [0,54 ≤ D ≤ 3,8]; ➢ k = 1,0; ➢ a = 0,266	

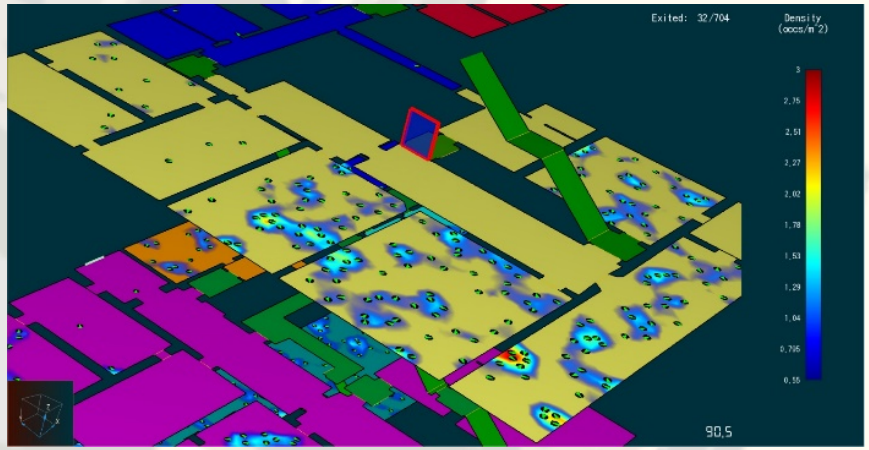
Exit route element	k
Corridor, aisle, ramp, doorway	1.40
Riser mm	Tread mm	
191	254	1.00
178	279	1.08
165	305	1.16
165	330	1.23

Pathfinder Simulation

In order to check Evacuation Time, egress simulation was performed, using Pathfinder

Comparison between hand calculation data and Pathfinder results





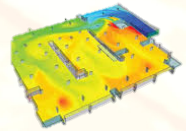
FIRE SCENARIO	RSET (ISO TR 16738)	RSET (Pathfinder)	Δ
S_01	440 s	390 s	- 13%
S_02	330 s	290 s	- 14%
S_03	330 s	310 s	- 6%
S_04	330 s	320 s	- 3%

Egress time evaluation

For every scenario RSET is calculated, considering all the parameters and a safety margin

Design Fire Scenario	t_{det}	t_a	t_{pre}	t_{tra}	RSET	t_{marg} 10%RSET e ≥ 30s	RSET + t_{marg}
S_01	85 s	0 s	120 s	235 s	440 s	45 s	**485 s**
S_02	85 s	0 s	120 s	125s	330 s	35 s	**365 s**
S_03	85 s	0 s	120 s	125s	330 s	35 s	**365 s**
S_04	85 s	0 s	120 s	125s	330 s	35 s	**365 s**

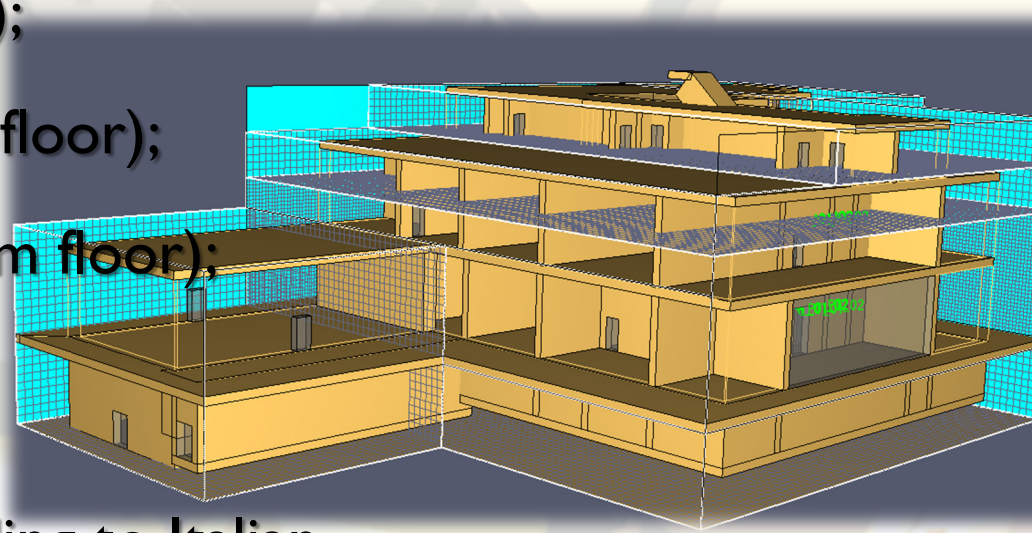
CFD Analysis



In order to evaluate Available Safe Egress Time (ASET), CFD Model is used. The software FDS is used.

In order to evaluate ASET value following parameters are considered:

- **Visibility** (at 2 meters from floor);
- **Temperature** (at 2 meters from floor);
- **Heat Radiation** (at 2 meters from floor);
- **FED** (at 2 meters from floor);

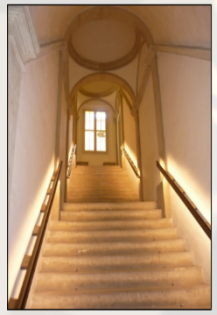


Parameters threshold is defined according to Italian Fire Code[5]

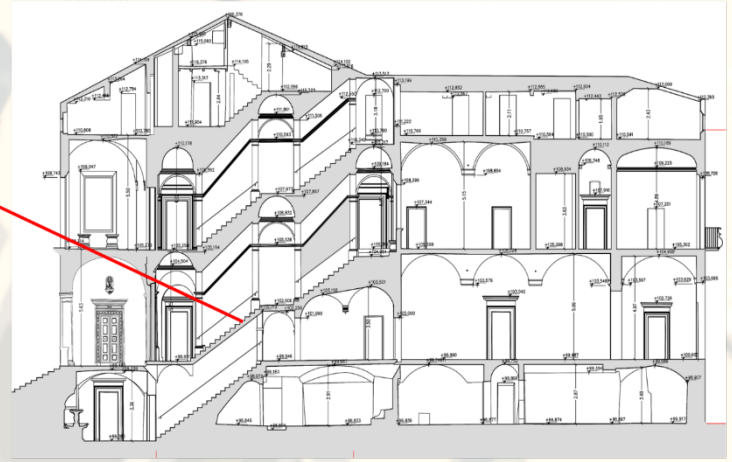
[5] DM 03/08/15 *"Approvazione di norme tecniche di prevenzione incendi, ai sensi dell'articolo 15 del decreto legislativo 8 marzo 2006, n. 139"*

Fire Scenario Definition

Worst fire scenarios, in terms of density of people respect the number of exit routes, were analyzed with the software FDS, in order to determinate Available Safety Egress Time (ASET).



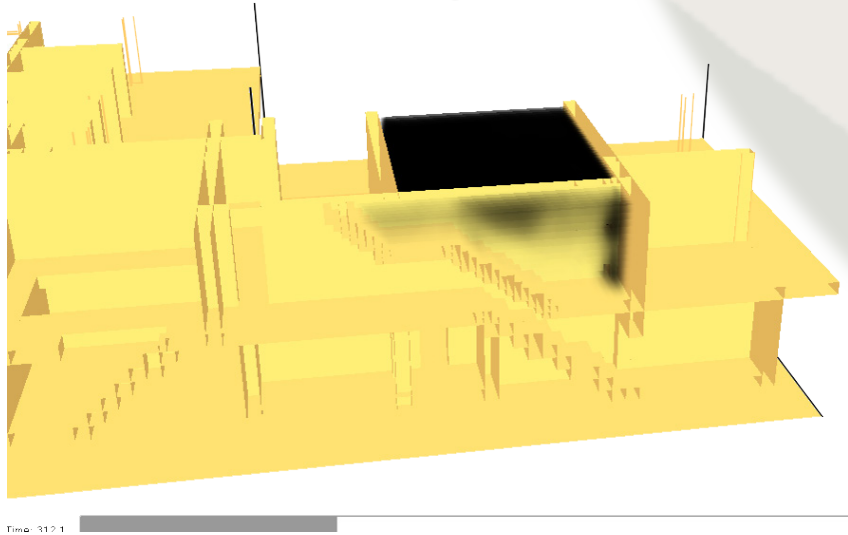
Section

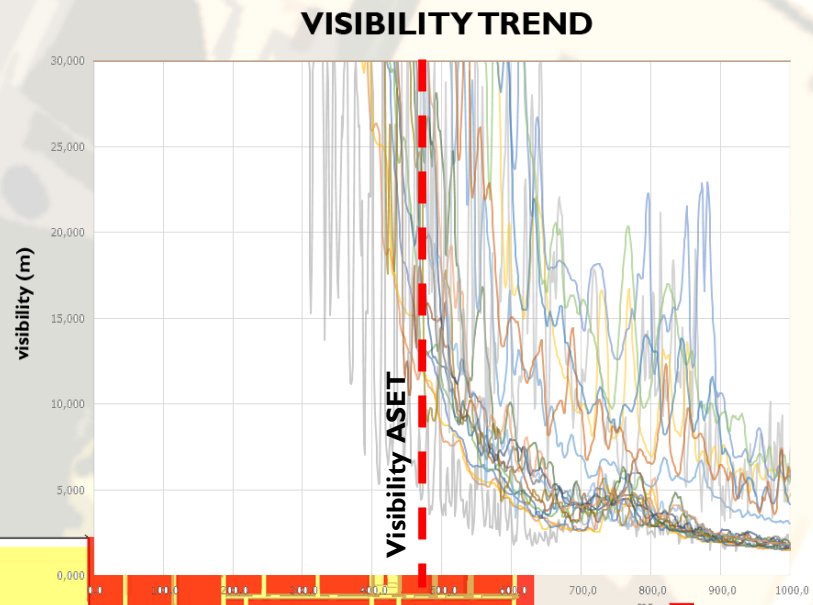


First floor plan

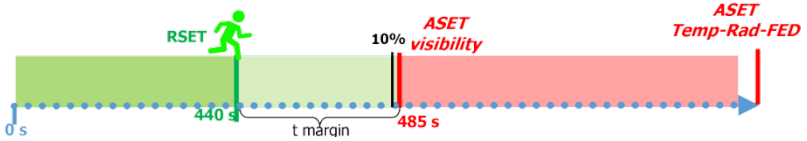
CFD Analysis results

For every design fire scenario the **comparison between ASET and RSET** was performed; for ASET calculation visibility, temperature, radiation and FED level were considered. The ASET was imposed equal to first evaluation parameters that exceed admitted threshold.





FIRE SCENARIO S_01				
Criterion	**Level**	**ASET (s)**	**RSET (s)**	**t_{marg} (s)**
Visibility	10 m @ 2 m	485 s	440 s	45 s (10%)
Temperature	60 °C @ 2 m	**> 1000 s**		>560 s (> 127%)
Radiation	2,5 kW/m² @ 2 m	**> 1000 s**		>560 s (> 127%)
FED	0,1 @ 2 m	**> 1000 s**		>560 s (> 127%)
Total ASET (the lower of the ASETs)		**485 s**	**440 s**	**45 s (10%)**



CONCLUSION

The analysis of the human wayfinding has led to develop new strategies for the evacuation in emergencies.

the Intelligent Active Dynamic Signage System (IADSS) has been considered to redirect people, indicating the viable and non-viable exits, depending on the position of the fire source identified by the automatic detection system.

low impact on the building since they do not need any layout modifications.

“active” (intelligent) wayfinding systems monitor human egress process, spreading of the fire and damages to building, and suggests the best escape paths depending on these conditions.

REFERENCE

- *BS PD 7974-6:2004 "The application of fire safety engineering principles to fire safety design of buildings – Part 6: Human factors: Life safety strategies – Occupant evacuation, behavior and condition (Sub-system 6)";*
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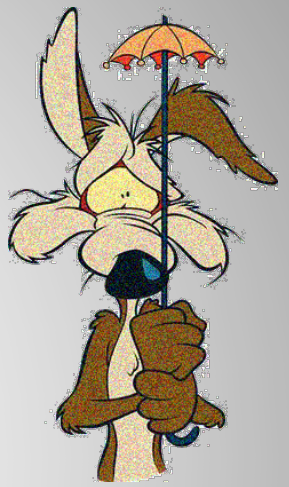

QUESTION TIME

HEADQUARTER
Via Rigosa, 6
40069, Zola Predosa, Bologna (Italy)
+39 051 6767431
www.guidiandpartners.com
info@guidiandpartners.com

GUIDI & PARTNERS S.r.l.

BUSINESS UNIT
Via Salomone, 43
20138, Milano (Italy)
+39 02 37920808

M.Eng. Matteo Pugnalin
matteo.pugnalin@guidiandpartners.com