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INSTITUT DE RECHERCHE EN SCIENCES
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DE L'UMONS

A SENSITIVITY ANALYSIS OF A HOSPITAL IN CASE OF FIRE

THE IMPACT OF THE PERCENTAGE OF PEOPLE WITH REDUCED MOBILITY AND THE STAFF TO OCCPANT'S RATIO

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Anass RAHOUTI [1], **Prof Sélim DATOUSSAÏD** [1], Dr Ruggiero LOVREGLIO [2]

[1] : Civil Engineering and Structural Mechanics Department, Faculty of Engineering, University of Mons, Belgium

[2] : Civil and Environmental Engineering Department, Faculty of Engineering, University of Auckland, New Zealand

Anass.RAHOUTI@umons.ac.be

OVERVIEW

Introduction & Objectives

Material & Methods

- Fire Risk Assessment Method for Engineering
- Agent-Based Model (Pathfinder)

Case study : Hospital “Clinique Sainte Elisabeth”, Namur, Belgium

- Hypothetical fire scenario and floor layout
- Occupants characteristics
- Evacuation strategy
- Evacuation procedure

Testing

Results

- Comparison, analysis & discussion

INTRODUCTION

- Statistics 2013: Belgian fire and rescue services attended over 22,733 fires including **236** in care homes and **79** in hospitals

- Health care facilities present a set of **challenges** from the perspective of fire safety:
  - Presence of a large number of vulnerable people → **ASSISTANCE** to evacuate
  - Preparation time needed for some patients (non-ambulant)
  - Low staff to occupant's ratio at night

- Real experiments are **prohibited** in such environment

- Simulation tools such as **Agent-based models** (e.g. Pathfinder) can be used

OBJECTIVES

- Simulate prescript **assisted evacuation** using **existing evacuation models** such as **Pathfinder**
- Evaluate the impact of **different percentages and types of patients** on the evacuation process
- Study the effect of **staff to patient's ratio** on the evacuation process

MATERIAL & METHODS

- **FRAME method**
- **PyroSim**
- **Pathfinder**

Mixture of Risk Assessment and Agent-based modeling techniques

Critical floor (s)

MATERIAL & METHODS

- **FRAME method**
- PyroSim
- Pathfinder

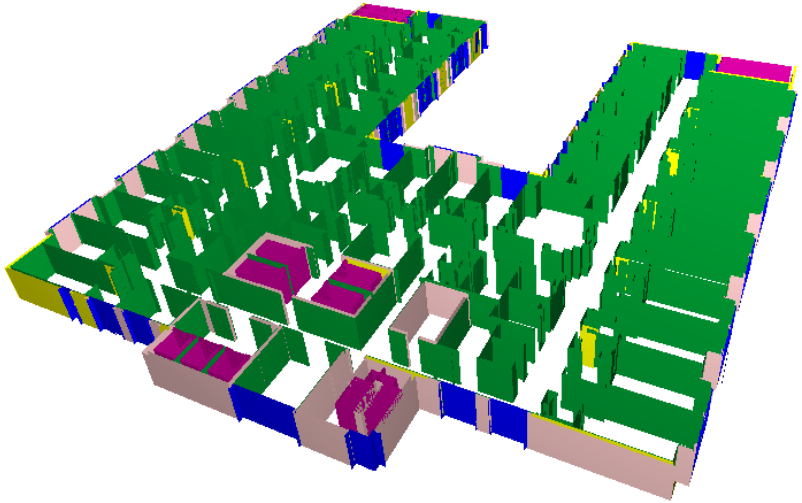
- **F**ire **R**isk **A**ssessment **M**ethod for **E**ngineering
- Developed by De Smet
- Tool to help a fire protection engineer to define a sufficient level and cost effective fire safety concept for new or existing buildings
- Risk for property and the content
- Risk for the activities
- Risk for **the occupants**

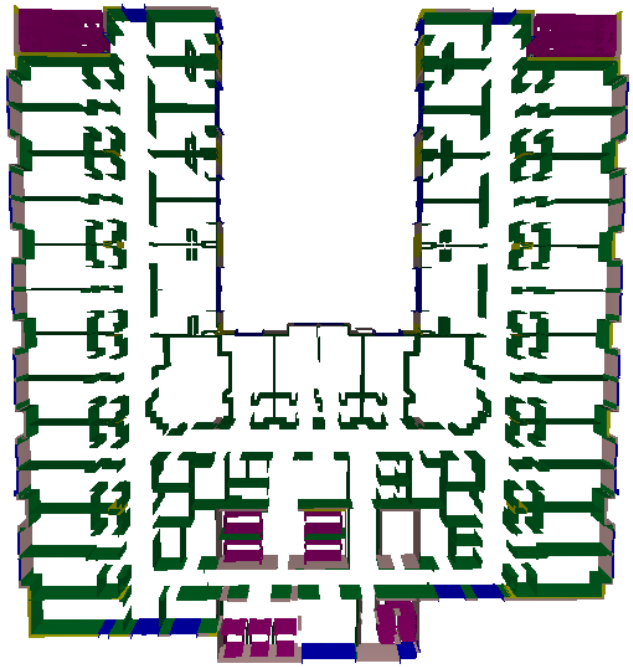
} **< 1 (well protected)**

- Industry, airports, cultural heritage buildings and **health care facilities**

MATERIAL & METHODS

- FRAME method
- **PyroSim**
- Pathfinder





MATERIAL & METHODS

- FRAME method
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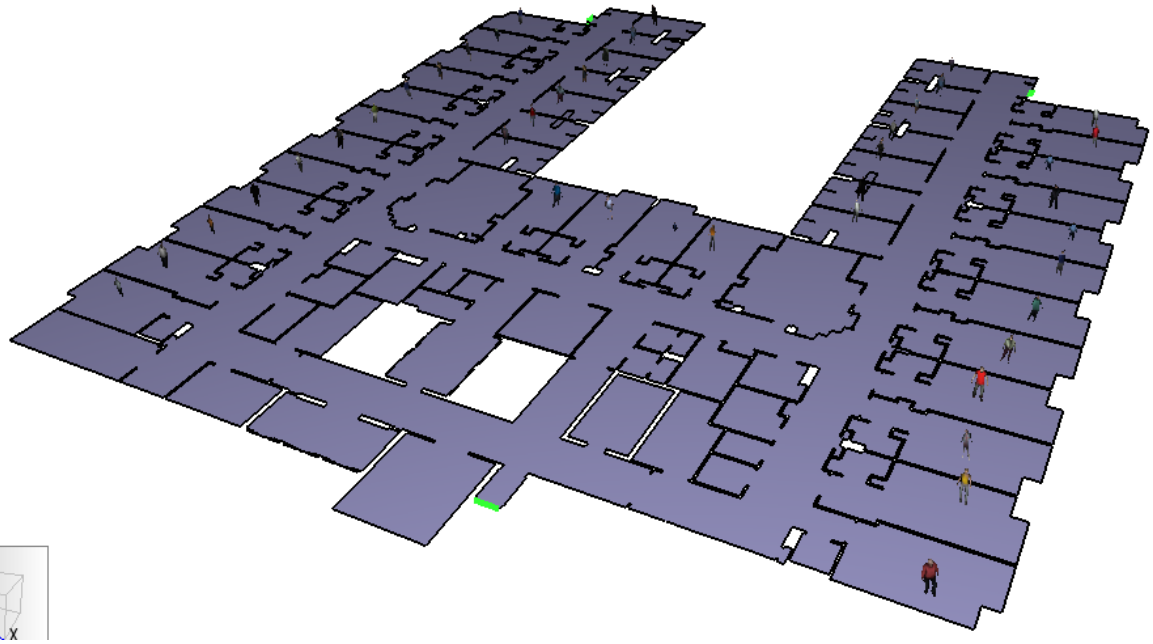
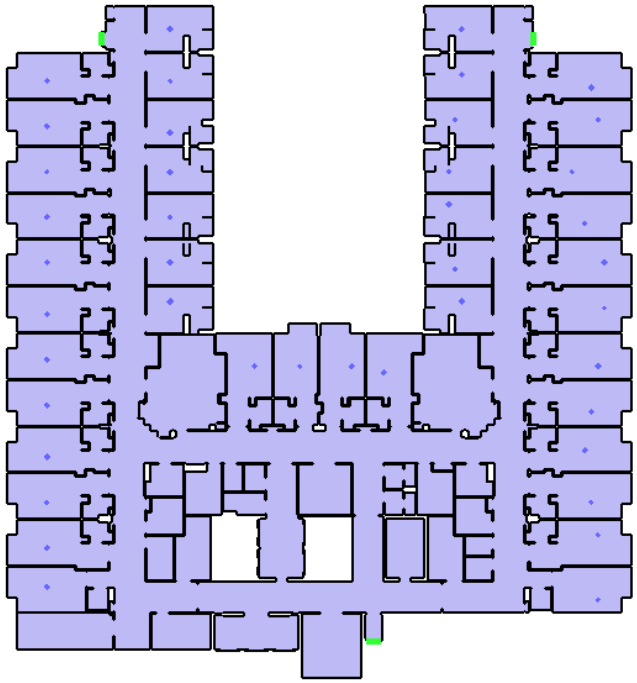
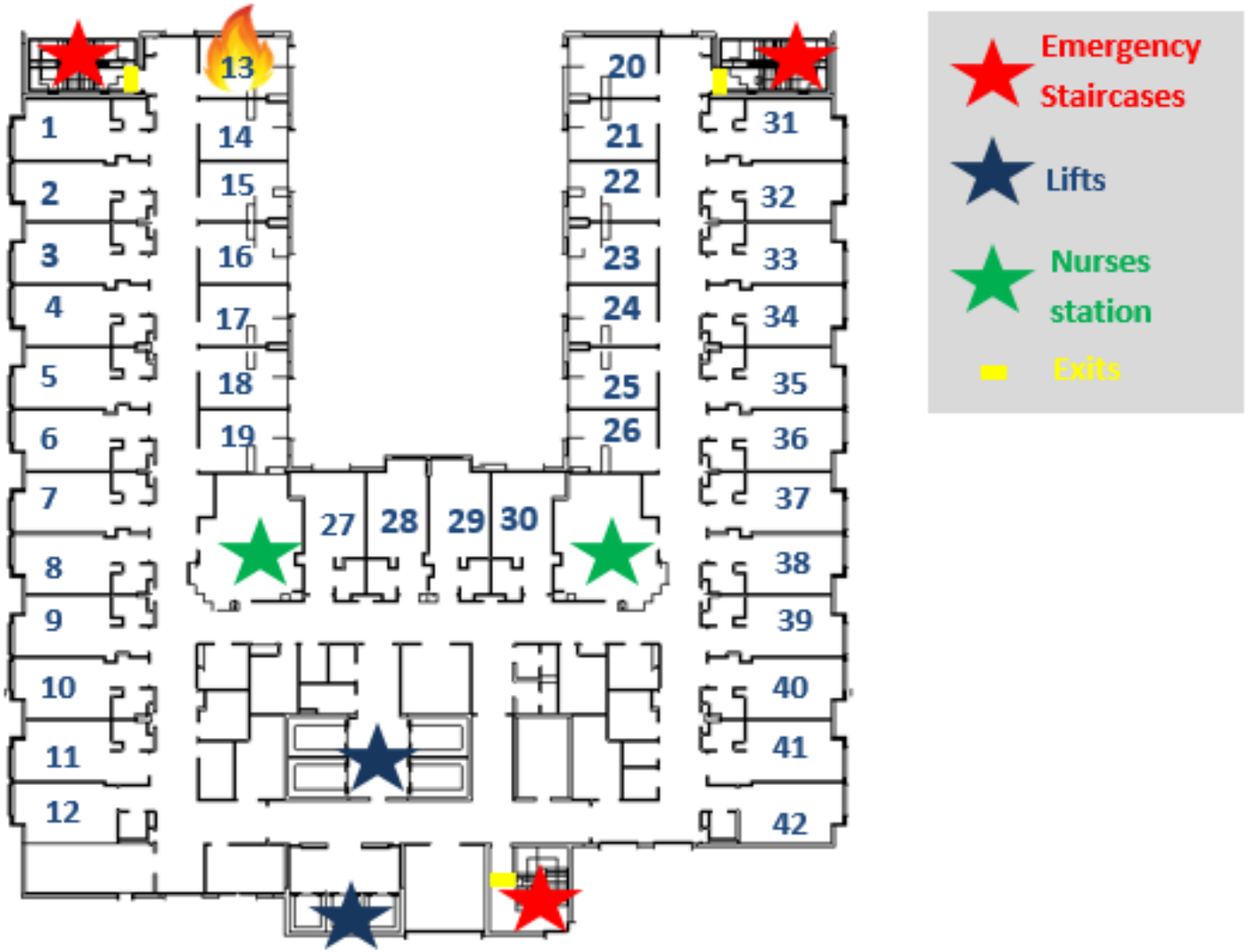




CASE STUDY

Hypothetical fire scenario and floor layout



CASE STUDY

Occupants characteristics

- In health care facilities, the occupants will be a mixture of visitors, staff and **patients**
- Patients will be **independent,** dependent or highly-dependent





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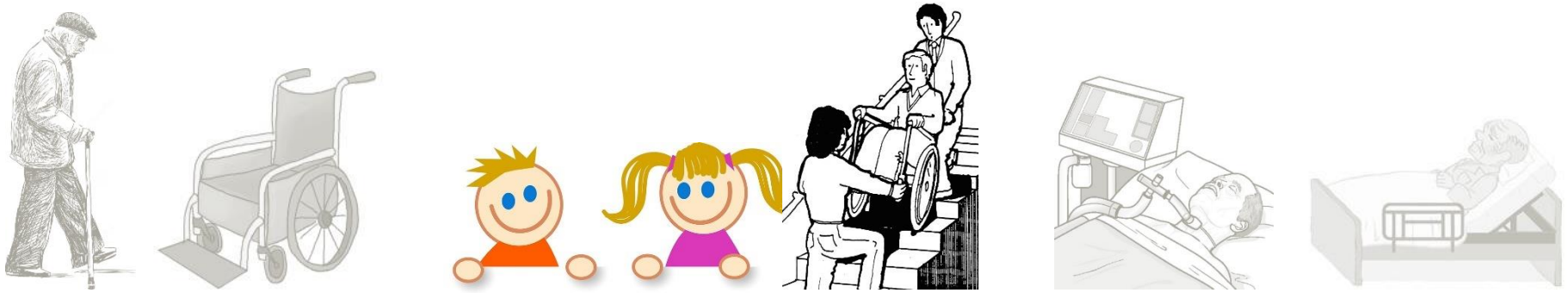

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- In health care facilities, the occupants will be a mixture of visitors, staff and **patients**
- Patients will be **independent, dependent or highly-dependent**

	Profile of independent patients		
	Mean	**σ**	**Range**
Pre-evacuation time [s]	50.8	-	30 – 66
Horizontal walking speed [m/s]	1.00	0.42	0.10 – 1.77

			Mean	**σ**	**Range**
Dependent patients	Evacuation Chair	Preparation time [s]	32.7	5.3	-
		Transportation walking speed [m/s]	1.46	0.09	-
	Stretcher	Preparation time [s]	77.7	19.2	-
		Transportation walking speed [m/s]	1.04	0.09	-
Highly dependent patients		Preparation time [s]	-	-	180 – 900
		Transportation walking speed [m/s]	0.40	0.04	-

- **Emergency groups** are composed **of 2 attendants** (staff members)

CASE STUDY

Evacuation strategy and procedure

- **Evacuation strategy :** horizontal evacuation only (most of hospitals focus on horizontal evacuation in the first stage of an emergency)

- **Evacuation procedure :** the objective is to evacuate as many patients as possible
  1) Patients in immediate danger
  2) Independent patients
  3) Dependent patients
  4) Highly-dependent patients

TESTING

Scenario 1: all the patients are ambulant (**basis scenario**)

Scenario 2: mix of ambulant and non-ambulant patients with different percentage of dependent and highly-dependent patients (6 attendants are present)

Sub-scenario	Number of independent patients	Number of dependent patients	Number of highly dependent patients
2.1	28	14	0
2.2	28	7	7

Scenario 3: mix of ambulant and non-ambulant patients with a fixed percentage of ambulant and non-ambulant patients but different staff to patients' ratios

Sub-scenario	Number of attendants	Emergency groups
3.1	8	4
3.2	12	6

RESULTS

FRAME Method

- Calculation of the potential risk carried on each floor of the building but only for the characteristic premises
- **R** is the calculated risk for the property and content
- **R1** is the calculated risk for the occupants
- **R2** is the calculated risk for the activities
- For a well protected compartment, R, R1 and R2 **shell be < 1**

		CALCULATION of the POTENTIAL RISKS			CALCULATION of the ACCEPTANCE LEVELS			CALCULATION of the PROTECTION LEVELS			RISK for		
		Property & content	Occupants	Activities	Property & content	Occupants	Activities	Property & content	Occupants	Activities	Property & content	Occupants	Activities
Floor Number	Compartment	P	P1	P2	A	A1	A2	D	D1	D2	R	R1	R2
R+7	Technical Room	1,59	3,51	1,01	1,39	1,29	1,35	1,53	2,53	0,96	0,74	1,07	0,78
	Technical Room + Small Room	0,42	3,19	0,27	1,50	1,40	1,45	2,02	3,39	1,29	0,14	0,67	0,14
R+6	Double Bedroom	0,34	2,85	0,26	1,47	1,37	1,45	1,64	2,16	1,05	0,14	0,96	0,17
	Single Bedroom	0,34	2,87	0,26	1,48	1,38	1,45	1,64	2,16	1,05	0,14	0,96	0,17
	Waste Room	0,17	2,79	0,11	1,50	1,40	1,45	1,82	2,39	1,16	0,06	0,83	0,06
R+5	Middle care	0,33	2,59	0,25	1,47	1,37	1,45	1,64	2,16	1,05	0,14	0,87	0,17
R+4	Medical Office	0,29	2,42	0,17	1,60	1,50	1,55	1,82	2,39	1,16	0,10	0,67	0,10
R+3	Dirt Laboratory	0,29	2,42	0,17	1,60	1,50	1,55	1,82	2,39	1,16	0,10	0,67	0,10
	Clean Laboratory	0,37	2,29	0,23	1,60	1,50	1,55	1,82	2,39	1,16	0,13	0,64	0,13
R+2	Head nurse room	0,68	4,78	0,43	1,50	1,40	1,45	1,92	3,72	1,23	0,24	0,92	0,24
	Operating Room	0,30	1,56	0,19	1,60	1,50	1,55	1,82	3,54	1,16	0,10	0,29	0,11
R+1	Dirty Laundry Unit	0,25	2,33	0,15	1,50	1,40	1,45	1,82	2,39	1,16	0,09	0,70	0,09
	Clean Laundry Unit	0,14	1,65	0,09	1,50	1,40	1,45	1,82	3,54	1,16	0,05	0,33	0,05
R0	Radiologie-Osseaux4	0,18	1,07	0,11	1,30	1,30	1,25	2,02	3,23	1,29	0,07	0,26	0,07
R-1	Pharmacy + Cold Storage	0,23	2,00	0,17	1,60	1,50	1,55	1,92	2,52	1,23	0,07	0,53	0,09
	Pharmacy + Archives	0,30	2,84	0,19	1,50	1,40	1,45	1,92	2,52	1,23	0,10	0,81	0,11
Legend			Slight risk			Medium risk					High risk		

RESULTS

FRAME Method

RISK for		
Property & content	Occupants	Activities
R	R1	R2
0,74	1,07	0,78
0,14	0,67	0,14
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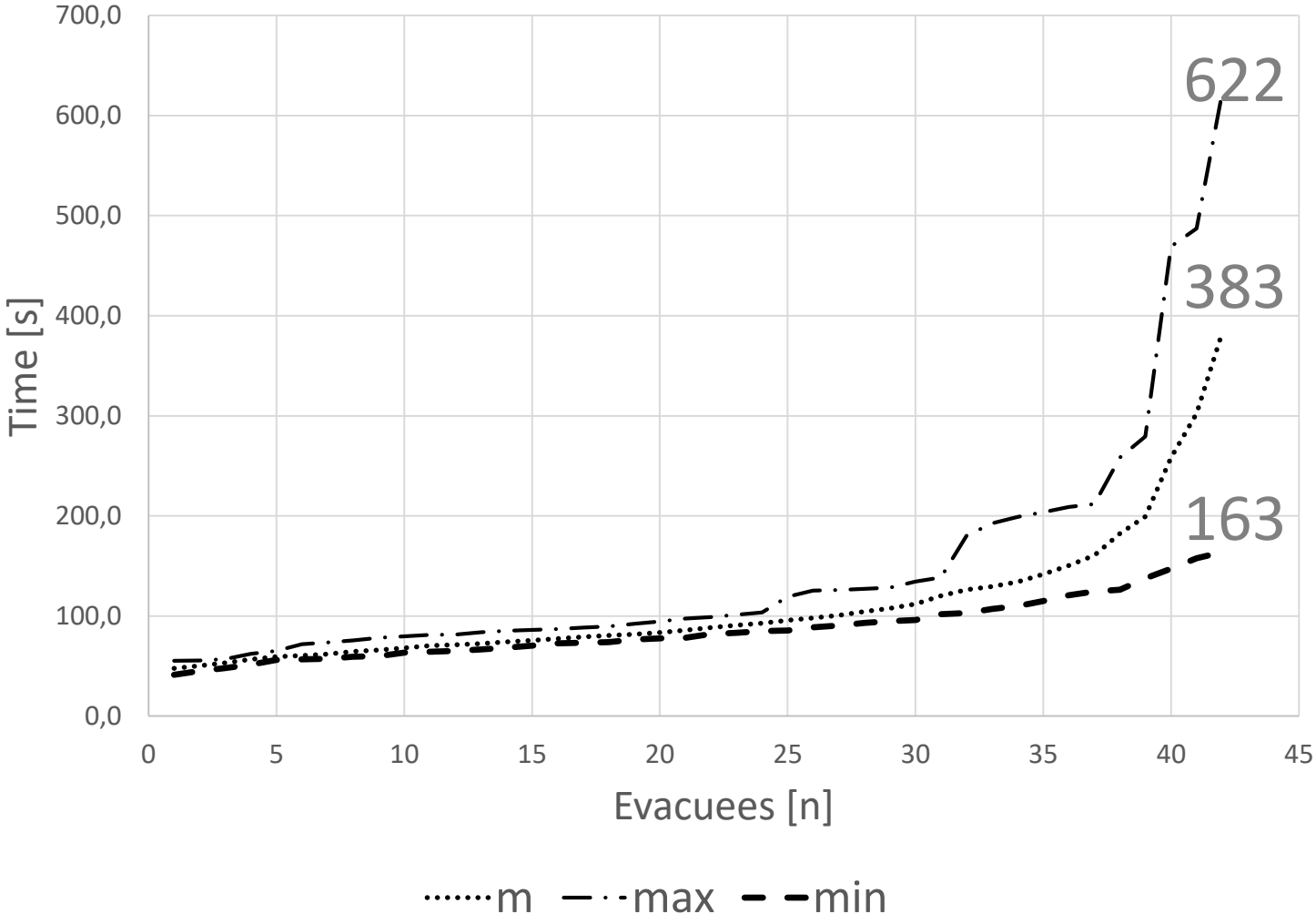
RESULTS

FRAME Method

- In general, the building is well protected against fire excluding the technical premise of the 7th floor in which the **R1 >1**
- Follows strictly the Belgian Prescriptive Codes (AR 6 November 1997)
- The risk for the occupants is greater than 1 due to the presence of the ventilation and heating machinery
- 7th floor : difficult access for firefighters but not accessible to the public (only the staff)
- The following critical premises are the sleeping rooms of the 6th floor
- Floor selecting for modelling → **6th floor**

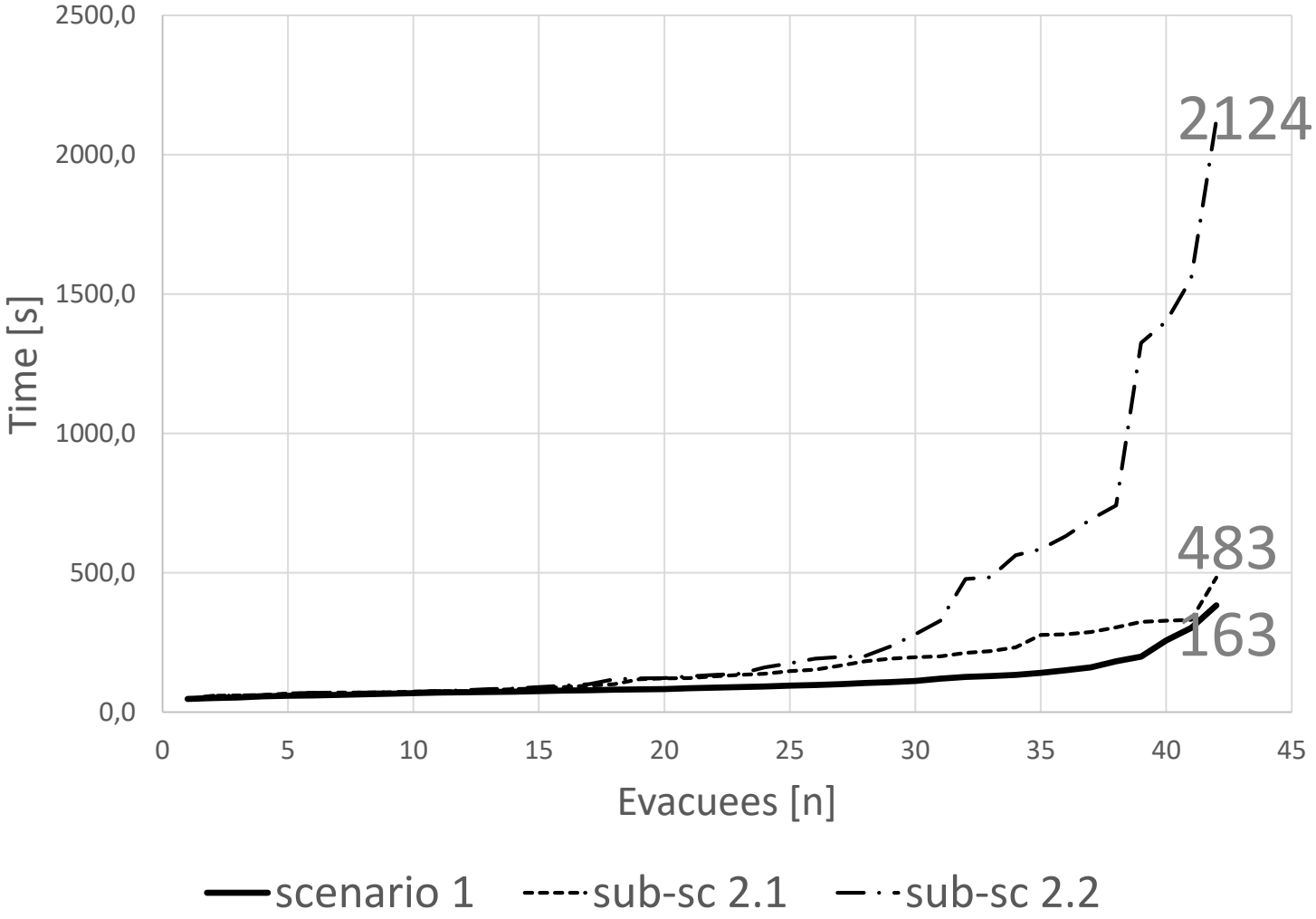
RESULTS

Scenario 1



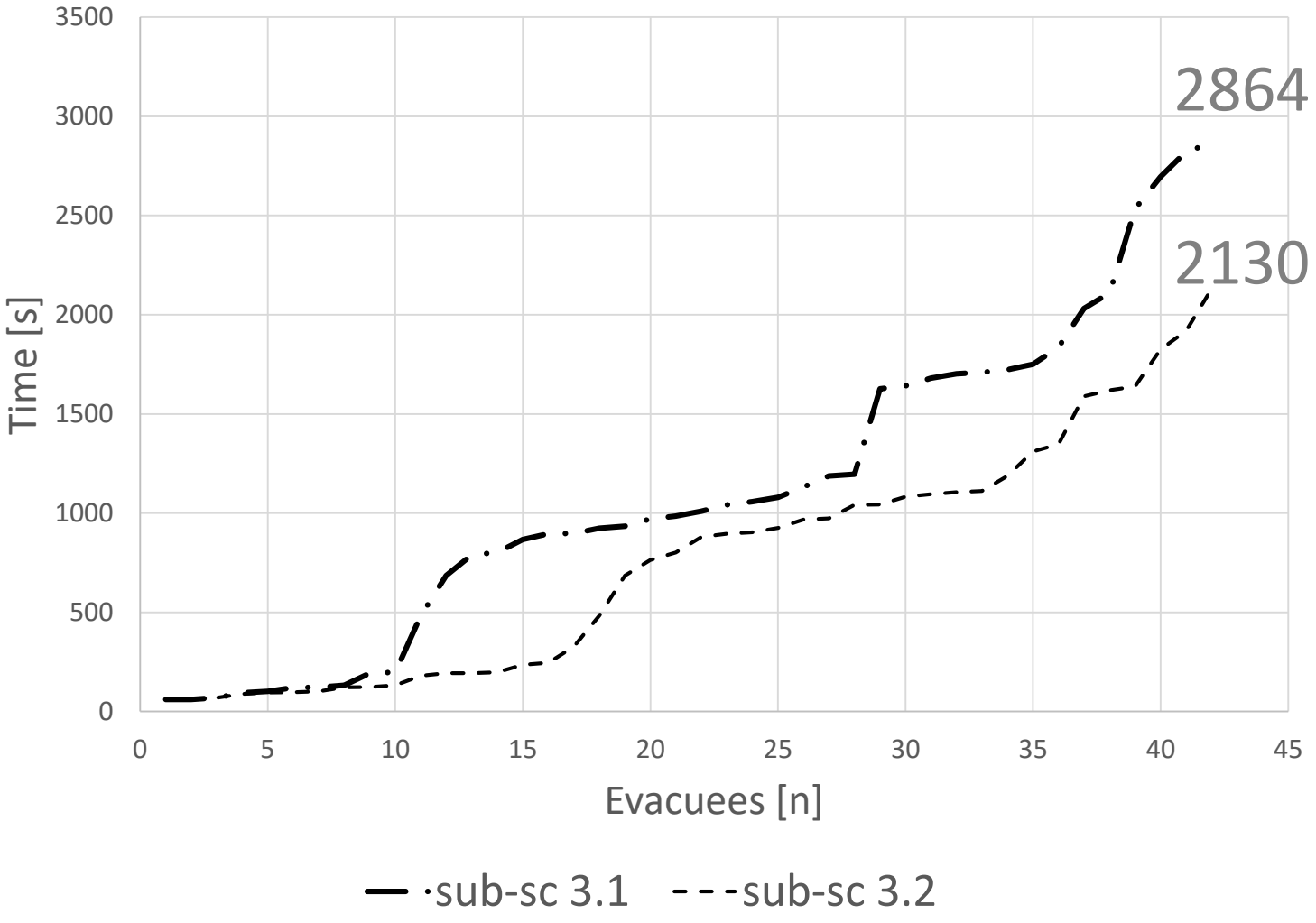
RESULTS

Scenario 1 & 2 (comparison)



RESULTS

Scenario 3



CONCLUSIONS

- Pathfinder is able to simulate prescript assisted evacuation (implicitly embedded by using the special features such as delays, assigned travel itineraries, etc.). However, the transportation devices are not modelled (interactions agents-devices are missing)

- The results showed that :

1) Conducting an assisted evacuation takes a higher time than an evacuation involving only ambulant patients;

2) The number of non-ambulant patients should be designed as few as possible to limit the time needed to conduct a safe evacuation;

3) The type of non-ambulant patients involved on the evacuation process influence the total evacuation time. Indeed, evacuating highly-dependent patients lead to a higher total evacuation time than evacuating dependent patients; and,

4) The presence of a large number of attendants leads to faster evacuation

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Thank you for your attention

Anass RAHOUTI [1], **Prof Sélim DATOUSSAÏD** [1], Dr Ruggiero LOVREGLIO [2]

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