Appendix

1. Summary of the expert session

The session was executed on the 15th of March on the BUas campus. Among the attendees were experts from the Event Safety Institute, the Police, the Dutch Defence Academy, Skills Crowd Management, and a municipality advisor in the field of fire and evacuation safety. The aim of the meeting was to gather experts in the field to participate in the CSR-Lab, developed by LCB. Furthermore, the creative session was used to gather qualitative insights and information into safety at events and the usage of the various guidelines and key figures.

The session started with a presentation from Justin van de Pas from LCB, explaining the CSR-Lab and the aim for this project. The attendees were asked about their pains in the industry and how LCB could help to overcome those pains.

After a small break, my part of the meeting started with a small presentation on the current situation within the industry, showing some examples of incidents and what the objective of my project is. To get the attendees more involved I created a Mentimeter questionnaire. They were able to answer and a discussion about the different guidelines stared among the experts. To show the difficulty of understanding some paragraphs in guidelines, we gave them an excerpt of the Dutch Evenementenhandboek, and the experts were asked to draw what was explained in the paragraph. The experts were unsure on how to draw it and discussions started among them, since they were all unsure how to interpret the text.

Afterwards, I asked the experts on feedback for the planning of my first experiment that would take place two weeks after the session. They gave valuable feedback and encouraged me. Then I also asked for other possible experiments that could be valuable for the experts. This started a small brainstorming session, where everyone added new ideas that would be interesting for their field.

The session then ended with food and drinks at the Innovation Square and the experts were able to talk among themselves, since they also did not know each other.

2. Transcript of the expert session

Attendees:

Syan Schaap & Manon Gijbels:	Event Safety Institute (ESI)
Kees and Daan van Eeden:	Policy officer, consultant
Mark Helgers:	Military science & military police operation, law enforcement and crisis management
Brandon Slootweg:	DCM application smart tech to crowd management
Iris Kamphorst	SKILLS Crowd Management crowd management large-scale festivals
Gerrit Vermeer:	Advisor municipalities in the field of fire safety and evacuation safety
Ronald Gearards:	Ucrowds, university lecturer in computer science, builds and develops simulation software

The creative session:

- Leaving in panic depends on various factors. 'analysis model escape safety', it is in a book by Basis for Fire Safety

o The location: how simple is it to understand?

o The urgency: is it a fire, or something less urgent?

o The type of crowd: are you old/young, drunk/sober, in what way are you alert, and can you get yourself to safety?

- These factors get you how quickly you can evacuate.

- Fire brigade: and can you open the door? Sometimes there is pressure.

- You have to recognise the danger first before they actually evacuate.

Iris: we are just in a new office where the fire alarm went off 3 times this morning. And everyone stayed seated while it went off several times again.

Fire Brigade & Roland: we always look at the exits and the type of exit you have. You should always do that as a FAFS officer.

Maarten: a recent problem was when iron flew off the roof due to a storm and we were all sent outside, when that's where the problem was.

Guides (Mentimeter)

- Bgbob

- Green Guide

- Building code

- Bb2012

- Nhev

- Nen standards

- Eurocodes

- Handbooks (new ones from all over the world)

- Venuepoll (about venues and safety) keep up with the news (ESI publishes it)

- Law

- Experience of organisers

Roland: crowd science is it science of art? You learn by doing it and by telling stories. You have to do it by experience and passing on stories. It's also a piece of recognition and experience.

Event data is behind in, say, logistics or other sectors. Because of these kinds of settings.

Legion = evacuation studies and crowd flows optimisation. It is fully validated, they did 1 event and made precise break estimates. But their data is based on 1 event instead of a series.

Event industry = money-driven, which is something we need to be aware of.

Organisers enter the conversation with sometimes it is political: then the municipality chooses, it is not always the case that the organisation chooses the numbers that are most favourable.

Fire service = building code & bgbob, often they pick 90 people per minute based on various factors. Risk-oriented thinking: Gerrit sees legislation as rope railing that I can hold on to, but I can go left with it, and I can go right with it. You can move within it based on various factors (e.g., subsoil of a meadow the event takes place on).

Syan: It is also very important to look at how much time it takes to evacuate your site when you look at the number of people who can get through an exit.

- You also have to think about the safest way to evacuate based on various factors

Military: we have 1 number for all types of people, while it also matters if you have certain particular target group. Older people are slower, for example.

- Target group

- Event type

- Alcohol & drugs

All those factors should be in the risk assessment of your event

Syan: What could be valuable for your research: you should be able to translate it into specific numbers and differentiate in this, for example:

- When it's a soft ground instead of a hard ground, how does that affect speed?

- Alcohol vs no alcohol

- Various target groups

- Etc.

Mark: Regulations are no substitute for common sense.

Numbers (mentimeter)

- 4 people per m2

- 135 people per minute

- 82 people per metre per minute

- 79 standard for stairs in Eurocode per minute per 1.20 metres

- when turning against the flow, 60 people

- 90 doors rotating in escape direction

There are different interpretations in legislation. We have taken pictures before to know what it means. It is difficult to understand, especially where the differences.

Syan: In manuals: the door must be immediately openable; no number is assigned to this.

Fire brigade: double door basically doubles your prefix of a single duration. However, it must always be the case that the single door is earlier in the escape process than the double door, otherwise bottleneck.

Maarten: with a corridor, 90 people can pass through per metre per minute. Whereas with a door it is found that there are then 110 people can pass through

Syan: you can just go in all directions, the door that doesn't bother you.

Conclusion: everyone interprets the guidelines differently. There is much debate even within the experts about the 'correct' way of drawing.

Syan: you should look at footage of events at regular event exits and measure how fast/slow it goes. You often see that it is not possible to escape as fast as you think it is possible. Use this kind of data to validate your outcomes.

Syan: for the guideline, only in the Netherlands is there a difference in the amount to cover. It may be that with longer stairs that there is a slower pace and greater risk of falling.

Justin: the guide in the UK is said to be the most reliable, is that still true.

- Not sure.

- Syan: if you don't know, choose the safest or the strictest.

Roland: to be critical, if you run our software over this, you will probably get a different picture. How do we validate what we translate? How do we ensure uniformity in complex situation?

- We use VROOM, but there are so many differences between all the factors.

Maarten: Vroom is from 1977, which is very old. When was this validated?

- Brandon: there is no validation of all sources and numbers.

Brandon: you have to use the lab to learn how to set up experiments and then put them out in the 'real world'.

Syan: you need to calibrate how fast a massive egress goes and use this to validate.

Brandon: the agents are programmed to behave in a certain way. I am curious when people are in a certain environment and by adding an element of surprise to get more insight into behaviour.

- Put some people in wheelchairs and see what effect it has.

Brandon: You have to repeat the experiment to validate whether you get the same results.

Feedback experiment

Gerrit; what kind of obstacle are you going to use?

- Something high and something you can't see over

- A pillar

Syan: when you separate flows, it makes the evacuation process faster?

Roland: Are you going to do the experiments with students? You get different results when you want to do it with different groups.

Manon: how often are you going to run the experiment? You have to do it more often to monitor validity.

Roland: it is very difficult to set up a GOOD experiment. I know an experiment of a red labyrinth; you have to include so many variables in a study. You have to invalidate a lot of journals. Really keep in mind that there are many experiments.

What experiments would be valuable?

- Different target groups give different results

- Use the same kind of setting with different variables

Syan: you can also do something with people who have reason to stay (when you stay you get something for free, when you don't you don't)

Brandon: I find it interesting to look at awareness (combine it with nudging), how can you better inform people about certain evacuation routes.

- Do people who are better informed respond than those who are not informed?

- At some events, messages are presented on screens, is this an effective way of communicating?

Only signage, or a fire warden? What is the effect on both options?

Also, differences between certain types of hazards

- Evacuation in case of fire

- Evacuation in case of gunshot

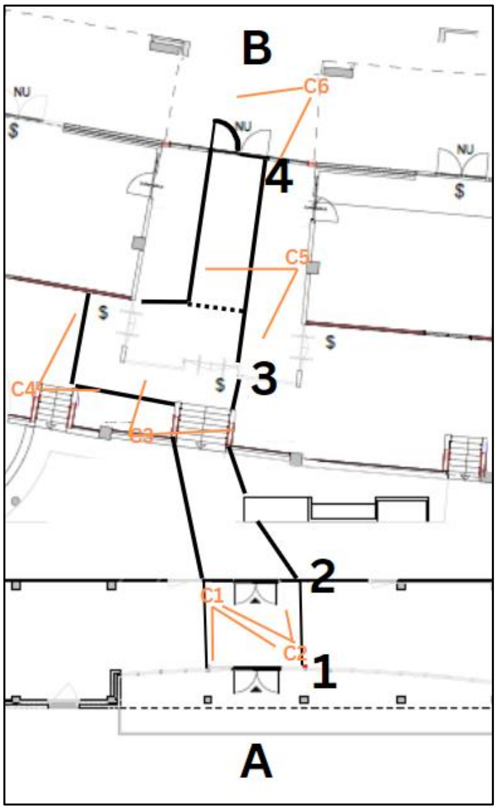
3. Operational plan Experiment 1

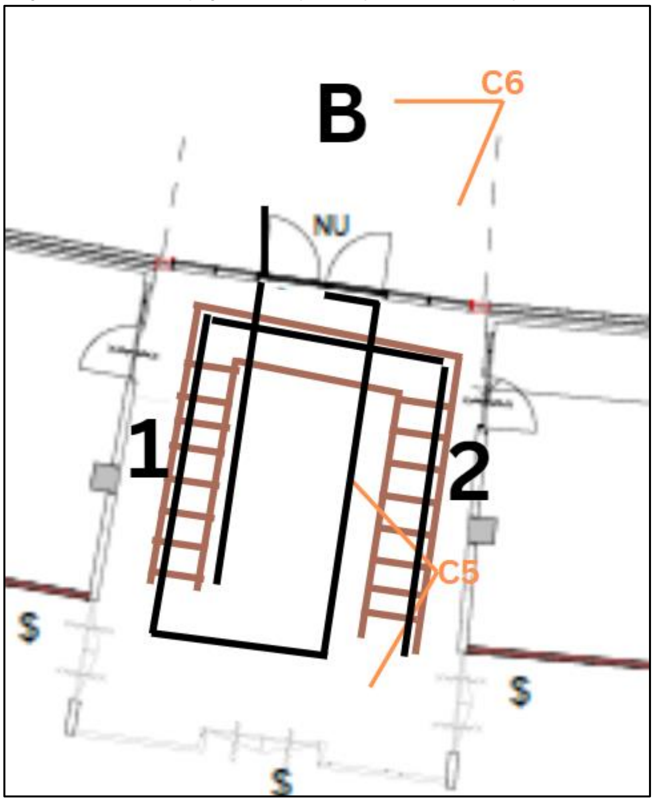
Foundation

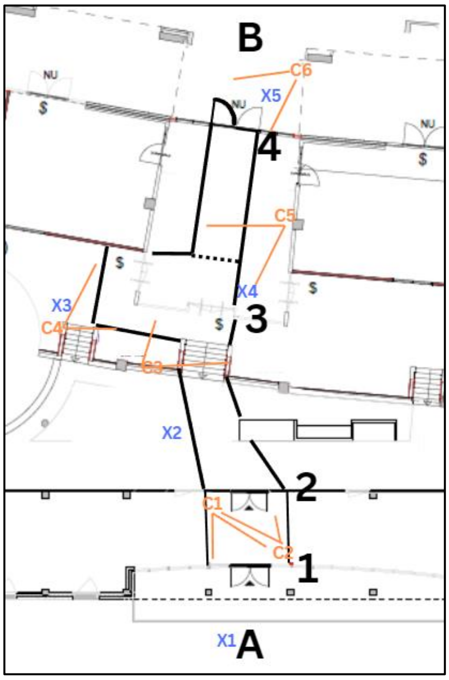
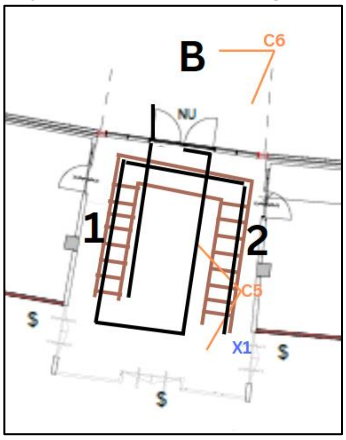
Research topic	Throughput of door and stairs
Theoretical Background	Guidelines from different countries
Vision / mission	Create more insights into safety key figures
Research questions	- How many people can pass through a doorway with a width of 1.00m and 2.00m? - How many people can walk up the stairs per meter per minute? - How many people can walk down the stairs per meter per minute? - Does the time differ if the urgency is higher?
Hypothesis / expectations	- The wider the opening in the door, the more people are able to pass - People will slow down the more stairs they have to walk up - The amount will increase in higher urgency
Materials	- 6 cameras - 15 barriers - Stopwatches - Information signs
Timeframe / Planning	(see table below)

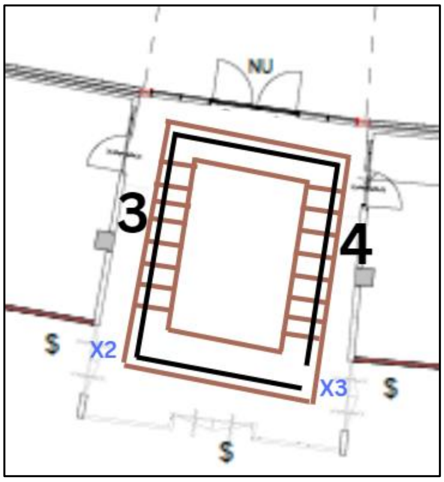
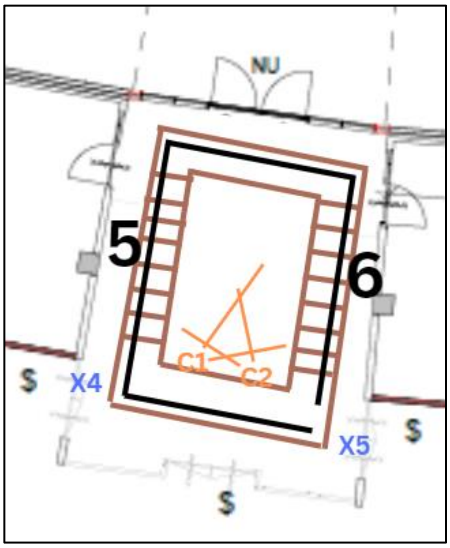
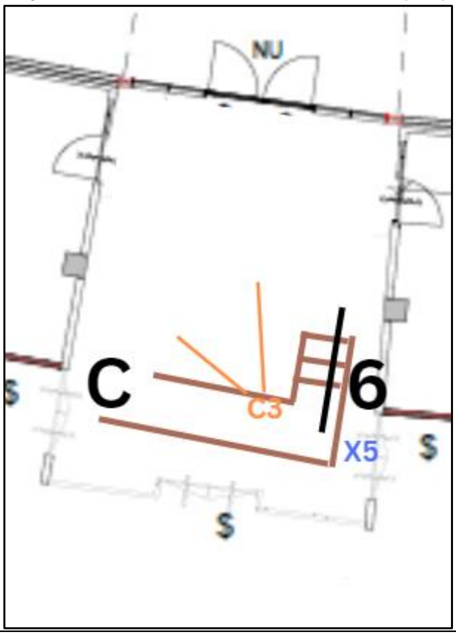
Date	Hour	Time	What
03/04/2023	13:30	25 minutes	walk-in of students at sportsbar
03/04/2023	13:55	30 minutes	Introduction with the students at Sportsbar
03/04/2023	14:25	5 minutes	Walk to area A
03/04/2023	14:30	5-10 minutes	Experiment 1a, urgency normal
03/04/2023	14:35	5 minutes	Experiment 1b, urgency normal
03/04/2023	14:40	5 minutes	Experiment 1a, urgency high
03/04/2023	14:45	5 minutes	Experiment 1b, urgency high
03/04/2023	14:50	15 minutes	Break, snacks at sportsbar
03/04/2023	15:05	5 minutes	Experiment 2a, urgency normal
03/04/2023	15:10	5 minutes	Experiment 2b, urgency normal
03/04/2023	15:15	5 minutes	Experiment 2a, urgency high
03/04/2023	15:20	5 minutes	Experiment 2b, urgency high
03/04/2023	15:25	5 minutes	walk back to sportsbar
03/04/2023	15:30	open end	Drinks

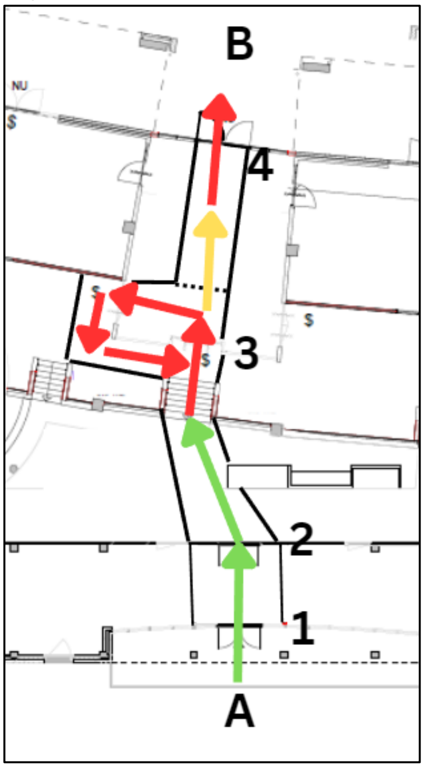
DIM-RAMP model / Touchpoints

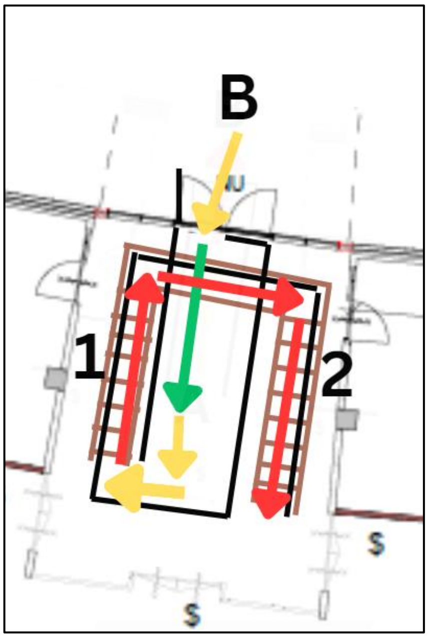
<table>
<tr><td>Design of the Experiment</td><td>Experiment 1


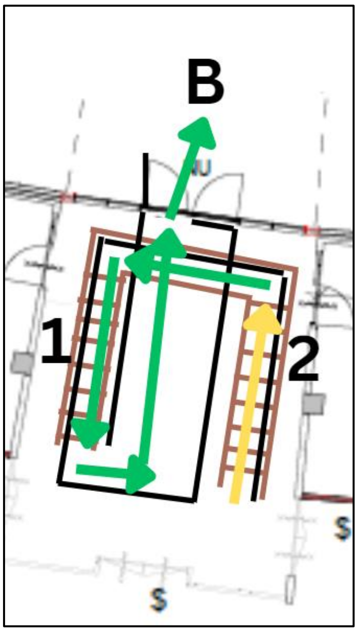
Experiment 2a (upwards); 2b (downwards)

</td></tr>
</table>

Information given to participants	Presentation: - Reason for research - Planning of the experiment - Design of the experiment - Information about cameras
Management of the experiment	Research team: - Gathering students in Sports bar - Take attendance - Communication among the team using WhatsApp or other tool - Lead students through experiment Locations of research team: **Experiment 1 (X1 – X5)**  **Experiment 2a & 2b – ground floor (X1)** 

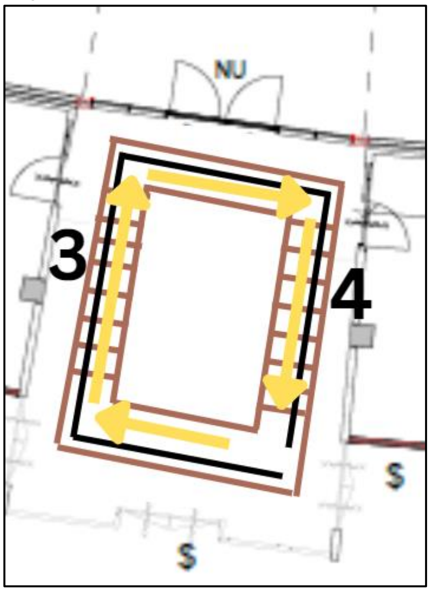
	Experiment 2a & 2b – first floor (X2 & X3)  **Experiment 2a & 2b – second floor (X4 & X5)**  **Experiment 2a & 2b – third floor (X5)** 

<table>
<tr><td></td><td></td></tr>
<tr><td>Route of the participants</td><td>Experiment 1


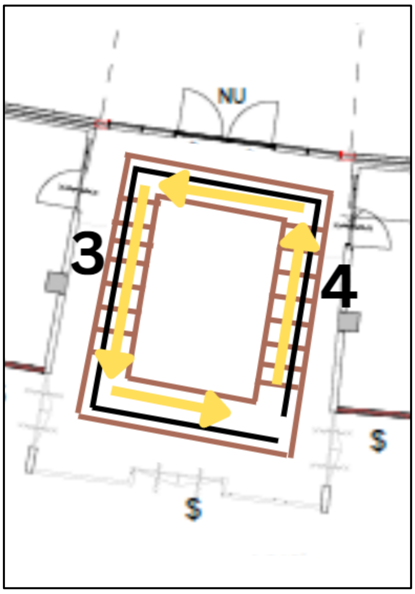
Experiment 2a – ground floor


Experiment 2b – ground floor

</td></tr>
</table>

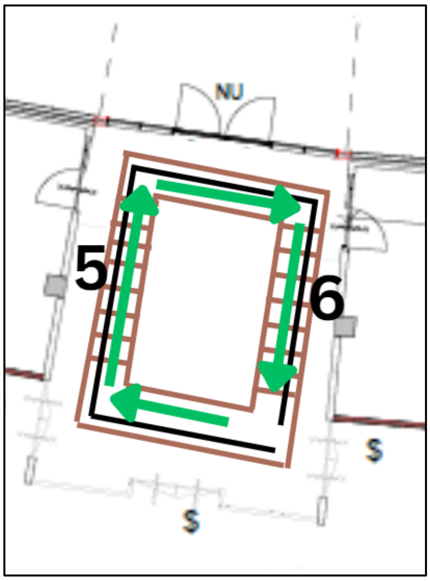
Experiment 2a – first floor



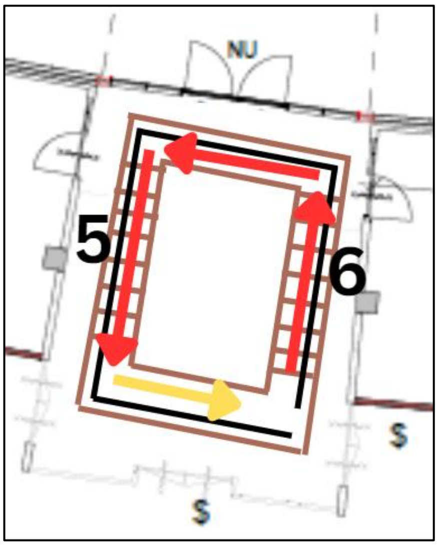
Experiment 2b – first floor



Experiment 2a – second floor

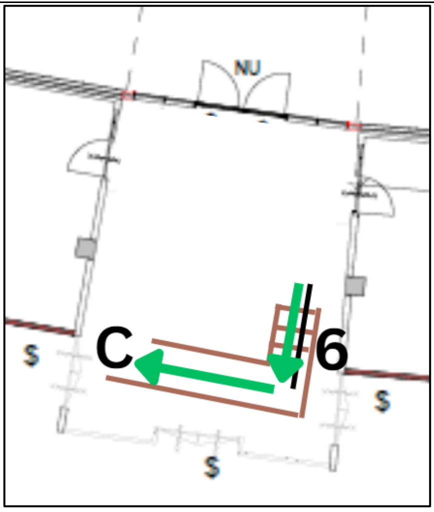


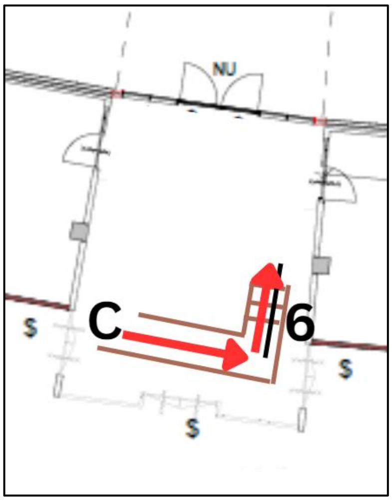
Experiment 2b – second floor



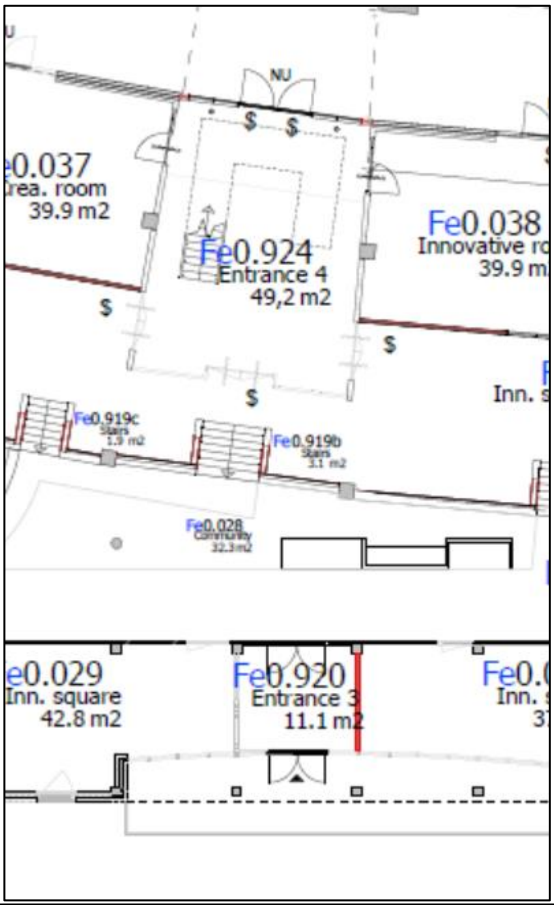
Experiment 2a – third floor

Experiment 2b – third floor

<table>
<tr><td></td><td>




The colours are based on the density expected in each area. Red meaning a very dense crowd, with around 3 people per m²; yellow meaning a less dense crowd with around 2 people per m² and green with around 1 person per m².
</td></tr>
<tr><td>Area of the experiment</td><td>
The area of the experiment is the Frontier building of the Breda University of Applied Sciences. It will be organized at the Innovation Square and the staircase next to the Innovation square, from the ground floor up the stairs to the third floor. The staircase has 49,2m², the entrance has 11.1m² and parts of the Innovation square are being used, which has 32.3m².



</td></tr>
</table>

Movement of the participants	The first experiment will start at around 14:25, where the students will walk from the sports bar to the starting point at area A. During the experiment they will walk/run outside to area B. Afterwards they will go back to area A. In between experiment 1 and 2, the students will walk back to the sports bar for a break. For experiment 2, the students will start in area B and walk/run up the stairs to the third floor. Afterwards they will walk/run down the stairs back to area B. Once all experiments are finished the students will walk back to the sports bar.
Profile of the participants	The profile of the participants are second-year students from Breda University. The age is between 18 and 25. They are familiar with the surroundings of the building. They are fit and mobile to execute the requirements of the experiment.

4. Operational plan Experiment 2

Foundation

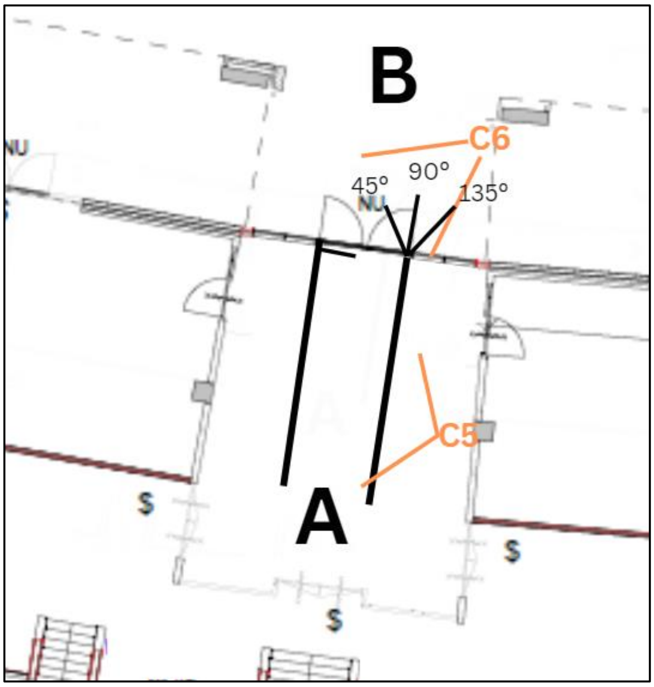
Research topic	Throughput of door and stairs
Theoretical Background	Guidelines from different countries
Vision / mission	Create more insights into safety key figures
Research questions	- How many people can pass through a doorway with a width of 0.80 m, 1.00m, 1.20m and 1.40m? - Does the angle (45°; 90°; 135°) the emergency exit door is opened influence the flow? - How many people can walk up the stairs per meter per minute? - How many people can walk down the stairs per meter per minute? - Does the time differ if the urgency is higher?
Hypothesis / expectations	- More people will be able to pass through the door if the angle is higher - The wider the opening in the door, the more people are able to pass - People will slow down the more stairs they have to walk up - The amount will increase in higher urgency
Materials	- 5 cameras - 4 fences or barriers - Stopwatches - Information signs - Prizes (5 festival tickets)
Timeframe / Planning	

Date	Hour	Time	What	Details
24/04/2023	13:45	5 minutes	walk-in of students at sportsbar	
24/04/2023	13:50	15 minutes	Introduction with the students at Sportsbar	
24/04/2023	14:05	5 minutes	Walk to parcour	
24/04/2023	14:10	5 minutes	Experiment 1a, urgency normal	
24/04/2023	14:15	5 minutes	Experiment 1a, urgency high	prize, 3 times through opening
24/04/2023	14:20	5 minutes	Experiment 1b, urgency normal	
24/04/2023	14:25	5 minutes	Experiment 1b, urgency high	prize, 3 times through opening
24/04/2023	14:30	5 minutes	Expreiment 1c, urgency normal	
24/04/2023	14:35	5 minutes	Experiment 1c, urgency high	
24/04/2023	14:40	15 minutes	break	
24/04/2023	14:55	5 minutes	Experiment 2a, urgency normal	
24/04/2023	15:00	5 minutes	Experiment 2a, urgency high	prize, 3 times through opening
24/04/2023	15:05	5 minutes	Experiment 2b, urgency normal	
24/04/2023	15:10	5 minutes	Experiment 2b, urgency high	
24/04/2023	15:15	5 minutes	Experiment 2c, urgency normal	
24/04/2023	15:20	5 minutes	Experiment 2c, urgency high	prize, 3 times through opening
24/04/2023	15:25	10 minutes	break	
24/04/2023	15:35	5 minutes	Experiment 3a, urgency normal	
24/04/2023	15:40	5 minutes	Experiment 3b, urgency normal	
24/04/2023	15:45	5 minutes	Experiment 3a, urgency high	prize, first 5 upstairs
24/04/2023	15:50	5 minutes	Experiment 3b, urgency high	
24/04/2023	15:55	5 minutes	walk to sportsbar	
24/04/2023	16:00	open end	Drinks	

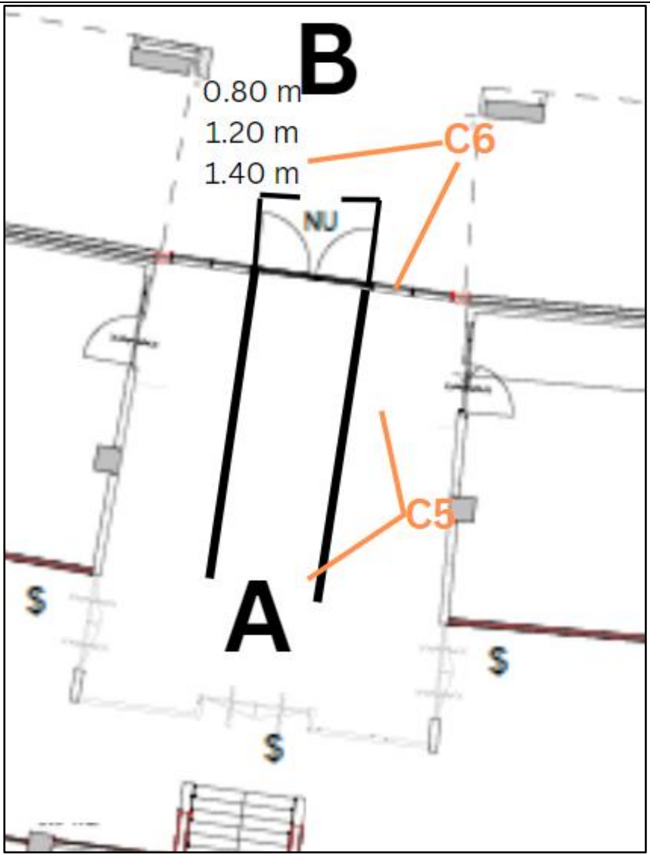
DIM-RAMP model / Touchpoints

Design of the Experiment

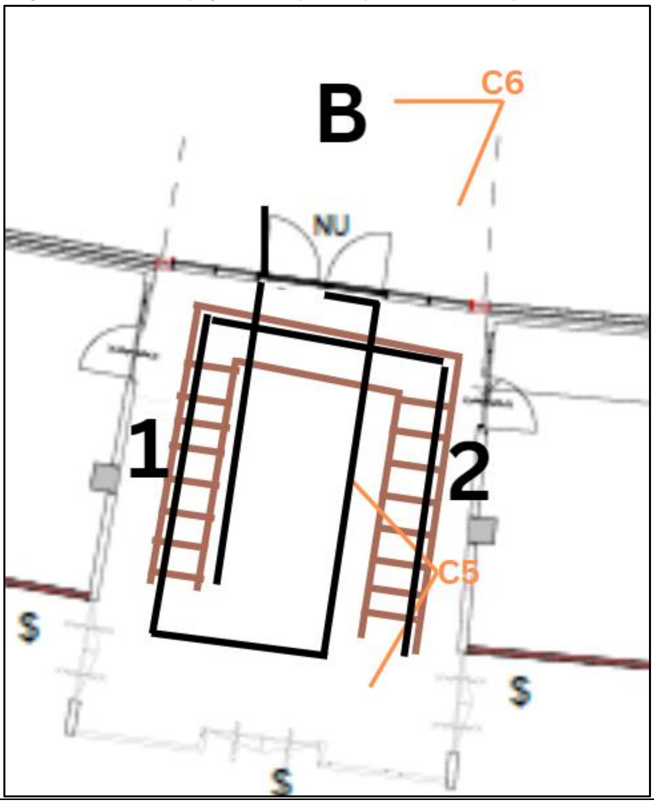
Experiment 1a (135°); 1b (90°); 1c (45°)

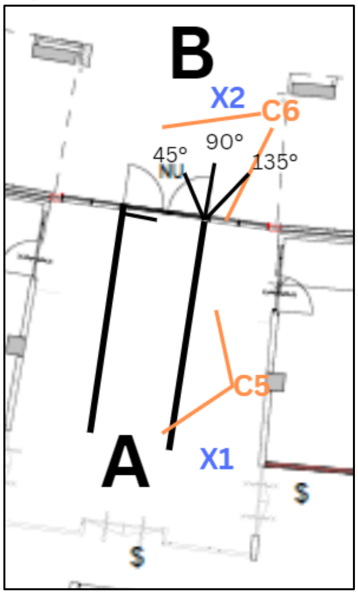


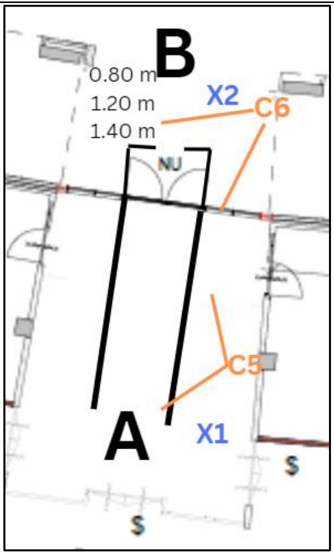
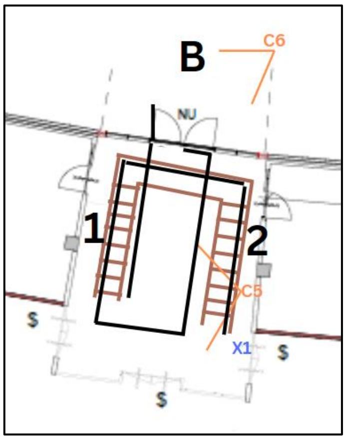
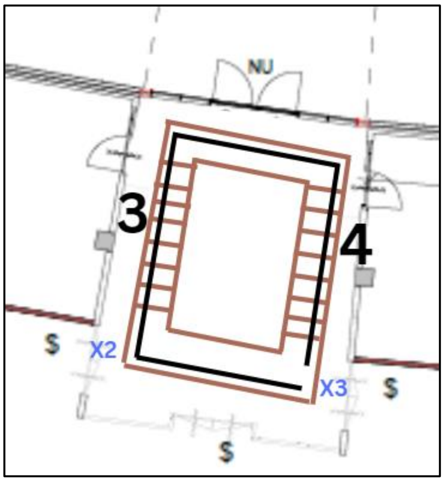
Experiment 2a (0.80 m); 2b (1.20 m); 2c (1.40 m)

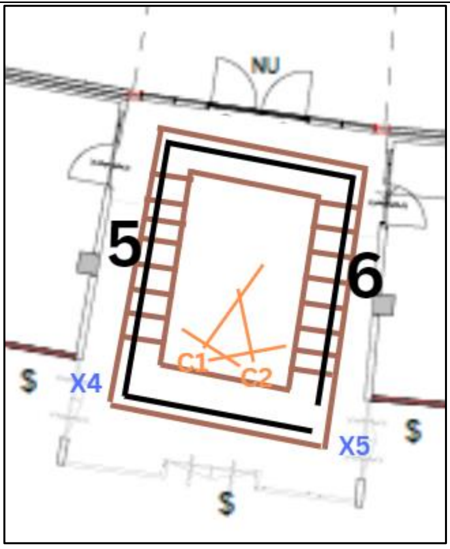
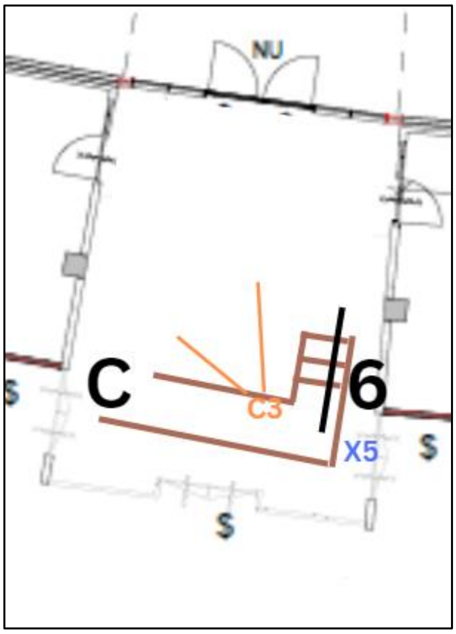


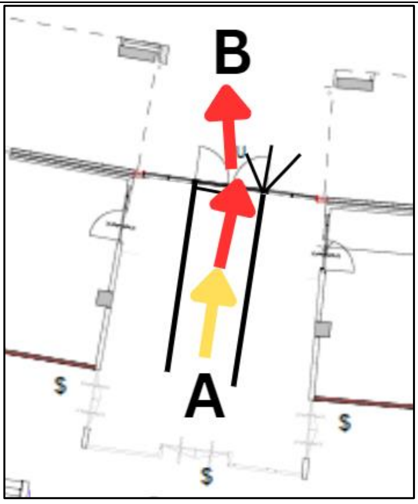
Experiment 3a (upwards); 3b (downwards)



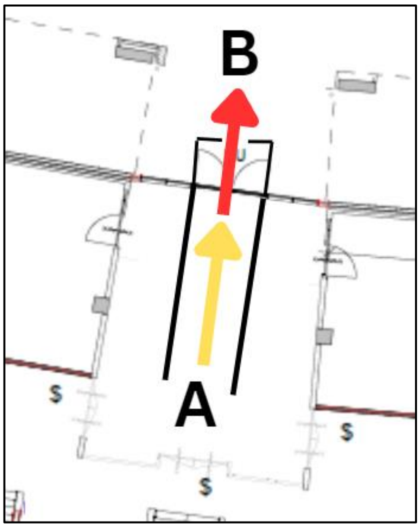
Information given to participants	Presentation: - Reason for research - Planning of the experiment - Design of the experiment - Information about cameras -
Management of the experiment	Research team: - Gathering students in Sports bar - Take attendance - Communication among the team using WhatsApp or other tool - Lead students through experiment - Prizes: first 5 through door get stamp on hand Locations of research team: **Experiment 1 (X1 & X2)**  **Experiment 2 (X1 & X2)**

	 **Experiment 3 – ground floor (X1)**  **Experiment 3 – first floor (X2 & X3)**  **Experiment 3 – second floor (X4 & X5)**

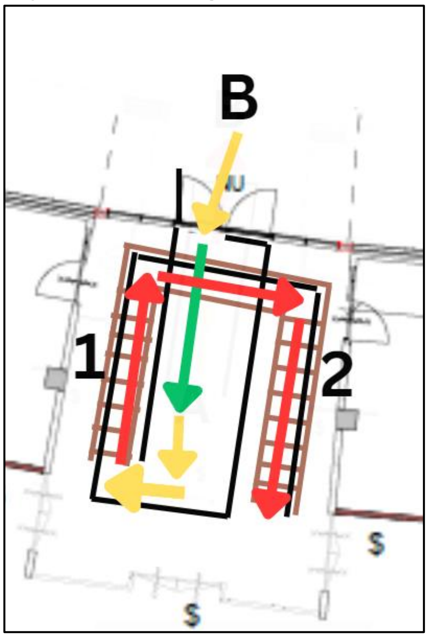
	 **Experiment 3 – third floor (X5)** 
Route of the participants	**Experiment 1**



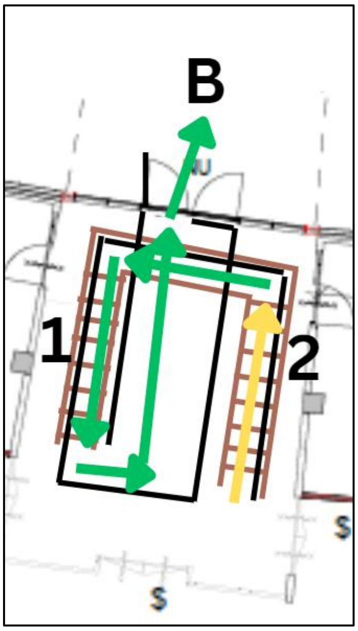
Experiment 2



Experiment 3a – ground floor

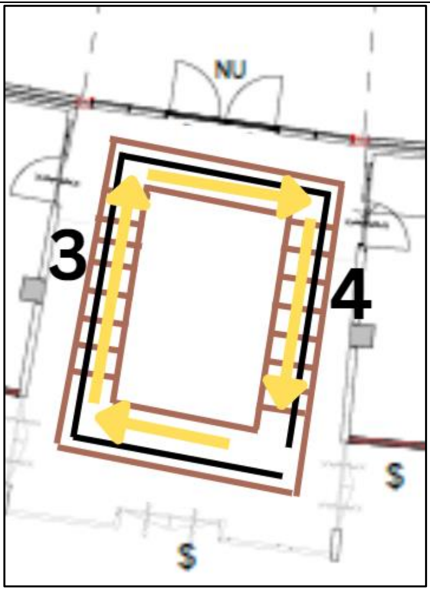


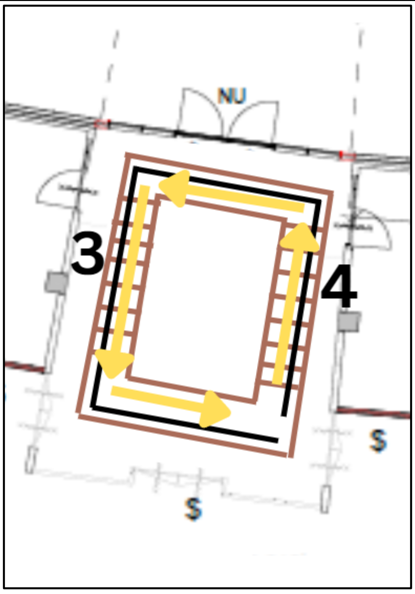
Experiment 3b – ground floor



Experiment 3a – first floor

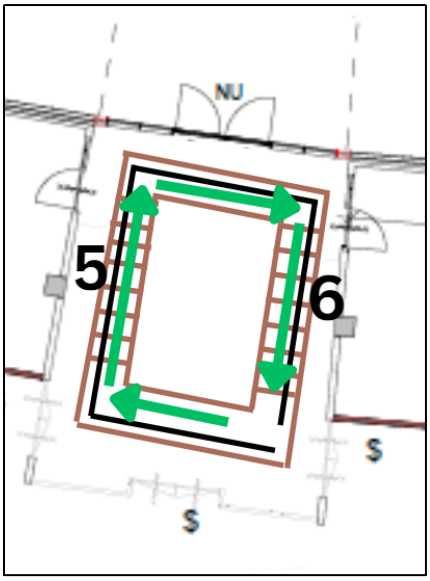
Experiment 3b – first floor

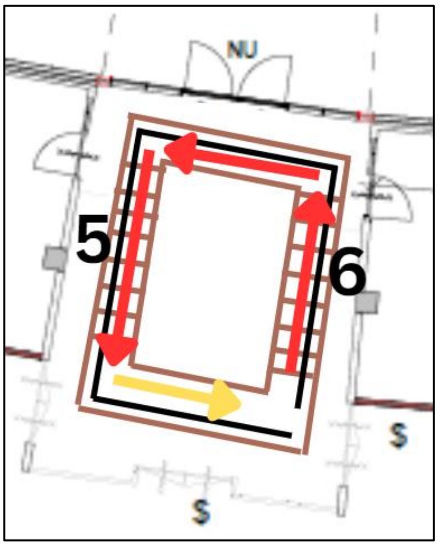




Experiment 3a – second floor

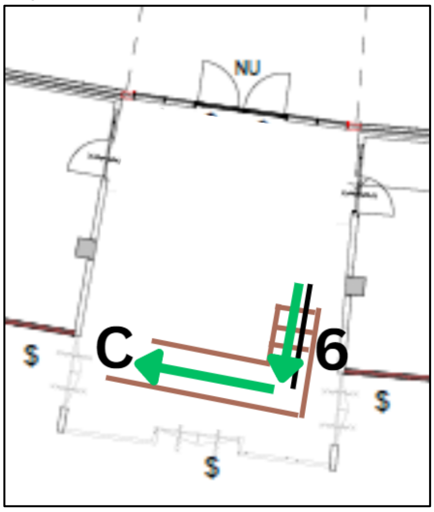
Experiment 3b – second floor

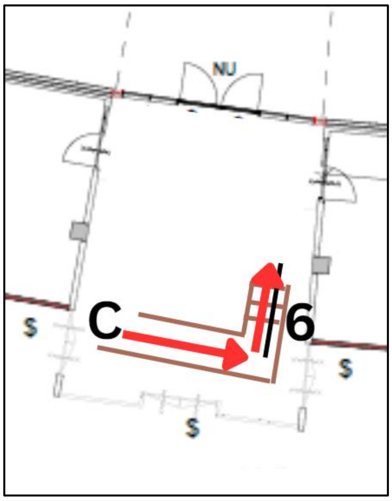


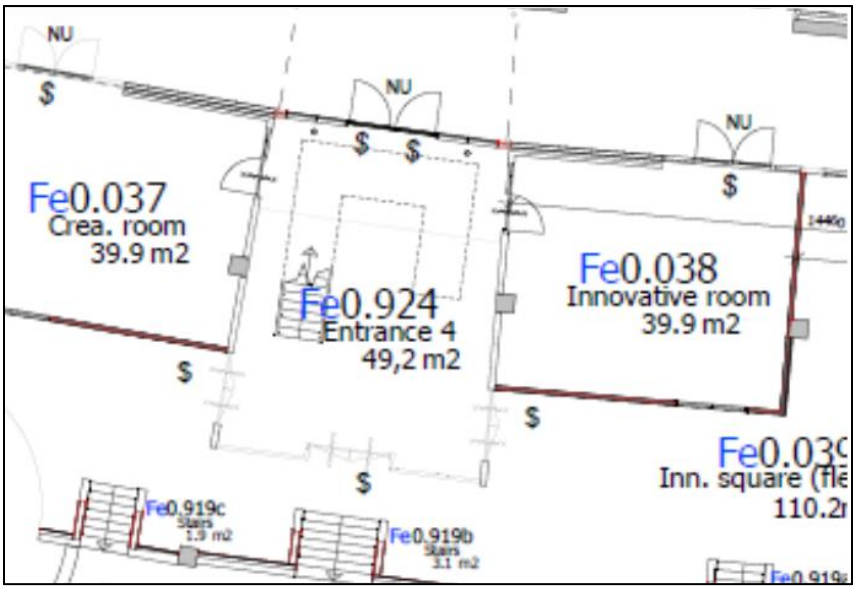


Experiment 3a – third floor

Experiment 3b – third floor





	The colours are based on the density expected in each area. Red meaning a very dense crowd, with around 3 people per m²; yellow meaning a less dense crowd with around 2 people per m² and green with around 1 person per m².
Area of the experiment	The area of the experiment is the Frontier building of the Breda University of Applied Sciences. It will be organized at the staircase next to the Innovation square, from the ground floor up the stairs to the third floor, as well as outside in front of the entrance to the staircase. The staircase has 49,2m². 
Movement of the participants	The first experiment will start at around 14:10, where the students will walk from the sports bar to the starting point at area A. During the experiment they will walk/run outside to area B. Afterwards they will go back to area A, and this will continue for experiments 1 and 2. In between experiment 1 and 2, the students will walk back to the sports bar for a break. For experiment 3, the students will start in area B and walk/run up the stairs to the third floor. Afterwards they will walk/run down the stairs back to area B. Once all experiments are finished the students will walk back to the sports bar.
Profile of the participants	The profile of the participants are second-year students from Breda University. The age is between 18 and 25. They are familiar with the surroundings of the building. They are fit and mobile to execute the requirements of the experiment.

5. Results of Experiment Day 1

Experiment 1 measurements using manual counting and camera counting

Source	Urgency	door 1 (p/30 sec)	Door 2 (p/30 sec)	Door 3 (p/min) - cam 3	Door 3 (p/min) - cam 5	Door 4 - 90° (p/min)
Manual counting	Normal	54	54	59		41
Camera	Normal	53 (within 24 sec)	53 (within 27 sec)	44 (within 30 sec) 62 (within 1 min)	44 (within 30 sec) 62 (within 1 min)	46 (within 30 sec)
Manual counting	High	?	all (within 15,46 sec)	84		all (within 20 sec)
Camera	High	53 (within 11 sec)	53 (within 13 sec)	75 (within 30 sec) 109 (within 1 min)	75 (within 30 sec) 109 (within 1 min)	53 (within 20 sec)

People passing per second and meter

Calculations:

Normal urgency:

Door 1 -> 53 p / 24 sec / 2 m = 1.10 p/sec/m
Door 2 -> 53 p / 27 sec / 2 m = 0.98 p/sec/m
Door 3 -> 44 p / 30 sec = 1.47 p/sec/m
Door 4 -> 46 p / 30 sec = 1.53 p/sec/m

High urgency:

Door 1 -> 53 p / 11 sec / 2 m = 2.41 p/sec/m
Door 2 -> 53 p / 13 sec / 2 m = 2.04 p/sec/m
Door 3 -> 75 p / 30 sec = 2.50 p/sec/m
Door 4 -> 53 p / 20 sec = 2.65 p/sec/m

People passing per minute and meter

Normal urgency:

Door 1 -> 1.10*60 sec = 66.25 p/min/m
Door 2 -> 0.98*60 sec = 58.89 p/min/m
Door 3 -> 1.47*60 sec = 88.00 p/min/m
Door 4 -> 1.53*60 sec = 92.00 p/min/m

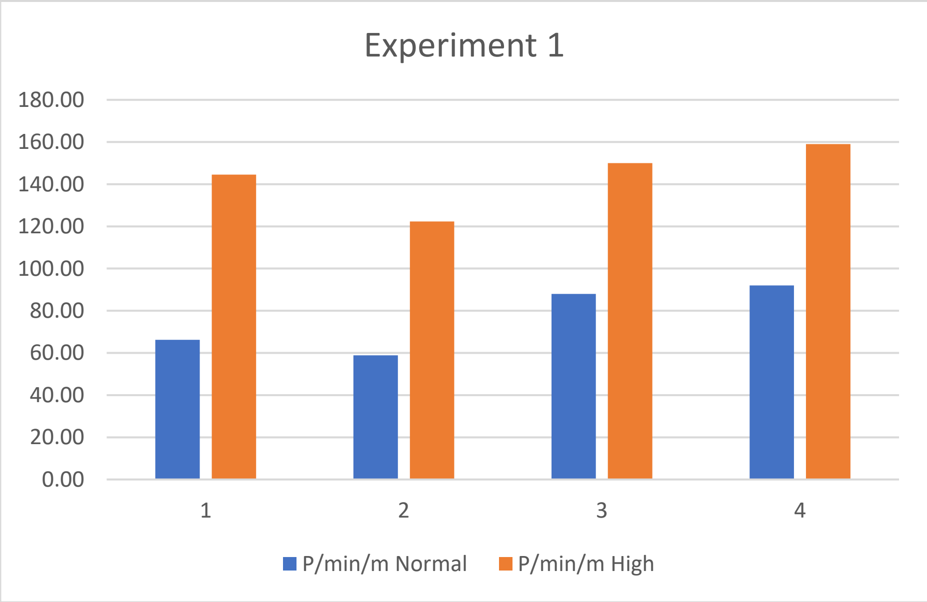
High urgency:

Door 1 -> 2.41*60 sec = 144.55 p/min/m
Door 2 -> 2.04*60 sec = 122.31 p/min/m
Door 3 -> 2.50*60 sec = 150.00 p/min/m
Door 4 -> 2.65*60 sec = 159.00 p/min/m

Urgency	Door 1	Door 2	Door 3	Door 4	Average	Total average
Normal	1.10	0.98	1.47	1.53	1.27	1.84
High	2.41	2.04	2.50	2.65	2.40	

Urgency	Door 1	Door 2	Door 3	Door 4	Average	Total average
Normal	66.25	58.89	88.00	92.00	76.28	110.12
High	144.55	122.31	150.00	159.00	143.96	

Graph of experiment 1 in normal and high urgency per minute



Comparison of key figures of other experiments and studies

Study	P/m/sec	P/m/min
My experiments	1.84	110.12
INTERNATIONAL MARITIME ORGANIZATION, 2002	1.33	79.8
Experimental study of pedestrian flow through a bottleneck, 2006	1.77	106.2
Understanding differences in emergency escape and experimental pedestrian crowd egress through quantitative comparison, 2016	1.81	108.6
Evacuation of crawlers and walkers from corridor through an exit, 2006	2.75	165

Experiment 2a measurements using manual counting and camera counting

Source	Urgency	Stairs 1 (p/min)	Stairs 2 (p/min)	Stairs 3 (p/min)	Stairs 4 (p/min)	Stairs 5 (p/min)	Stairs 6 (p/min)
Manual counting	Normal		50	50	46	41	42
Cameras	Normal	31 (within 30 sec) 52 (within 54 sec)	25 (within 30 sec) 50 (within 1 min)		21 (within 30 sec) 46 (within 1 min)	21 (within 30 sec) 44 (within 1 min)	21 (within 30 sec) 41 (within 1 min)
Manual counting	High		52	52 (within 42 sec)	52 (within 47 sec)	52 (within 47 sec)	50
Cameras	High	50 (within 30 sec) 52 (within 33sec)	44 (within 30 sec) 52 (within 38 sec)		31 (within 30 sec) 52 (within 47 sec)	26 (within 30 sec) 52 (within 52 sec)	25 (within 30 sec) 52 (within 1 min)

People passing per second and meter

Calculations:

Normal urgency:

Stair 1 -> 31 p / 30 sec = 1.03 p/sec/m
Stair 2 -> 25 p / 30 sec = 0.83 p/sec/m
Stair 3 -> 50 p / 60 sec = 0.83 p/sec/m
Stair 4 -> 21 p / 30 sec = 0.70 p/sec/m
Stair 5 -> 21 p / 30 sec = 0.70 p/sec/m
Stair 6 -> 21 p / 30 sec = 0.70 p/sec/m

High urgency:

Stair 1 -> 50 p / 30 sec = 1.67 p/sec/m
Stair 2 -> 44 p / 30 sec = 1.47 p/sec/m
Stair 3 -> 52 p / 42 sec = 1.24 p/sec/m
Stair 4 -> 31 p / 30 sec = 1.03 p/sec/m
Stair 5 -> 26 p / 30 sec = 0.87 p/sec/m
Stair 6 -> 25 p / 30 sec = 0.83 p/sec/m

Urgency	Stairs 1	Stairs 2	Stairs 3	Stairs 4	Stairs 5	Stairs 6	Average	Total average
Normal	1.03	0.83	0.83	0.70	0.70	0.70	0.80	0.99
High	1.67	1.47	1.24	1.03	0.87	0.83	1.18	

People passing per minute and meter

Calculations:

Normal urgency:

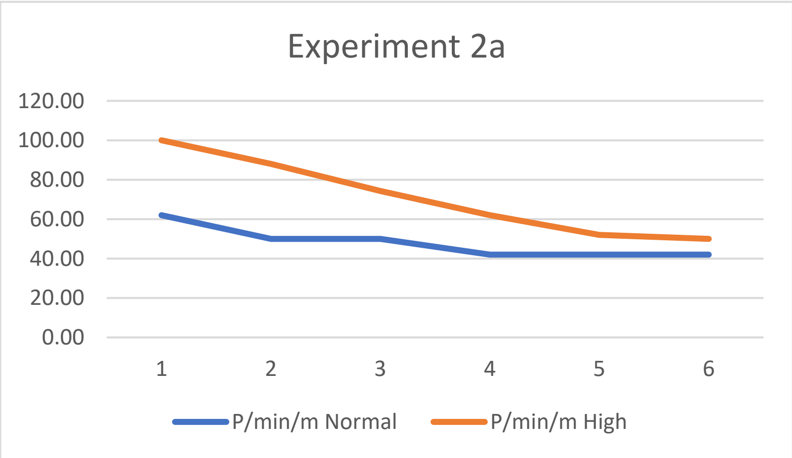
Stair 1 -> 1.03*60 sec = 62 p/min/m
Stair 2 -> 0.83*60 sec = 50 p/min/m
Stair 3 -> 0.83*60 sec = 50 p/min/m
Stair 4 -> 0.70*60 sec = 42 p/min/m
Stair 5 -> 0.70*60 sec = 42 p/min/m
Stair 6 -> 0.70*60 sec = 42 p/min/m

High urgency:

Stair 1 -> 1.67*60 sec = 100 p/min/m
Stair 2 -> 1.47*60 sec = 88 p/min/m
Stair 3 -> 1.24*60 sec = 74,29 p/min/m
Stair 4 -> 1.03*60 sec = 62 p/min/m
Stair 5 -> 0.87*60 sec = 52 p/min/m
Stair 6 -> 0.83*60 sec = 50 p/min/m

Urgency	Stairs 1	Stairs 2	Stairs 3	Stairs 4	Stairs 5	Stairs 6	Average	Total average
Normal	62.00	50.00	50.00	42.00	42.00	42.00	48.00	59.52
High	100.00	88.00	74.29	62.00	52.00	50.00	71.05	

Graph of experiment 2a in normal and high urgency per minute



Comparison of key figures of other experiments and studies

Study	P/m/sec	P/m/min
My experiments	0.99	59.52
INTERNATIONAL MARITIME ORGANIZATION, 2002	0.88	52.8

Experiment 2b measurements using manual counting and camera counting

Source	Urgency	Stairs 6 (p/min)	Stairs 5 (p/min)	Stairs 4 (p/min)	Stairs 3 (p/min)	Stairs 2 (p/min)	Stairs 1 (p/min)
Manual counting	Normal	52 (within 53 sec)	51	52 (within 55 sec)	52	51	
Cameras	Normal	32 (within 30 sec) 52 (within 53 sec)	31 (within 30 sec) 52 (within 54 sec)	27 (within 30 sec) 52 (within 55 sec)		27 (within 30 sec) 52 (within 57 sec)	27 (within 30 sec) 52 (within 58 sec)
Manual counting	High	52 (within 43 sec)	52 (within 48 sec)	52 (within 48 sec)	52 (within 51 sec)	52 (within 55 sec)	
Cameras	High	31 (within 30 sec) 52 (within 40 sec)	38 (within 30 sec) 52 (within 43 sec)	38 (within 30 sec) 52 (within 46 sec)		29 (within 30 sec) 52 (within 53 sec)	35 (within 30 sec) 52 (within 1 min)

People passing per second and meter

Calculations:

Normal urgency:

Stair 1 -> 27 p / 30 sec = 0.90 p/sec/m
Stair 2 -> 27 p / 30 sec = 0.90 p/sec/m
Stair 3 -> 52 p / 60 sec = 0.87 p/sec/m
Stair 4 -> 27 p / 30 sec = 0.90 p/sec/m
Stair 5 -> 31 p / 30 sec = 1.03 p/sec/m
Stair 6 -> 32 p / 30 sec = 1.07 p/sec/m

High urgency:

Stair 1 -> 35 p / 30 sec = 1.17 p/sec/m
Stair 2 -> 29 p / 30 sec = 0.97 p/sec/m
Stair 3 -> 52 p / 51 sec = 1.02 p/sec/m
Stair 4 -> 38 p / 30 sec = 1.27 p/sec/m
Stair 5 -> 38 p / 30 sec = 1.27 p/sec/m
Stair 6 -> 31 p / 30 sec = 1.03 p/sec/m

Urgency	Stairs 1	Stairs 2	Stairs 3	Stairs 4	Stairs 5	Stairs 6	Average	Total average
Normal	0.90	0.90	0.87	0.90	1.03	1.07	0.94	1.03
High	1.17	0.97	1.02	1.27	1.27	1.03	1.12	

People passing per minute and meter

Calculations:

Normal urgency:

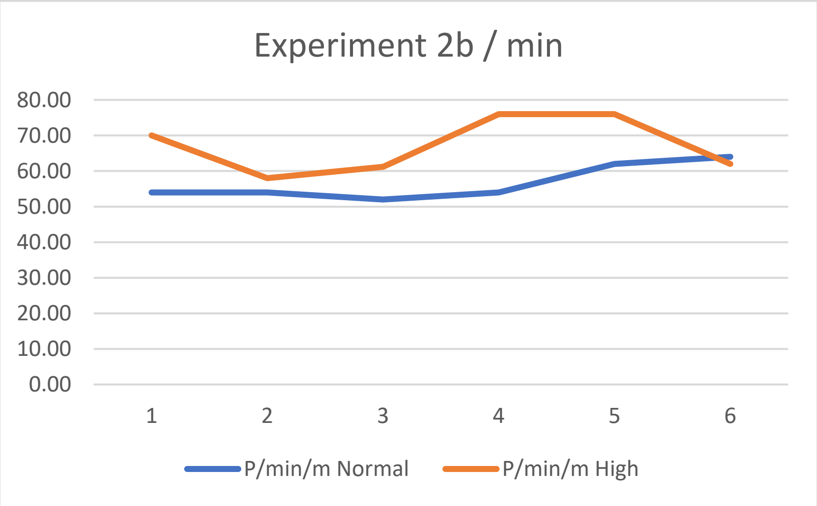
Stair 1 -> 0.90*60 sec = 54 p/min/m
Stair 2 -> 0.90*60 sec = 54 p/min/m
Stair 3 -> 0.87*60 sec = 52 p/min/m
Stair 4 -> 0.90*60 sec = 54 p/min/m
Stair 5 -> 1.03*60 sec = 62 p/min/m
Stair 6 -> 1.07*60 sec = 64 p/min/m

High urgency:

Stair 1 -> 1.17*60 sec = 70 p/min/m
Stair 2 -> 0.97*60 sec = 58 p/min/m
Stair 3 -> 1.02*60 sec =61.18 p/min/m
Stair 4 -> 1.27*60 sec = 76 p/min/m
Stair 5 -> 1.27*60 sec = 76 p/min/m
Stair 6 -> 1.12*60 sec = 67.20 p/min/m

Urgency	Stairs 1	Stairs 2	Stairs 3	Stairs 4	Stairs 5	Stairs 6	Average	Total average
Normal	54.00	54.00	52.00	54.00	62.00	64.00	56.67	61.00
High	70.00	58.00	61.18	76.00	76.00	62.00	67.20	

Graph of experiment 2a in normal and high urgency per minute



Comparison of key figures of other experiments and studies

Study	P/m/sec	P/m/min
My experiments	1	61
INTERNATIONAL MARITIME ORGANIZATION, 2002	1.1	66

6. Item list for interview with Armin Seyfried

Definition Topic	**Item**
General	- Do you actively work in the event sector, or do you prefer to teach or research? - What do you find interesting about the topic? - Why do you work at the research centre Jülich?
Guidelines	- Which guidelines do you know or use? - Do you know what the ratios are based on? - Were your experiments used for this? - Do you think it would make sense to create a uniform guideline for Germany?
Experiments	- Which experiments were you involved in? - What were the results? - Were the results applied in the following events? - What do you think about the results of our experiment? - Have you already planned further experiments?
Trends and developments	- What requirements do you see in the event sector in terms of crowd management? - How does Covid-19 influence the behaviour of visitors?
Crowd behaviour	- What is the behaviour of a crowd during an evacuation? - How can the behaviour of a crowd be influenced?

7. Transcript Interview 1 – Armin Seyfried

Hallo Herr Seyfried, vielen Dank, dass Sie sich bereit erklärt haben, mich bei meiner Bachelorarbeit zu unterstützen. Während meiner ersten Recherche bin ich auf Sie und die Arbeit des Forschungszentrums Jülich gestoßen. In meiner Bachelorarbeit beschäftige ich mich mit den verschiedenen Richtlinien in verschiedenen Europäischen Ländern und durch Experimente wollen wir herausfinden, welche Richtlinien am sichersten und zuverlässigsten sind. Sie haben bereits viele Experiments in diesem Bereich durchgeführt und können mir hier hoffentlich weiterhelfen. Können Sie sich vielleicht kurz einmal vorstellen und Ihre Arbeit erklären?

Kein Problem, ich helfe Ihnen gerne weiter. Ich habe mich schon früh für das Crowd Management interessiert und arbeite schon seit 2004 am Forschungszentrum Jülich. Zudem gebe ich Vorlesungen an der Bergischen Universität Wuppertal zum Thema Computersimulation für Brandschutz und Fußgängerverkehr. Am Forschungszentrum Jülich arbeite ich vor allem an Verbesserung von Sicherheitskonzepten mit Hilfe von Experimenten.

Das klingt sehr interessant und Sie haben bereits viel Erfahrungen sammeln können. Während meines Projektes habe ich mich mehr mit den verschiedenen Richtlinien in Bezug auf Evakuierungen in einigen Europäischen Ländern beschäftigt und diese verglichen. Dabei sind uns einige Unterschiede aufgefallen. Haben Sie sich auch schon mal damit beschäftigt und kennen Sie die Richtlinien aus anderen Ländern, wie zum Beispiel der ‚Purple Guide' aus England?

Während meiner Arbeit habe ich mich fast ausschließlich mit den deutschen Richtlinien beschäftigt und kenne den ‚Purple Guide' zum Beispiel leider nicht. Ich interessiere und unterrichte eher die deutschen Bauvorschriften und Versammlungsvorschriften, da wir hier in Deutschland sind. Allerdings kann ich mir sehr gut vorstellen, dass es durchaus deutliche Unterschiede in den Ländern gibt. Aus meiner Erfahrung weiß ich, dass jedes Land seine eigenen Vorschriften entwickelt und mache strenger sind als andere. In Deutschland rechnen wir oft bei Evakuierungen mit 1,20 Meter Notausgang pro 600 Personen in Freien und 1,20 Meter Notausgang pro 200 Personen. Ob das immer der Wahrheit entspricht, ist nicht immer sicher, da die Zahlen schon etwas älter sind und man einfach von einer Staffelung ausgeht. Je mehr Personen, desto mehr 0.6 Meter mehr Notausgang ist nötig. Das ist sehr mathematisch gedacht und macht an sich auch Sinn, aber während Events, kann man dies nicht einfach anwenden.

Ja, diese Werte habe ich bei meiner Recherche auch gefunden und mich gewundert wie des berechnet wurde. In anderen Ländern wird dies anders angegeben.

Wie wird es denn angegeben? Sind die Zahlen in den Richtlinien auf Notausgangstüren bezogen?

Ja genau, in den Richtlinien werden Personen pro Minute und Meter angegeben. Also in der UK, in den Niederlanden und in Schweden habe ich diese Werte gefunden. Aber um noch mal auf Ihre anderen Experimente zu kommen, an welchen haben Sie teilgenommen und wie organisieren Sie diese? Ist es ein so großer Aufwand, wie ich es mir vorstelle?

Ja, die Experimente, die wir im Zug vom BaSiGo durgeführt haben, waren sehr aufwendig und bedürfen einer langen Vorbereitungszeit. Im Schnitt kann man mit ca. 1 Jahr Arbeit pro Person rechnen, da man ja die ganze Technik organisieren muss und alle Bedingungen für die Experimente vorbereiten muss. Auch die Auswahl der Probanden ist sehr wichtig, da jede Zielgruppe unterschiedlich ist. Vor allem wenn man die Laufwege der einzelnen Probanden verfolgen möchte und Dichten präzise messen möchte, muss man sehr aufwendige Technik bereitstellen. Man brauch mehr als eine Kamera und diese müssen synchronisiert werden, ansonsten passen die Bilder nicht zueinander. Im Nachhinein ist die

Auswertung immer sehr aufwendig, obwohl wir eine sehr gute Software haben, wird es trotzdem immer noch mal per Hand korrigiert.

Ja, das klingt sehr aufwendig. Wir von LCB arbeiten jetzt auch mit einer neuen Software und sind momentan am Testen welche Funktionen für uns wichtig sind.

Ja, was ich festgestellt habe, ist dass die meisten Softwares, die es aktuell auf dem Markt gibt, bei geringen Dichten relativ zuverlässige Daten bieten. Wenn man aber dann ins Crowd Management geht und hohe Dichten hat, da versagen viele Softwares, da sie die einzelnen Personen nicht mehr erkennen können. Einer unsere Kollegen, der Herr Boltes, hat sich mit dem Thema beschäftigt und eine Doktorarbeit dazu geschrieben. Er hat auch eine Software entwickelt, die man auch bei hohen Dichten zuverlässige nutzen kann. Diese Software ist auch frei zugängig und es gibt Anleitungen zur Nutzung dieser Software. Aber da sollten Sie auch mal reinschauen.

Sehr interessant. Das werde ich mir auf jeden Fall einmal anschauen. Zuverlässige Daten sind immer sehr wichtig bei Experimenten. An welchen Projekten arbeiten Sie gerade?

Aktuell arbeiten wir an unserem neuen Projekt CroMa. Dies ist vielleicht auch für Sie interessant in Bezug auf die Vorbereitung eines Experiments. Wir haben gerade das Guidance Paper herausgebracht, ich schicke es Ihnen gerade schnell.

Oh, das klingt sehr spannend. Vielen Dank.

Im Zuge dieses Experiments haben wir so zu sagen ein Zirkeltraining für die Probanden aufgebaut. Die mussten dann zwischen 3 verschiedenen Experimenten hin und her gehen, um Wiederholungen mit den gleichen Probanden zu vermeiden. Also, in diesem Paper wird der Aufwand und die Arbeit, die wir uns vor dem Experiment machen noch einmal genauer erklärt.

Super, vielen Dank. Das werde ich mir nach unserem Gespräch noch einmal genauer anschauen. Und nach den Experimenten, wie analysieren Sie die Ergebnisse, die sie gesammelt haben?

Das hat sich bei uns über die Jahre deutlich weiterentwickelt. Wir haben angefangen mit den Laufwegen, mit 25 Bilder pro Sekunden, kann man dann die Position der Probanden nachvollziehen. Das macht man dann für alle Personen und das sind sehr große Datenmengen. Aber dadurch hat man die Laufwege sehr genau und sogar Zentimeter genau vorliegen und damit kann man dann wirklich präzise Dichtmessungen und Geschwindigkeitsmessungen machen. Das war, was wir am Anfang gemacht haben. Danach haben wir angefangen diese Laufwege mit Informationen über die Person an sich anzureichern, wie das Gewicht, das Alter, das Geschlecht und so weiter. Um das zu erreichen, müssen die Probanden aber auch gekennzeichnet werden. Daher haben all unsere Probanden Hüte mit Barcodes auf, die diese nötigen persönlichen Informationen gespeichert haben. Seit kurzem arbeiten wir auch mit einer Psychologin, die Frau Sieben, zusammen. Sie liegt den Fokus mehr darauf, wie sich die Personen fühlen. Daher haben wir angefangen die elektro-verbale Haut Leitfähigkeit und Herzrate als Indikator für Stress zu nutzen und das fügen wir auch noch in die Ergebnisse hinzu. Dazu wurden auch schon Research Paper veröffentlicht, die sollten Sie sich auch mal anschauen.

Ja, das werde ich auf jeden Fall tun. Die Emotionen der Personen in einer Menschenmenge sind auch sehr wichtig, um deren Verhalten zu analysieren.

Ja genau! Danach haben wir angefangen die Bewegungen der Arbeit und Beine der Probanden zu analysieren. Manche bekommen dann einen Anzug an und diese misst dann auch die 3D-Bewegungen einer Person. Aktuell sind wir noch dabei die Daten von den Kameras mit den Daten der Anzüge zu verknüpfen. Genau, wir sind eben bei den Laufwegen angefangen, und jetzt versuchen wir uns weiterzuentwickeln und immer mehr Daten einzusammeln durch neue Technologien.

Sehr interessant! Man entwickelt sich auf jeden Fall weiter, je mehr Experiment man durchführt und mit Hilfe der Technik kann man immer mehr und genauere Daten sammeln. Und wie ist es dann mit Ihren Ergebnissen? Wo werden die veröffentlicht und werden die vor allem von Experten und Event Organisatoren genutzt?

Die Ergebnisse veröffentlichen wir auf unserer Website, in den Publikationen. Und ich hoffe das diese Ergebnisse auch von der Event Branche genutzt werden. Ich kann Ihnen auch noch ein Experiment schicken, wo wir Warteschlangen im Feld und in Labor untersucht haben.

Vielen Dank dafür. Haben Sie auch während Ihrer Experimente Covid-19 berücksichtigt oder Verhaltensänderungen in den Menschenmengen erkannt?

Ja, da haben wir uns lange drüber Gedanken gemacht, wie wir die Effekte der Pandemie möglichst aus den Experimenten heraushalten können. Wir haben sogar ein sogenanntes „Eisbecher-Experiment" durchgeführt. Vor den eigentlichen Experimenten haben wir alle Probanden in einen engen Raum gestellt und dort ein paar Minuten warten lassen, damit sie sich wieder an die Nähe zu anderen Menschen gewöhnen. Wir sind uns aber nicht sicher, ob dies eine Auswirkung auf die Experimente hatte, aber wir haben es zu mindestens versucht.

Wow, das ist echt interessant, dass Sie so versucht haben dieses Problem zu verhindern und ja, es ist schwer zu wissen, ob es einen Einfluss hatte oder nicht. Aber ich finde eine Menschenmenge verhält sich anders nach der Pandemie.

Ja, da gab es ein verändertes Verhalten, aber ich finde das es mittlerweile schon schwächer wird und die Menschen wieder zu dem normalen Verhalten zurückkehren. Im Sommer werden wir denke ich auch wieder das Verhalten sehen, die wir vor der Pandemie gesehen haben.

Man brauch auch viel Geld dafür.

Was meinen Sie genau?

Für die Experimente. Man benötigt auch die Probanden und das kann auch sehr teuer werden, je nachdem wie viele man benötigt. Wenn man ein sehr großes Experiment veranstaltet, dann ist es wieder ein Event an sich. Dann haben die Probanden Lust auf dieses Event und es ist wahrscheinlicher, dass sie an dem Experiment teilnehmen wollen. Oder Sie arbeiten mit Medien oder bekannten Künstlern zusammen. Da kann man einen Künstler vielleicht auftreten lassen und im Hintergrund dann verschiedene Experimente durchführen. Ein anderer Ansatz sind auch noch Feldstudien. Da ist man nah dran an den Events und am realen Geschehen, wenn man diese entsprechend ausrüstet.

Ja, da haben Sie recht. Das ganze Thema ist auf jeden Fall sehr interessant und ich bin Ihnen sehr dankbar, dass Sie mir meine Fragen beantwortet haben.

Das ist kein Problem. Ich send Ihnen noch einige meiner Dokumente zu, da ich zu diesem Thema immer mehrere Vorlesungen an der Uni Wuppertal halte. Das ist am einfachsten, wenn Sie sich diese mal anschauen und wenn Sie noch weitere Fragen haben, können Sie sich gerne bei mir melden. Schauen Sie sich auch noch die Publikationen von Frau Sieben und Herrn Boltes an, die können sehr interessant für Sie sein.

Vielen Dank, ich werde mir die Dokumente und mich bei Fragen bei Ihnen melde.

Alles klar, dann Ihnen einen schönen Tag noch.

Danke, Ihnen auch.

8. Summary interview 1 – Armin Seyfried

The interview was arranged with Armin Seyfried from the Research Centre in Jülich, Germany. He studied at the University of Wuppertal and started working at the Research Centre in 2004. Since then, he has been working on improving safety concepts with the help of experiments. He also gives lectures at the University of Wuppertal about computer simulation for fire protection and pedestrian traffic.

During the interview I explain my research project and asked him about his knowledge on the safety guidelines of different countries and if he uses any of them. He explained that he mainly focusses on the safety guidelines in Germany and that he is not aware of other guidelines, but he can imagine that there are differences between the countries. He explained the guidelines for Germany are often not completely reliable, since some data is outdated, and new technology has been developed to improve the data.

Due to his experience in executing large experiments, I was interested in his preparations for the experiments. He explained that it is a lot of work to prepare a good experiment, it often takes around 1 year of work per person. An important aspect is the selections of the test subjects, since every target group is different. All technical aspects need to be prepared, since more than one camera is being used. They need to be synchronised, otherwise the data will not be valuable for the research. Afterwards, the analysis of the data is very time consuming since it is being checked and corrected manually by our team. He explained that many software that are available on the marked is able to give valuable data when the density of the crowd is low, but when the density is higher, many software struggles to deliver usable data. Therefore, a colleague of his, Mr. Boltes, developed a new software that works reliable also with very dense crowds.

I was also interested in his way of analysing the data that he has gathered during an experiment. He explained that this process has been constantly developed since he started working there in 2004. They started with analysing the walking routes of the test subjects using cameras that deliver 25 pictures a second. With this he is able to track the movement of the test subjects very precise and centimetre-accurate and develop density and speed measurements. After that they tried to enrich the walking routes with information about the person itself, such as weight, age, and gender. They use barcodes with this information on hats that the test subjects wear during the experiment. They recently also started working together with a psychologist, Mrs. Sieben, who focuses on how the test subjects feel. They have started to use electro-verbal skin conductance and heart rate as indicators of stress, and they are adding that to the results as well. Currently they are trying to also implement the movements of the arms and legs, using specific suits. This is still in the testing phase.

The results of his experiments are being published on the website of the Research Centre and he hopes that event organizers and other people working with crowds are using this data for their work.

Due to the pandemic, he has noticed small changes in the behaviour of the crowds, but they tried to keep the effects of the pandemic out of the experiments. They even put all test subjects in one small room for a few minutes, to get they used to being close to other people again. He is not sure if this had an impact on the results of the experiment, but they wanted to make sure they did everything to exclude the effect. However, he sees the changed behaviour due to the pandemic being less and less. People are going back to the normal behaviour, and he is sure that this summer everything will be back to normal.

He also said that it is expensive to organize a good experiment, because of all the technical requirements. Paying the test subjects can be a large cost, depending on the size of the crowd needed for the experiment. Since my second experiment was not possible because of the missing test subjects, he explained that the bigger experiments are an event in itself, which makes the people excited to go. Other possibilities are collaborations with the media or famous artists. Having an artist perform somewhere and doing research with the crowd could be a good possibility. Otherwise, going to real events and doing field research is also a good option.

He promised to send me further information on the topic, since he gives lectures on this topic and has much valuable information for me. He also directed me to the publications of Mr. Boltes and Mrs. Sieben since they could also be valuable for my research.

9. Item list for interview with Syan Schaap

Definition topic	Item
Guidelines	- What are guidelines that you use during your work? - How do you keep up to date with the newest developments?
Experiment results	- How reliable are the numbers of the first experiment? - How do the numbers of the experiment reflect the real-life situation at events? - Do you see a difference in the usage of stairs upwards of downwards? - How come there is only a little difference? - How does the surrounding of the experiment influence the outcome? - What results can be drawn from the experiment?
Crowd behaviour	- Are you working with the analysis model of escape safety? - What is the behaviour like during an evacuation? - How can it be influenced? - Do you know other models that analyse the behaviour?

10. Transcript interview 2 – Syan Schaap

Hello Syan, how are you?

I'm good. I am in a small booth here in the office, where you can have calls. Nobody can hear you.

Yeah, that's very nice! Thank you for agreeing to have a meeting with me because the deadline is getting closer, and I need to finish this project. The first experiment was in the beginning of April. I have some results and I wanted to validate the results with this second experiment and but as I wrote in my email it didn't take place because the students didn't show up. I'm now trying to see how I can still use the data that I got from the first experiment. I also did some further research in to other experiments that have been done over the years to compare the numbers. I can share my screen. Okay, so these are for example my results from my first experiment that was focusing on how many people can fit through the door. At the top the blue table is what we counted. We did it both in normal urgency and high urgency and doors one and two were two meters wide and doors three and four were one meter wide. With this I calculated how many people can go through per second per meter and then calculated it up until per minute per meter.

Alright, you have manual counting and camera counting. Was it done at the same moment or was it two different runs?

No, it was the same run.

Okay, so as I understand it through door one which was two meters wide you say, you've got 54 people in 30 Seconds.

53 people passed through there within 24 seconds they were faster than we expected.

Okay, but above this I see 54 with manual counting and 53 with camera accounting.

Yes, I checked it again. There were some mistakes, and it wasn't very accurate the manual counting.

Okay, I understand.

At the bottom underneath I calculated its down and I used the camera counting because it was more accurate, and this is people per second per meter, so I calculated it down the two-meter width to one meter. With this I calculated an average at the end here. From the normal and high urgency, I also calculated in average.

So, this is 1.84 people per second per meter?

Yes, and then I calculated it up per minute, because in the guidelines it is always mentioned per minute, so I am able to compare it. Then I made these graphs. The left one is again per second and the right one is again per minute. Do you have any thoughts on it already or do you recognize this?

Well, if you have a higher speed in emergency situation than normal situations, I would be interested in the starting phase where you brought people together. How many students did you use?

We had 53 students.

When you would compare that to like football stadium filled with spectators looking at a concert, they would be hindered by each other to move towards an exit more than you would expect with a smaller group with 54. What I would expect comparing that with your experiment is that the speeds difference that you have now would not occur in a larger crowd. They would hinder each other so much they would not be able to go faster than they would normally like to do. Maybe I showed in the minor course, but we have some egress footage of the Phillips Stadium Eindhoven after a concert. People are going out as soon as they can because there's nothing more to do so you see them all moving out towards the exits. You see this paddling kind of walk, when you are too close to the other because you don't have the space to take normal steps and that's always sign that people are in a high-density moving crowd. So, if you would see that in your normal egress then you would be able to say: okay, we've got a high density they are also slowed down by density but if you're normal situation egress would have had people moving out quite quickly without any trouble by hindering each other than you would take to accounts that that wouldn't be comparable to a large crowd.

Yes, we had it at door 3. We had them walk around in a circle for two minutes and then they were also doing the penguin walk, but you can't really see it in the numbers.

I understand, you weren't about to measure the speed as in how many meters per second they could walk. Then you would have an extra validation option because the 'Green Guide' has got a table which gives some insight into how fast people still can walk when they are in a certain density. It starts with 1.34 meter per second so that somebody walking quite fast, but it goes down to about 60% of their speed when you are at three people per square metre walking towards an exit. This slowing down of your egress you would see that in a larger crowd but maybe not with 53 students. That is one thing that strikes me and for the rest I don't know what are your own thoughts about it?

It's pretty average I think because I looked at other numbers. I also compare them, and I wrote them down here. It's from other studies that I found. I think I am quite close to what they found out. At the top this is my own experiment, so I think I'm close.

I mean the most important thing would be now to give some context in your report, because what can you learn from this? How should you compare these results with actual real-life situations. I guess you didn't have a muddy floor, you didn't have darkness, you didn't have people being drunk. All those kinds of things that slows people down, so that would be a maximum egress rate. Then you have all kinds of factors slowing the process down for certain percentage I don't know what exactly, but you could expect it to go down.

Okay, what was your aim of the experiments exactly?

The aim was to check the guidelines again, what's really the correct number, what is the most reliable guideline.

About the Dutch building code: of course, with the 134 people per minute, you can say that's quite significantly higher than what you got from your results. You're experiments comes up to about 110 you could say that the guideline in the Dutch building goes are pretty high, maybe too high when you compare it with this experiment. Another thing could be that there are so many factors in places that bring down the maximum speeds in real life maybe figures of around 80 or 85 for example are more likely. The British number would be a safer number to work with because it calculates in the certain extra factors. But to compare it with the guidelines that are in place you could say something in relation to some of those guidelines.

Yeah, that's very good! I also did another experiment about the stairs with students going up and going down. We had them walk up from the ground floor up to the third floor so 6 stairs, two stairs

per floor and we had them walk up and then down and then with high urgency up and down again with high urgency. Then we counted on each stair apart from stairs number three, where we didn't have a camera unfortunately, but the other stairs were all covered. I did the calculations again with the average. You can clearly see that it slows down the higher they get.

This figure that I'm seeing here, is that 100 people per meter steps per minute?

The stairs were one meter wide as well and then we had a line on the stairs and then we counted how many crossed the line in one minute.

Okay, so you have on average 59.52 people. What's the difference between up and down I don't see it here.

Yes, it's on a different slide. The results look a little different. You have to read it from the right to the left. From stairs 6 they go down, but this speed is kind of stable, that's what I noticed. The figure is kind of the same a little bit faster going down and going up because when you are going up you have to defy the gravity. I also looked at other studies. On the left it's going up and on the right it's going down. I only found one other study or the code which is similar to my result and the other studies I found they all only measured the speed of the people going up and down, so I didn't know how to compare it to my results.

Yes, I understand. But you are in between those two with your results, it's also the average of the two figures that we mostly work with, the building code and the Green Guide. We always use the safest option. When we do calculation, we used 82 for flat floors and the 45 for the stairs, because we want to be on the safe side. If you would use only the building code of the Netherlands, we would have a too high number for going through an emergency exit, but when we would use only the Green Guide numbers, we would have a high rate for the stairs. That is why we take the lowest number of both.

Better to be safe than to be sorry! I'm quite happy that I'm pretty close to other research because it was the first time, we did an experiment and I'm glad that it worked. I also focus on the crowd behaviour during an emergency evacuation, and you also mentioned during the expert session in March this one model 'Escape Safety Model'. I'm trying to incorporate that somehow into my research. Do you use this model at all doing your work?

This model states which factors are there in place that could influence escape time like the complexity of location, the way to fire would spread and what kind of composition your crowd has but it doesn't say anything about factors within crowd composition that have an influence on going faster or slower. It's one model that says something, but you would have to look more to the results of like studies that were done after night club fires and try to show what makes people go slower or faster. Recently we did some research on the Rhode Island station nightclub fire and I read what other people already wrote and what struck me there is there's always this moment of first sensing danger but wanting to verify whether the danger is real or not. When this verification process goes very fast because you feel the heat or you don't only hear the alarm go off, but also see smoke coming or maybe a fire marshal steps in and says it is a real danger that you have to go away, then people would go faster or move away faster. That is one thing, going away quickly could be that you would try to escape just by yourself and try to get out danger and in this what you mostly see with fire because there is such a big risk there to get burned that people just go to their primal Instinct to escape from the fire. We also have a course on this topic and in this course, he also talks about what happens in the brain during emergency and that you shut off some functions and others activate your primal instincts. You shut off noticing signs or interpreting what people are still saying. You are only focusing yourself on surviving the situation. That is what you see in nightclub fires, where people are upon each other at the exit points. They only try to get out and we're not able anymore to think more rationally or calmly about other options than going through the front door. They are not in a position to listen to a security guard or listen to somebody's speaking to them about that there are other exits, where maybe it's better to go that way because the danger is at the exit. In other situations, where people are very efficacious helping each other in a social way they help the elderly to escape, and they help people that are maybe stuck under a brick building to escape while they are also in danger themselves but still, they stop and try to help others. He explains that through the 'social identification model' which is also psychological model for understanding crowd behaviour. The identification theory is mostly about why in some circumstances people help each other and in other circumstances people do not show these social skills to act a group or act one. I think that mostly in situations where you're still in a position to have time to think this through that this social identification model is very helpful to understand, because it also slows the evacuation down.

Yes, I also found a few experiments that have been done on people egressing, but some have a motivation to go out and then the competitive behaviour started, and it slowed it down actually instead of people working together to get out and form a line.

Yes, it a bit ambiguous, because when you stop evacuating because you want to help somebody else to get out then you slow yourself down, but another way helping each other could speed up the situation where you act orderly and get people space to get out instead of blocking exit by going to the same point altogether. I don't think that there's a linear way of thinking about this, that if people work more closely together, it will always go faster.

Yes, it's difficult and different per scenarios.

In most cases there is not a reaction of a direct impact. Most cases would be a storm coming out for maybe a fire somewhere else in the building or in the city centre occurs and people have to get away but are not in direct danger. Then you get to see people help each other, I guess. It could also be that somebody using a wheelchair slows down the whole group then it will be better if people act more like a group to have some kind of strategy to come out there altogether.

Yeah, that's true! It all depends, every event is different, and every group is different.

When you have a strong motivation to stay there, it could also slow the evacuation down. If there is a big artist coming on stage shortly and you don't want to accept that this won't go through because of the storm coming out.

I have experienced that in real life. It was at a festival and a thunderstorm came and we were also asked to evacuate, and some people stayed close to the stage and didn't want to lose their spot at the front of the stage. It was outside and then they wanted to evacuate us into the stadium next to the area. Some people tried to stay but they forced them to still go.

It should be very clear for people to understand that they are in danger here and that it makes no sense to stay. There are three ways of reacting to this situation; fight, flight, or freeze. There are people that immediately start helping and come into an action phase where they immediately start doing the right things, like telling others to go away from the danger and showing them where the accident is or maybe getting people out of the incident. Then there's a bigger group that needs to guidance, that's 80%. According to a psychologist it's 10% that act very adequately, 80% needs guidance; what should we do now, but they will do what you tell them to do and then there's 10% that doesn't accept the situation and lock. They have a brain block. There are two different blocks, as I understand from Erica our teacher from the
psychology course, one is a live lock, and the others is a dead lock. When you are in a life lock you are still standing up and just don't want to go away you, you're so confused you don't understand what's

going on, but you're not able to think adequately. When you're in a deadlock you just drop down. You can't react anymore.

Wow very interesting. There are so many aspects on this topic so I'm trying to navigate what I'm going to include and what not. All right, I think those were my main questions.

Okay, was I able to help you?

Yes, definitely! I just wanted to validate the data with someone who's in the industry.

Would it also be an idea to work on something for our website maybe?

I'm working on a knowledge clip for LCB and a one pager about this project.

It would be interesting for people that get our newsletter and there are always people interested in these kinds of subjects that you did so yeah would be nice to publish something there.

Yeah, of course. I will keep in contact.

Perfect, I would like to read about your results.

Alright, thank you again for your help and see you soon.

No problem, see you soon. Bye.